
Upgrading the System of Innovation in Late-Industrialising Countries

– The Role of Transnational Corporations in
Thailand's Manufacturing Sector

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Upgrading the System of Innovation in Late-Industrialising Countries

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Zusammenfassung

Die vorliegende Arbeit untersucht, welchen potenziellen Beitrag transnationale Unternehmen (TNU) zur Verbesserung des Innovationssystems in spät-industrialisierenden Ländern leisten können. Hierzu werden TNU-Zweigbetriebe im verarbeitenden Gewerbe in Thailand analysiert und mit einheimischen Firmen sowie Unternehmen in Penang (Malaysia) und Singapur verglichen.

Technologischer Fortschritt in spät-industrialisierenden Ländern bedeutet vielfach, moderne Technologien aus Industrieländern zu absorbieren, zu adaptieren und inkrementell zu verbessern. Voraussetzung für diesen Prozess ist, dass Unternehmen externes Wissen aufnehmen und sich aneignen können (Absorptionsfähigkeit). Hierzu sind zeit- und kostenaufwändige Lernprozesse notwendig, durch die Firmen technologische Fähigkeiten aufbauen. Erst diese Fähigkeiten ermöglichen ihnen Innovationen hervorbringen. Da interaktives Lernen eine wichtige Komponente dieses Lernprozesses ist, spielt die Qualität des Innovationssystems eine entscheidende Rolle. Typischerweise sind diese Systeme in spät-industrialisierenden Ländern allerdings schwach ausgeprägt und fragmentiert. Gleichzeitig beherbergen sie leistungsfähige TNU. Somit stellt sich die Frage, inwieweit TNU zur Verbesserung der Innovationssysteme beitragen können.

Aufbauend auf Merkmalen und Bestimmungsgründen der Internationalisierung von Unternehmen betrachtet die Arbeit deswegen die Auswirkungen von TNU auf Gastregionen, insbesondere hinsichtlich des Lernpotenzials für einheimische Unternehmen. Hieraus werden anschließend die theoretisch zu erwartenden Einflüsse von TNU auf Innovationssysteme in spät-industrialisierenden Ländern und Hypothesen für die empirische Untersuchung abgeleitet.

Die Analyse von Sekundärstatistiken und vorliegenden Studien belegt ein recht schwach ausgeprägtes Innovationssystem in Thailand: Vielen Unternehmen mangelt es an Fähigkeiten für Produktentwicklung, Forschung- und Entwicklung, Design und Engineering. Forschungseinrichtungen verzeichnen im internationalen Vergleich einen geringen wissenschaftlichen Output und ihre Forschung ist nicht unternehmensrelevant. Das Ausbildungssystem bringt zu wenige und zu schlecht ausgebildete Absolventen hervor, insbesondere im technisch-naturwissenschaftlichen Bereich. Die Technologiepolitik ist durch eine Vielfalt an Institutionen und Programmen gekennzeichnet, die einer effektiven Förderung im Wege stehen.

Auf Basis von schriftlichen und mündlichen Unternehmensbefragungen wird anschließend die technologische Leistungsfähigkeit von TNU-Tochterunternehmen im Vergleich zu einheimischen Betrieben untersucht, um festzustellen, ob diese geeignete Lern- und Kooperationspartner für einheimische Unternehmen sind und somit zur Verbesserung des Innovationssystems beitragen können. Während dies für die Gesamtgruppe der Unternehmen nur eingeschränkt zutrifft, sind in der Gruppe der fortgeschrittenen Unternehmen TNU deutlich überlegen. Insbesondere tragen sie aktiv zum internationalen Wissens- und Technologietransfer bei, indem sie externe Technologien in Form von Maschinen, Lizenzen und Patenten sowie Ergebnisse von FuE-Aktivitäten nach Thailand transferieren. Ferner sind sie stärker als einheimische Unternehmen in internationale und nationale Wissens- und Kooperationsnetzwerke eingebunden und können somit als aktive Wissens- und Technologievermittler zwischen der internationalen und nationalen Ebene wirken. Dies trifft insbesondere auf TNU zu, die in Thailand Produkt- und Prozessinnovationen hervorbringen. Diesbezüglich ist derzeit ein Anstieg von Aktivitäten zu beobachten. Die Folge ist eine Intensivierung von Innovationsaktivitäten in ganzen Produktionsnetzwerken von der auch einheimische Unternehmen erfasst werden. Allerdings ist die Aufnahmefähigkeit für neue Technologien und die Intensivierung von Innovationsaktivitäten für viele einheimische Unternehmen beschränkt, weil es an gut ausgebildetem Personal mangelt. Zum einen wird dieser Mangel durch TNU verschärft, die hauptsächlich höher qualifizierte Personen beschäftigen, zum anderen tragen einige TNU intensiv zur Weiterqualifizierung von ihren Angestellten und zur Verbesserung der Ausbildung in Universitäten bei.

Aus den Ergebnissen werden Handlungsempfehlungen zur stärkeren Verankerung von TNU sowie zur Verbesserung des Innovationssystems und lokaler Lernmöglichkeiten abgeleitet.

Summary

The objective of this thesis is to investigate the potential contribution of transnational corporations (TNC) to the upgrading of systems of innovation in late-industrialising countries. This study looks specifically at TNC-affiliates in Thailand's manufacturing sector and compares them with firms in Penang (Malaysia) and Singapore.

Technical change in late-industrialising countries is primarily a process of absorption, adaptation and incremental improvement of modern technologies available in advanced economies. This technology and knowledge transfer necessarily involves costly and time consuming learning processes that require absorptive capacity and a certain level of commitment from the receiving company. For latecomer firms, the main objective becomes the development of technological capabilities, which are a pre-requisite for further innovative capabilities. An important determinant of the opportunities for interactive learning and technological capability development is the quality of the respective system of innovation. In late-industrialising countries these systems are typically fragmented and strongly influenced by a presence of TNCs. Taking the characteristics and reasons for the internationalisation of firms into account, this study examines the expected impacts that TNCs have on host economies, emphasising the learning opportunities that may arise for local firms as a result. The theoretical section concludes with an assessment of the potential impact of TNC-affiliates on the system of innovation in late-industrialising countries and, additionally, deduces hypotheses for the empirical analysis.

In order to evaluate the present state of Thailand's system of innovation (SI), secondary data and previous studies are reviewed. Ultimately, this review leaves a fairly poor impression of the Thai SI: Many companies lack capabilities for product development, research and development, design and engineering. In terms of international comparison, research institutes and universities display weak scientific output and, moreover, the research does not match the needs of industry. In addition, the quantity and quality of graduates, especially in science and technology, coming out of the education system is insufficient. Government policies, because they depend on a large assortment of different organisations and programmes responsible for S&T development, are regarded as inefficient.

The thesis examines the technological capabilities of TNC-affiliates vis-à-vis local firms in order to assess whether or not TNC-affiliates are suitable learning and cooperation partners for local firms, and can, consequently, be considered as capable contributors to the improvement of the system of innovation. Based on postal firm surveys and additional personal interviews, the empirical analysis comes to the conclusion that, in general, this is only partially the case. However, with the analysis shifted to include only advanced firms, TNCs prevail more clearly. Advanced TNCs are especially able to foster the development of the national system of innovation by transferring embodied (e.g. machinery) and disembodied (e.g. patents) technology as well as research results to Thailand. Moreover, they are more frequently embedded in international and domestic knowledge and cooperation networks. In consequence, advanced TNC-affiliates can act as gateways for the diffusion of internationally available technology and knowledge in Thailand. In particular, foreign firms that perform product and process innovations in Thailand are strongly embedded within the SI. Recently, an increase in respective activities has lead entire production networks – including local firms – to upgrade. However, the absorptive capacity of local firms for the absorption of new technology and the potential for enhanced innovation activities is restricted, due to a lack of skilled labour. On the one hand, TNCs absorb much of the scarce high-skilled labour by employing, in general, better educated personnel, on the other hand, some TNC-affiliates actively try to improve and extend the human skill base by providing further training for their workforce and by contributing to university programmes.

Based on these empirical results, the thesis concludes with policy recommendations, which could act as guidelines for the further embedding of TNC-affiliates in the host economy, the strengthening the system of innovation, and the fostering technological learning by local firms.

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List of Abbreviations

ACAP	Absorptive capacity
BERD	Business enterprise expenditure on R&D
BIOTEC	National Center for Genetic Engineering and Biotechnology
BMR	Bangkok metropolitan region
BOI	Board of investment
CII	Collaboration Intensity Index
CKD	Completely Knocked Down
ESR	Eastern seaboard region
FDI	Foreign direct investment
FSA	Flex suspension assembly
GDP	Gross domestic product
GDP	Gross domestic product
GERD	Gross domestic expenditure on R&D
GNI	Gross national income
HBA	home-base-augmenting
HBE	home-base-exploiting
HDA	Head disk assembly
HDD	Hard disk drive
HGA	Head gimbal assembly
HSA	Head stack assembly
HQ	Headquarters
IDEMA	International Disk Drive Equipment and Material Association
ISO	International Organisation for Standardisation
JIT	Just in time supply chain management
LCF	latecomer firms
MA	Manufacturing arm company
MNC	Multinational corporation
MNE	Multinational enterprise
MOSTE	Ministry of Science, Technology and Energy (later Environment)
MTEC	National Metal and Materials Technology Center
NECTEC	National Electronics and Computer Technology Center
NESDB	National Economic and Social Development Board
NIA	National Innovation Agency
NIC	Newly industrialising country
NRCT	National Research Council of Thailand
NSI	National system of innovation
NSTC	National Science and Technology Policy Committee
NSTDA	National Science and Technology Development Agency
OBM	Own brand manufacture
ODM	Original design and manufacture
OEM	Original equipment manufacture

OLI	Ownership- Location – Internalisation- Advantage
QC	Quality Control
PCB	Printed circuit board
PIS	Penang Innovation Survey
R&D	Research and development
RHQ	Regional headquarters
RSI	Regional system of innovation
RTO	Public research and technology organisations
S&E	Science and engineering
S&T	Science and technology
SCI	Science Citation Index Expanded
SI	System of innovation
SIS	Spatial system of innovation
SME	Small and medium sized firm
SNIS	Singapore National Innovation Survey
SSCI	Social Sciences Citation Index
SSI	Sectoral system of innovation
STDB	Scientific and Technology Development Board
TC	Technological capabilities
TDRI	Thailand Development Research Institute
TIS	Thailand R&D/ Innovation Survey
TNC	Transnational corporation
TQM	Total quality management
TRF	Thailand Research Fund
TS	Technological system
TT	Technology transfer

1 Introduction

“Countries can sustain industrial growth today only if the key players – individual enterprises – are able to develop competitive capabilities. Building capabilities requires conscious technological and other effort. And this effort is not very different whether an enterprise is creating new technologies or learning the efficient use of technologies brought from other countries. Whether such effort is undertaken, and how well it is managed, varies from enterprise to enterprise, according to its management, strategy and resources. But it also depends vitally on the economic environment in which the enterprise functions” (UNIDO, 2002: 93).

Regions, nations and people can only prosper if the companies they host are successful. In order to be successful companies need to be competitive. In an increasingly globalised world, with very strong competitors operating in the domestic as well as the global market, companies must make additional efforts to strengthen their competitiveness.

Thailand has been picked as a case study, because it is a good example of an ‘ordinary’ late-industrialising country. It is not a highly successful ‘tiger economy’ such as Korea or Taiwan, nor is it a special case of a city state such as Hong Kong or Singapore – moreover, it currently finds itself in a ‘sandwich position’ in respect to its competitive advantage. After having experienced remarkable growth in the decades prior to the Asian crises in 1997, Thailand is no longer a true low-wage country, but it is not a high-skill, knowledge economy either. The pressure from ‘beneath’ is strong: new entrants on the global stage such as China offer large domestic markets, low wages and a rapidly improving workforce and infrastructure (e.g. Vongpivat, 2002: chapter 2, Altenburg et al., 2003: pp. 33). Hence, Thailand needs to upgrade quickly, in order to sustain and enhance its competitive position. If it does not manage to improve the human skill base, the technological capabilities of local and transnational companies and the supporting infrastructure, the ‘doomsday scenario’ of massive disinvestment by transnational corporations (TNCs), decreasing world market shares and, consequently, a decline in economic growth rates and poverty reduction lingers on the horizon. This is a challenge Thailand shares with other late-industrialising countries.

Thai-based firms, like those in most late-industrialising countries, do not drive the technological frontier by inventing ‘new to the world’ products and processes. Rather, they try to improve their competitive position in order to catch up with leading companies in advanced countries. This catching-up process requires rapid learning and technological upgrading on behalf of the latecomers (Wong, 1999a). Consequently, latecomer firms need to be very innovative – not by developing truly new products, but by acquiring, adapting, using and improving already existing technology from advanced countries. While firms all over the world try to stay competitive by upgrading, i.e. by making better products, producing more efficiently, or moving into more skilled activities

(Humphrey & Schmitz, 2002), latecomer firms need to upgrade and learn more quickly than their advanced country equivalents in order to close the gap and catch up.

Upgrading is not a simple intra-firm task, but requires interaction with other parties. For example, a company must be aware of new developments in process technology, new organisational methods or the latest standards of key customers in lead markets. It needs to know about possible technology, where to buy and how to use it; it has to find out about consumer preferences and new market niches. It is obliged to enhance the knowledge base of its human capital. In order to achieve all this, a company has to rely on information and co-operation networks. The quality of these networks is determined by the quality and the quantity of nodes (e.g. companies and universities) and their interactions. Additionally, the institutional set-up (such as policies, laws, regulations, etc.) has a strong impact on firms' behaviour. The analysis of these environmental conditions: actors, interactions and institutions, is at the heart of the 'systems of innovation' (SI) concept. However, developing countries have been neglected in innovation systems literature (Carlsson, 2004: 14) – creating a gap this study strives to narrow.

Since spatial proximity seems to foster certain kinds of knowledge transfer the quality of their national or regional system of innovation is essential for firms. This is not, however, a one-way benefit, but works mutually: innovative firms participate in a regional/ national network and therefore strengthen the quality of the network, while simultaneously benefiting from this network through knowledge flows and co-operation opportunities.

Nevertheless, to consider only the national and regional scale would be misleading. Even companies within strong systems must have access to interregional and global knowledge. Therefore, interfaces or gateways to the international available pool of knowledge and technology are important for any region – but they are particularly important in late-industrialising countries, which are typically characterised by a fragmented system of innovation (Ernst, 2002).

Therefore, in the context of late-industrialising countries, affiliates of TNCs play a particular role: First, they account for a high share of economic activity in many of these countries. Second, they are exposed to breakneck competition on global markets, which forces them to apply the latest technology, to develop new products, to improve quality, and to reduce costs permanently. This pressure is transferred to domestic rivals and suppliers alike, because TNCs demand high quality, low prices and high standards. Therefore, TNCs push local companies to become more competitive. But at the same time, they support local firms, either directly by offering assistance or indirectly by knowledge spillovers, demonstration effects etc. Consequently, TNCs can act as gateways or interfaces between the regional/ national systems of innovation and the globally available pool of knowledge and technology.

Following this line of argument the objectives of the thesis are

- to expand upon the contribution made by TNC-affiliates to the SI and the technological learning of firms in late-industrialising countries theoretically,
- to ascertain the current state of the Thai-SI,
- to assess the technological capabilities and knowledge-network embeddedness of TNC-affiliates in comparison to local Thai-firms, and firms in Penang and Singapore, in order to evaluate their suitability as collaboration partners and technology senders within the Thai-SI,
- to investigate the main characteristics of advanced and embedded TNC-affiliates,
- to elaborate upon the key mechanisms by which TNC-affiliates improve the Thai-SI and foster technological learning by domestic firms,
- to identify weaknesses of the SI as perceived by firms and elaborate policy recommendations for strengthening the SI and the impact of TNC-affiliates.

To meet these objectives, the following key questions will be addressed:

a) Theoretical aspects:

- 1) What are the characteristics and challenges of late-industrialising countries and latecomer firms?
- 2) Why is the development of technological capabilities quintessential for technical change in late-industrialising countries?
- 3) What is a national, regional and sectoral system of innovation and how does it relate to the development of technological capabilities in late-industrialising countries?
- 4) How do SIs in late-industrialising countries differ from those in advanced economies?
- 5) What are characteristics of TNCs and how can they theoretically influence host regions economies and local firm's technological learning?
- 6) Based on the theoretical overview, what are the (potential) impacts of TNCs on SIs in late-industrialising countries?

b) Literature review and secondary data:

- 7) What is the current state of the SI in Thailand? Which strengths and weaknesses can be identified?
- 8) What level of quality exists among the primary components of the system, namely firms, knowledge-related organisations and government?

c) – f) Questions for the empirical quantitative data analysis:

- 9) Are TNC-affiliates more capable than local firms in terms of technological and innovation capabilities as well as absorptive capacity? In which respect can differences be identified?
- 10) Are these differences between local and foreign firms smaller for more technologically advanced firms?

- 11) How strong is the embeddedness of technological advanced firms in domestic and international innovation networks?
- 12) How do these findings compare to the results of the benchmarking regions Penang (Malaysia) and Singapore?
- 13) What are key characteristics of technologically advanced and embedded firms in Thailand?
- 14) What are the main bottlenecks for technological upgrading perceived by local and foreign firms in Thailand?

c), e), f) Questions for the case studies:

- 15) What is the state of technological capabilities in selected firms in the automotive and hard disk drive (HDD) industry in Thailand?
- 16) How strongly are the firms embedded into the local economy in terms of inputs, outputs and external collaborations?
- 17) To what extent do these firms carry out process and product innovations in Thailand? How is the innovation process organised between TNC-affiliates in Thailand and their headquarters abroad?
- 18) What is the firm's perspective on the human capital base and how do they try to improve it?

f) In conclusion:

- 19) Based on the answers to these questions: What policy recommendations can be given for fostering technological capabilities and embeddedness of TNC-affiliates as well as local firms in Thailand?

The thesis is organised into six chapters. First, the theoretical background is provided consisting of three blocs: The first bloc sheds light on the particular challenges faced by companies in late-industrialising countries. The concept of **technological capabilities** is introduced, which allows the measurement of a firm's technological performance. Furthermore, basic concepts for the development of technological capabilities via technological learning are presented, namely organisational learning processes, absorptive capacity, technology transfer, and crises construction. Finally, the different technology trajectories are presented, which companies in South-East and East Asian countries utilise for catching-up.

In the second bloc the concepts of **systems of innovation** are considered. Spatial (national and regional) as well as non-spatial (sectoral and technological) SIs are defined. Moreover, their applicability to late-industrialising countries in South East Asia is reflected upon.

In the third bloc characteristics of **transnational corporations** and **global production networks** are examined. Motives, types and strategies for the internalisation of production and R&D are analysed. This section also explores the notion of embeddedness and possible impacts of TNC-affiliates on the host economy.

The final bloc of the theoretical section tries to bring the three lines of theoretical arguments together, by providing a condensed picture of the possible contribution by TNCs to the SI in late-

industrialising countries and, therefore, to the technological learning efforts of domestic firms. Based on these theoretical arguments, hypotheses for the empirical investigation are deduced.

Second, the data and methodology are presented. Basically, this thesis utilises two sources of information: first, unique survey data from the Thailand R&D and Innovation Survey 2000 and 2002, which encompasses about 1,200 and 1,400 manufacturing companies and secondly, data from qualitative in-depth interviews with ten firms in the automotive and eleven firms in the HDD-industry.

Third, an overview is given of Thailand's economic development in the last thirty years and the current status of the national system of innovation is analysed based on secondary data and a literature review.

Fourth, the deduced hypotheses are tested with the available quantitative data. For this, first local and foreign firms are compared in respect to technological capabilities and absorptive capacity. Subsequently, only technologically advanced firms are considered. Moreover, the embeddedness of these firms is analysed. Explorative statistics enquire into key characteristics of the technologically advanced and embedded firms. Furthermore, weaknesses of the Thai-SI are determined as perceived by the surveyed firms.

Fifth, using the qualitative data from the interviews a number of in-depth insights from the automotive and HDD-industry are used to illustrate and further analyse these findings.

Finally, several conclusions are drawn from the presented analyses and further policy recommendations are given on how to strengthen the Thai system of innovation, to better embed TNC-affiliates into the Thai systems of innovation, to enhance innovation activities by TNCs in Thailand as well as how to reduce bottlenecks for the interaction between TNCs and local companies.

2 Transnational corporations in the system of innovation of late-industrialising countries: theoretical aspects

This chapter provides a theoretical framework for the subsequent data analysis. It draws on three main blocs: First, it reviews literature on the specific characteristics, challenges and opportunities of late-industrialising countries and latecomer firms, thereby introducing the concept of technological capabilities and technological learning. Secondly, it introduces the notion of systems of innovation (SIs), which are the primate settings in which these learning and upgrading processes take place and which influence these developments. Thirdly, transnational corporations (TNCs) and their global activities are scrutinised, because these are essential actors within the world economy, have a particular importance in late-industrialising countries and can have a major impact on the SIs as well as on technological learning and upgrading. The final chapter of this section weaves these three lines of reasoning together in order to provide a theoretical perspective on the role played by TNC-affiliates in the system of innovation of late-industrialising countries.

2.1 *The challenge for late-industrialising countries: catching up*

2.1.1 Late-industrialising countries and latecomer firms

It is necessary to set the term '**late-industrialising**' into a time-context. For example Germany was a late-industrialising country in comparison to Britain in the 19th century and managed to catch-up successfully (Gerschenkron, 1962; Mathews, 2002). Nowadays, countries that started their transformation from an agrarian to industrial economy in the mid 20th century like Thailand, Malaysia and Singapore are considered late-industrialising. Ernst and O'Connor (1989: 10 and pp. 54) identify specific features of today's late-industrialising countries: They have a short history of industrial development, their capital goods industries, parts and components suppliers and related support services display a low competitiveness, they are dependent on generic technologies and product standards developed in OECD countries, and finally they have a relatively weak human resource base (similar Hobday, 1995a: pp. 33).

In Amsden's (1991: 285) view, today's industrialising countries face different conditions: "whereas industrialisation in the eighteenth and nineteenth centuries was propelled by new products and processes, late industrialisation is being driven by borrowing technology or 'learning'".

Late-industrialising countries have different choices on how to industrialise: Three types of industrialisation strategies can be distinguished: the export of indigenous commodities, the import substituting industrialisation and the export-oriented industrialisation (Dicken, 2003a: pp. 175). Import substitution is a process in which a country starts manufacturing products which it imports, in order to substitute for these imports. It has predominantly been the initial stage of the industrialising process in late-industrialising countries. Nevertheless, the export-oriented industrialisation soon became fashionable and the "conventional wisdom among such international agencies as the Asian Development Bank and the World Bank" (ibid.: 177). It can be seen as "an essential ingredient of latecomers' growth" (Radošević, 1999a: 3), because import substitution by

its own did not manage to achieve the desired level of industrialisation. Due to liberalization, shrinking transport costs and parallel growth of world trade (globalisation), the export-oriented strategy became feasible for most emerging economies in South East Asia.

In order to export products, companies in late-industrialising countries need to be competitive in the world market. While from a traditional macroeconomic point of view competitiveness was only caused by prices, costs and exchange rates, research by Fagerberg (1988) gives evidence that international competitiveness is based on technological competitiveness and the ability to compete in delivery, while the influence of cost competitiveness is less important. Therefore, “competitiveness can be seen as the outcome of a continuous process of innovation that enables firms to catch up and keep up as technology and the mode of competition change” (Mytelka, 1999: 17). Consequently, innovation is at the core of technological competitiveness and of economic growth¹.

Not only countries can be late entrants into the industrialisation process and the world market, but also firms within these countries. **Latecomer firms** may be defined by the following distinctive conditions: Due to historical reasons the latecomer firm is a late entrant, which is initially resource-poor, for example lacking access to technology and markets. Its strategic intention is to catch-up, for which it has some initial competitive advantages, such as low costs, which it can utilise to leverage a position within the chosen industry (Mathews, 2002: 472).

For this, latecomers have certain disadvantages as well as advantages compared to earlier entrants. The advantages of first movers like early capture of consumers, pre-emption (e.g. key resources), and learning curve effects, pose **disadvantages** for latecomers. Additionally, their rapid learning efforts are hindered by their distance from lead-user markets and from leading sources of technology, both of which are primarily located in advanced countries. Moreover, they suffer from “relative shortage of specialized input resources and inadequate public infrastructures” (Wong, 1999a: 5). While the first set of disadvantages is experienced by all new entrants, the later ones are unique to companies in late-industrialising and developing countries.

¹ Economic growth has been defined as “a long-term rise in capacity to supply increasingly diverse economic goods to its population, this growing capacity based on advancing technology and the institutional and ideological adjustments that it demands” (Kuznets, 1973; cited in Todaro & Smith, 2003: 85). Despite the importance of technological change for economic growth, neoclassical growth theory (Solow, 1956) treated the rate of technological progress as an exogenous factor for many years. The growth function only included the stock of capital and labour: $Y = F(K,L)$ (Solow, 1956). Due to the diminishing returns on capital and labour the model approaches long-run equilibrium and results into convergence to zero growth in all countries (Todaro & Smith, 2003: pp. 130). It was not until the late 1980s that Romer (1990) and Grossman and Helpman (1991) internalised technological change into the growth function. The new growth model sees technological change as the driving force of economic growth. Key determinants of technological change are human capital and knowledge. While human capital encompasses all the knowledge and skills that are bound to a person, the term knowledge describes information in the form of publications or blueprints. Thus, neoclassical theory was now able to model non-converging development paths (due to persistent growth) and stressed the importance of technical change for economic growth as well as for comparative advantages (for the latter see Grossman & Helpman, 1990) (for more on new growth theory see e.g. Koschatzky, 2001: chapter 3 and Maier & Tödtling, 2002, chapter 6). Additionally, it included more realistic assumptions, such as increasing marginal returns to capital investment, economies of scale and imperfect competition (Todaro & Smith, 2003: 147, Schätzl, 2001: pp.202). Hence, growth in and competitiveness of a region/country is influenced by the stock of human capital and the knowledge that was transferred from other regions/countries; moreover, convergence as well as divergence between countries/ regions could be explained (Koschatzky, 2001:81).

On the other hand, latecomers also enjoy certain **advantages**, such as low switching cost, if there is a significant change in consumer taste, technology or organisational characteristics, which are difficult for established companies to adapt to. Furthermore, late-movers benefit from information externalities spawned by technology pioneers and by information asymmetries, because they can observe the experiences made by the pioneers. Moreover, late-movers from late-industrialising countries possess the advantage of (at least) initially lower factor costs and of (often) sheltered markets. Additionally, information on competitors in the advanced countries are easily available, whereas information on the newcomers from late-industrialising countries is more difficult to gather (Wong, 1999a, Hobday, 2000).

“Latecomer firms, like latecomer nations, are able to exploit their late arrival to tap into advanced technologies, rather than having to replicate the entire previous technological trajectory. They can accelerate their uptake and learning efforts utilizing various forms of collaborative processes and state agencies to assist with the process, bypassing some of the organizational inertia that holds back their more established competitors” (Mathews, 2002: 470).

In essence, when latecomer firms begin operating, they must import technology from abroad and build up technological capabilities (see 2.2) in order to use, adapt and improve these technologies. To foster this technological learning (see 2.3), firms have to work on linking, leveraging and learning:

- **Linking:** connecting with outsiders to acquire needed technologies and skills. Since resources are frequently gained through firm-to-firm contractual connections and not from open market transactions (Mathews, 2002: 476), it is important for latecomers to access production networks (see chapter 2.3.3) and to utilise linkage opportunities through outsourcing, OEM-contracting, local sourcing, second sourcing and technology licensing (ibid.).
- **Leveraging:** “going beyond arms-length transactions to squeeze as much as possible from new relationships with outsiders” (UNIDO, 2002: 95). The concept of resource leverage was introduced by Prahalad and Hamel (1990, also Hamel & Prahalad, 2000) to depict the capacity of firms to tap into financial, technological and other resources for accelerating their entry into new product markets or for enhancing process technology upgrading.
- **Learning:** to make the links and the resource leverage work, companies need to make an effort, i.e. to learn. Learning is necessary in order to master acquired process and product technologies. But learning is also essential for building up absorptive capacity (Cohen & Levinthal, 1990, see chapter 2.1.3.2), so that firms can combine new and existing knowledge for the adaptation, improvement and recombination of technology. Hence, the ability to learn rapidly is a necessary pre-requisite for the latecomer’s catch-up process (UNIDO, 2002, Mathews, 2002).

The basic idea of the **catching-up hypothesis** is that followers use capital stock that is based on older technology than that of leaders. Therefore, the follower will experience a larger leap in productivity gains when acquiring new capital goods than the leader and will eventually close the gap between it and the leader. However, the potential for growth decreases as the follower approaches the leader's productivity level (Abramovitz, 1986). Freeman (1999) shows for East Asian countries that technical change plays a decisive role in the catching-up process. Catching-up is often linked to imitation and following the same path of development, but "technological imitation serves a more complex function than simply pursuing the same path of development as that of more industrialised countries. It involves a critical stage in the process of learning to industrialise..." (Juma & Clark, 2002: 4).

Tab. 2.1: Innovation strategies and their characteristics

Innovation Strategy	Catch- up Strategies (latecomers)	Keep-up Strategies (quick followers)	Get-Ahead Strategies (front runner)
Capabilities	1 problem solving innovation - attention to "know-why" - learning to learn 2 improvements in productivity and machinery maintenance 3 imitation 4 adaptation	1 introduction of variety 2 improvement in quality 3 reduction in costs 4 incremental change	1 new combinations of generic technologies 2 pushing back the frontiers of knowledge
Critical Knowledge Inputs	Engineering and management capabilities: feedback from production process, product scanning and adaptation capabilities	Engineering, testing, design and marketing: linking design and production within firm	Scientific research and scaling up of laboratory models. Linking of R&D and marketing within the firm
Policy Objectives	Technology transfer, diffusion, demonstrating, training	Technology development, R&D networking	In-house research, technology development; R&D networking
Useful Partnership Linkages	To apprenticeship programs, productivity centres, clients, equipment suppliers and intermediaries	To university engineering faculties, consultancy firms, design centres, technology institutes, users	Windowing through a broad array of long-term R&D collaborative projects with research institutions, user & material suppliers

Source: Mytelka, 1999: 20

Despite the recognition of the importance of **path dependency**, catching-up is not a linear and unidirectional process: "As long as technology is understood as a cumulative unidirectional process, development will be seen as a race along a fixed track, where catching up will be merely a question of relative speed. Speed is no doubt a relevant aspect, but history is full of examples of how successful overtaking has been primarily based on running in a new direction" (Perez & Soete, 1988: 460). Therefore, the **leapfrogging hypothesis** claims that latecomers do not have to follow all technological stages, but can leap frog certain stages while catching-up. Technological paradigm shifts, especially, offer windows of opportunity, i.e. major shifts in technology which result into everybody being a newcomer (e.g. Perez & Soete, 1988, Soete, 1985).

Latecomers and their strategies for catching-up are obviously different from technology leaders, that generate new products and processes, or technology followers, that managed to catch-up but still operate behind the technological frontier (Hobday, 1995b, Mytelka, 1999; see Tab. 2.1). Once a company has caught up with state-of-the-art companies, it needs to switch to a keep-up strategy,

and might want to aim for a get-ahead strategy, by working at the edge of the technology frontier (see also Ernst et al., 1998a, Hobday, 1995b, a).

Only few companies from late-industrialising countries such as Korea have so far achieved this level. Since the creation of technological capabilities can be seen as a key factor for successful catch-up, the next section introduces the notion of technological capabilities and different frameworks that facilitate the evaluation of companies and their development over time.

2.1.2 Technological capabilities

If latecomer firms in late-industrialising countries decide to follow the export oriented strategy (see 1.1.1), they need to compete in a global market. Typically, a domestic capital goods industry cannot be relied upon to provide them with state-of-the-art machinery; rather they have to import technology from advanced countries. To produce on a competitive basis, they are faced with at least two challenges: first, they need to acquire the right technology and use it efficiently; second, in order to stay competitive they need to improve their production process/ technology constantly. Neither task is trivial. Beginning with a static view, it is not sufficient for latecomer firms to simply acquire technology and start operating. “If technology were simply a matter of information, competitiveness would be relatively easy to achieve and sustain, and catching up economically would be much less difficult than it has been. But in fact technology consists of complex ‘bundles’ of information – both codified and tacit² – as well as physical capital” (Bell & Pavitt, 1995: 74). Since the tacit components are not transferred easily, it is necessary for latecomer firms to build up **production capabilities**: firms have to accumulate experiences by trial and error, by experimenting and understanding the technology. Because of this, every technology has to be combined with a local effort of adaptation and learning in order to be run efficiently: “Technology has many tacit elements that require a new user to build skills, knowledge and institutional routines (capabilities)” (UNIDO, 2002: 94). A more dynamic analysis, suggests that it is not enough to reach a competitive production capability. Rather, in order to stay competitive in an ever changing environment, it is necessary to improve constantly. Therefore, latecomer firms need to develop **technological capabilities** to generate and manage technical change (Bell & Pavitt, 1995: 78).

“Once firm-level technological change is understood as a continuous process to absorb or create technical knowledge, determined partly by external inputs and partly by past accumulation of skills and knowledge, it is evident that ‘innovation’³ can be defined much more broadly to cover all types of search and improvement effort. From a firm’s point of view, there is little difference in essence between efforts to improve technological mastery, to adapt technology to new conditions, to improve it slightly or to improve it very significantly – though in terms of detailed strategies, degree of risk and potential rewards these efforts will certainly be different”

(Lall, 1992: 166; also UNIDO, 2002).

² Codified knowledge is written down in manuals or embedded in technology and tacit knowledge is bound to specific persons or organisations. Refer to chapter 2.1.3.1 for more information on codified and tacit knowledge.

³ For a discussion/ definition of the term innovation see 2.1.3.1.

Consequently, the main processes of technological change in late-industrialising countries are acquiring and improving on **technological capabilities**, not innovating at frontiers of knowledge. Hence, technical change essentially consists of learning to use and improve technologies that already exist in advanced economies (Lall, 2000: 13).

Technological capabilities have been conceptualised since the early 1980s. This concept encompasses the stock of technological knowledge and the use of that knowledge. It is connected to the notion that latecomer firms develop technological capabilities over time and become eventually 'technologically mature' firms (Dutrénit, 2000: 10).

There are various ways to categorise firm-level TCs (see Bell & Pavitt, 1995, Lall, 1992, Marcelle, 2002, Wong, 1999b, Ernst et al., 1998a, UNIDO, 2002). One of the first illustrative concepts was presented by Lall (1992; Appendix A1) and is based on previous work by Lall (1987), Katz (1984, 1987) and Dahlman et al. (1987). It distinguishes two functional categories: investment and production, which are each subdivided into more specific functions. Further elaborating on this concept, Bell and Pavitt (1995) identified additional supporting activities and the distinction between production and technological capabilities (see above) to emphasize the dynamic aspect of technical change (Tab. 2.2). For one of the latest versions of the technological capabilities frameworks please refer to UNIDO (2002) (Appendix A2).

Despite the variety of frameworks all concepts agree with Kim (1999) that technological capability has (at least) three elements: production, investment and innovation. This limits the frameworks to purely technological categories, despite the recognition that these have to be accompanied by organisational/ institutional capabilities. As a result, some of the later frameworks include marketing capabilities, because of their particular importance for the development of technical capabilities (Wong, 1999b, Ernst et al., 1998a, UNIDO, 2002). While almost all concepts display the TCs on a matrix, indicating different 'depths' of sophistication, such as basic, intermediate and advanced, there is some disagreement on how to include innovation: Some frameworks consider innovation as a separate category (e.g. Ernst et al., 1998a, Kim, 1999) while others – in accordance with the above presented understanding of technical change – see innovation rather as an integrated part of each TC-category, indicating different levels of sophistication (e.g. Bell & Pavitt, 1995, UNIDO, 2002).

For a brief review of empirical studies using different types of TC-frameworks refer to Dutrénit (2000 pp. 13-17). The main criticism of the concept is that it is a relatively descriptive framework which suggests a sequential order. This, however, is not necessarily the way firms evolve. Furthermore, it is restricted to technological aspects and its categories are fairly broad, allowing companies with different levels of sophistication to fall into the same box as a consequence (ibid.).

The interviews conducted by the author (see chapter 6) additionally show that some companies found it difficult to indicate just 'one box', but rather claimed to possess a few intermediate as well as advanced TCs. Moreover, the presented frameworks are meant to be universally applicable for different industries (the same approach has been followed by the author in his research), which allows cross-industry comparison, but neglects industry-specific technologies or 'state-of-the-art'. For example, a particular technology might be basic and common in one industry and rather

advanced in another industry. Therefore, it seems worthwhile for industry-specific research to build upon the presented frameworks in order to apply a more detailed and narrow framework (e.g. Ariffin & Figueiredo, 2002, Ariffin & Figueiredo, 2004).

Nevertheless, the merits of this type of framework are that it offers a convenient yardstick for evaluating a firm's stage of technological learning, because it structures some of the key functions performed by companies. Consequently, the the empirical case studies (chapter 6) will use a Bell and Pavitt (1995: 84)-type TC-framework (see Tab 2.2), which distinguishes basic production from technology capabilities in investment, production and supporting activities. The framework elucidates what activities are to be expected at the basic, intermediate and advanced stages of the different technological aspects. It is therefore a convenient empirical tool to ascertain the current stage of companies in late-industrialising countries on their way to 'technological maturity'. For the application in the automotive and hard disk drive industry, the general framework has been subject to some specification and modification by Afzulpurkar in order to adapt it to industry 'keywords' (see 3.2.2, Tab. 3.9).

2.1.3 Building technological capabilities: technological learning

Technological capabilities are the result of **technological learning**. In this process a company acquires codified knowledge, combines it with existing tacit knowledge and builds up a stock of firm specific tacit knowledge. This is a conscious and purposive as well as a costly and time-consuming process, which is non-linear but path-dependent and cumulative. Because of its interactive and technology-specific nature, there is no single trajectory but a range of possible development paths (Lall, 2000: pp. 16, Ernst et al., 1998b: 333). Chapter 2.1.3 deals with the different aspects of knowledge and learning in detail.

Whether companies develop technological capabilities and how they do it is at least partly influenced by the structure and the efficiency of the business environment in general and the regional and national system of innovation more specifically: „successful technological learning ... requires an effective national innovation system“ (Kim, 1997: 219; cf. also Wong, 1999a, Fischer et al., 2001). Consequently, chapter 2.2 presents the concepts of systems of innovation in more detail.

2.1.3.1 Learning, knowledge and innovation

“It is assumed that the most fundamental resource in the modern economy is knowledge and, accordingly, that the most important process is learning” (Lundvall, 1992c:1). This is as true for late-industrialising as it is for industrialised countries.

Basically, **learning** is a process whereby an individual or a firm “acquires, creates and disseminates new knowledge” (Kim, 1999: 119) by combining and recombining different pieces of knowledge into something new (Gregersen & Johnson, 1997: 480). Strictly speaking, only individuals can learn, organisations – made up of individuals – can foster this individual learning and try to integrate it into their routines, organisational processes and finally products.

Tab. 2.2: Industrial technological capabilities: an illustrative framework

	PRIMARY ACTIVITIES				SUPPORTING ACTIVITIES	
	INVESTMENT		PRODUCTION		Developing Linkages	Capital Good Supply
	Facility User's Decision-making and Control	Project Preparation and Implementation	Process and Production Organisation	Product-centred		
Basic Production Capabilities (capacities to use existing production techniques)	Engaging prime contractor. Securing and disbursing finance. Officiating at opening ceremony.	Preparation of initial project outline. Construction of basic civil works. Simple plant erection.	Routine operation and basic maintenance of given facilities. Efficiency improvement from experience in existing tasks.	Replicating of fixed specification and design. Routine QC to maintain existing standards and specifications.	Procurement of available inputs from existing suppliers. Sale of 'given' products to existing and new customers.	Replication of unchanging items of plants and machinery.
TECHNOLOGY CAPABILITIES (CAPABILITIES TO GENERATE AND MANAGE TECHNICAL CHANGE)						
BASIC	Active monitoring and control of feasibility studies, technology choice/sourcing, and project scheduling.	Feasibility studies. Outline planning. Standard equipment procurement. Simple ancillaries engineering.	Commissioning and debugging. Improved layout, scheduling, and maintenance. Minor adaptation.	Minor adaptations to market needs, and incremental improvement in product quality and mechanical properties.	Searching and absorbing new information from suppliers, customers, and local institutions.	Copying new types of plants and machinery. Simple adaptation of existing designs and specifications.
INTERMEDIATE	Search, evaluation, and selection of technology/ sources. Tender/ negotiation. Overall project management.	Detailed engineering. Plant procurement. Environment assessment. Project scheduling and management. Commissioning. Training/ recruitment.	Process improvement. Licensing new technology. Introducing organisational changes.	Licensing new product technology and/ or reverse engineering. Incremental new product design.	Technology transfer to suppliers and customers to raise efficiency, quality, and local sourcing.	Incrementally innovative reverse engineering and original design of plant and machinery.
ADVANCED	Developing new production systems and components.	Basic process design and related R&D.	Process innovation and related R&D. Radical innovation in organisation.	Product innovation and related R&D.	Collaboration in technology development.	R&D for specifications and designs of new plant and machinery

Source: Bell & Pavitt, 1995: 84

However, this kind of organisational learning is more than the sum of the individual learning efforts (Nonaka & Takeuchi, 1995, Kim, 1999). **Knowledge** can be implicit/ tacit or explicit/ codified. While codified knowledge is written down in articles and manuals or is embedded in technology, tacit knowledge is bound to specific persons or organisations. It reflects a person’s skills or a firm’s routines and is context-specific. Since tacit knowledge is difficult to articulate, its transfer is restricted to social interaction such as observation, imitation and practice. Because of this, the transfer requires face-to-face contacts (Polanyi, 1966, Kim, 1999) and as a result tacit knowledge has been termed “sticky information” (e.g. Hippel, 1994). In contrast, codified knowledge is globally available by means of modern communication technologies or trade. However, rather than conflicting, these knowledge categories are complementary: “Human knowledge is created and expanded through social interaction between tacit and explicit knowledge” (Nonaka & Takeuchi, 1995: 61) – a process referred to as knowledge conversation (Tab. 2.3).

Tab. 2.3: Modes of knowledge conversion

		To	
		Tacit knowledge	Explicit knowledge
From	Tacit knowledge	Socialisation	Externalization
	Explicit knowledge	Internalization	Combination

Source: Nonaka & Takeuchi, 1995: 62

This conversation consists of four modes:

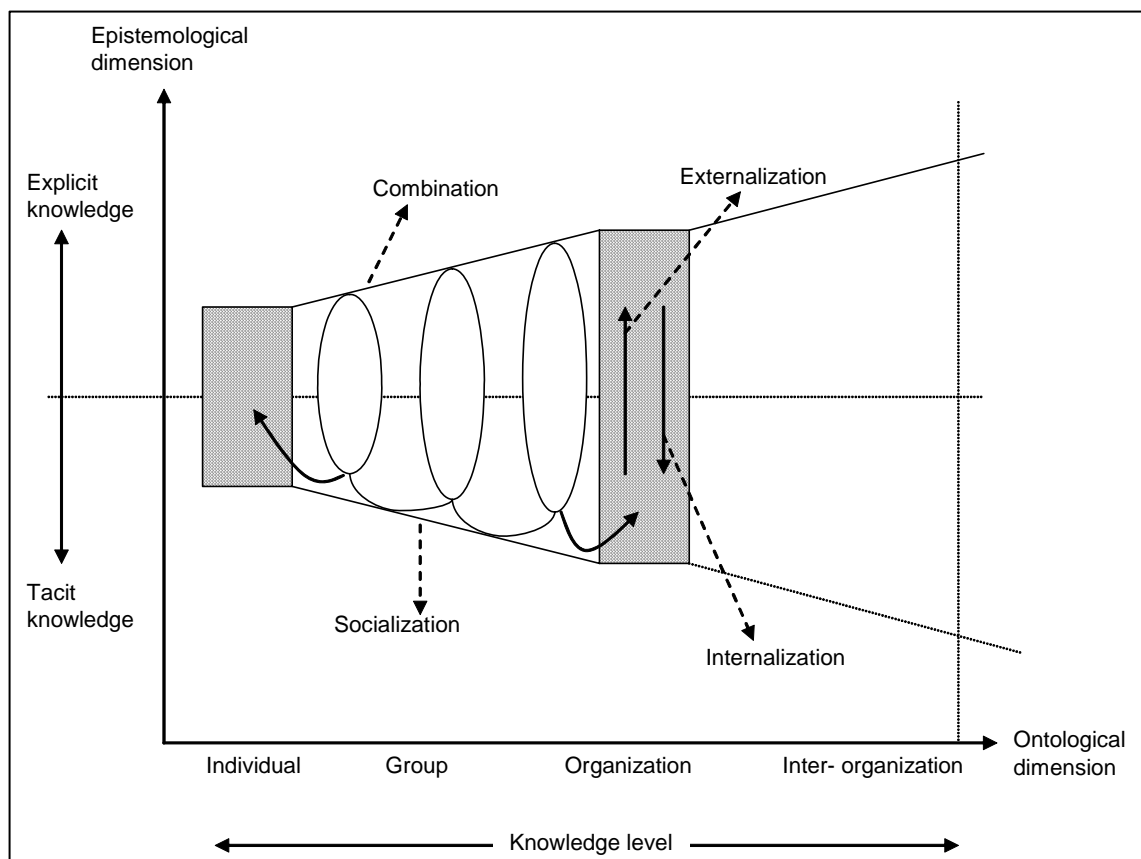
- **Socialisation:** Transforming tacit knowledge into tacit knowledge by sharing experiences, hereby creating shared mental models, technical skills etc.
- **Externalisation:** Articulating tacit knowledge into explicit concepts. This is seen as a quintessential knowledge-creating process “in that tacit knowledge becomes explicit, taking shapes of metaphors, analogies, concepts, hypotheses, or models” (ibid.: 64).
- **Combination:** Merging pieces of explicit knowledge. Through reconfiguration of existing information new knowledge is created, e.g. via formal education in schools.
- **Internalization:** Explicit knowledge is internalized into an individual’s tacit knowledge base, a process that is closely related to ‘learning by doing’ (ibid.: 62).

Figure 2.1 depicts the notion of the knowledge spiral, which describes the interplay between explicit and tacit knowledge via the four modes of conversation and results in an extension from the individual basis to the organisational or even inter-organisational basis, thereby extending the knowledge base of the ‘learning organisation’ (e.g. Cohen & Sproull, 1997, Nooteboom, 2002). Due to inter-organisational learning among spatial clustered firms ‘collective learning’ can occur (see e.g. Camagni, 1991, Keeble, 1999, Lawson & Lorenz, 1999, Capello, 1999).

In order to learn from others, it is necessary to share tacit knowledge by socialisation. Alternatively, it can be externalised first by the ‘sender’, transferred, and subsequently internalised by the ‘receiver’ into the new context. Consequently, new knowledge can only be utilised if its adapted to the new context in which it should be utilised (Brödner et al., 1999). In general four main modes of learning can be differentiated (e.g. Bathelt & Glückler, 2002: pp. 244):

1. Learning by searching: Companies learn while conducting R&D-activities in order to explore new knowledge and technology.
2. Learning by doing/ using: Companies learn while producing goods (learning by doing; Arrow, 1962) as well as by using products, e.g. capital goods (learning by using; Rosenberg, 1976).
3. Learning by training/ hiring: Companies learn by acquiring human capital, either through personnel-training (learning by training) or through recruitment of professionals (learning by hiring).⁴
4. Learning by interacting: Companies learn while interacting with other companies, especially customers and suppliers (Lundvall, 1988). Due to its interactive and therefore social character, learning by interacting is strongly influenced by institutional and organisational frameworks. While learning by interacting seems possible between remote partners under the condition of stable and standardised technology (and hence encompassing many already codified components) (Lundvall, 1988: 355), it is fostered by spatial and cultural proximity in an uncertain business environment with complex technologies and rapid technological change (which is characterised by more tacit forms of knowledge).

Figure 2.1: Knowledge spiral



Source: Nonaka & Takeuchi, 1995: 73

In summary, learning is mainly a cumulative and interactive process that is strongly influenced by the institutional and structural set-up of an economy (Gregersen & Johnson, 1997, Johnson, 1992). A prerequisite for organisational learning is individual learning of the workforce. This implies that

⁴ The number of “learning by...” routes has multiplied in recent years, for an overview see Malecki, 1997:59.

individual learning capabilities are essential for the development of TCs in companies in late-industrialising countries. Therefore, formal learning (e.g. learning by training in university), non-formal learning (e.g. training on the job) and informal training, “which is defined as a lifelong process by which persons who work in foreign affiliates or in domestic companies which closely interact with foreign TNCs [Transnational Corporations] may acquire values, attitudes and beliefs embedded in the organizational culture of TNCs through daily experience, observation and exposure to indoctrination” (Ernst et al., 1998a: 16), have to be taken into account.

Put simply, **innovation** can be regarded as a ‘learning result’ (Gregersen & Johnson, 1997: 481). According to Joseph Schumpeter, technological change can be divided into three steps: a) invention, i.e. the discovery of new problem solutions; b) innovation, which describes the very first (economic) implementation of the invention and c) diffusion, in which the innovation is spread across the economy by imitation and adaptation (Schätzl, 2001: pp. 155). For the “impact on the economy, it is not the basic innovation but its diffusion across industry or the economy, and the speed of this diffusion, that matters” (Malecki, 1997: 75).

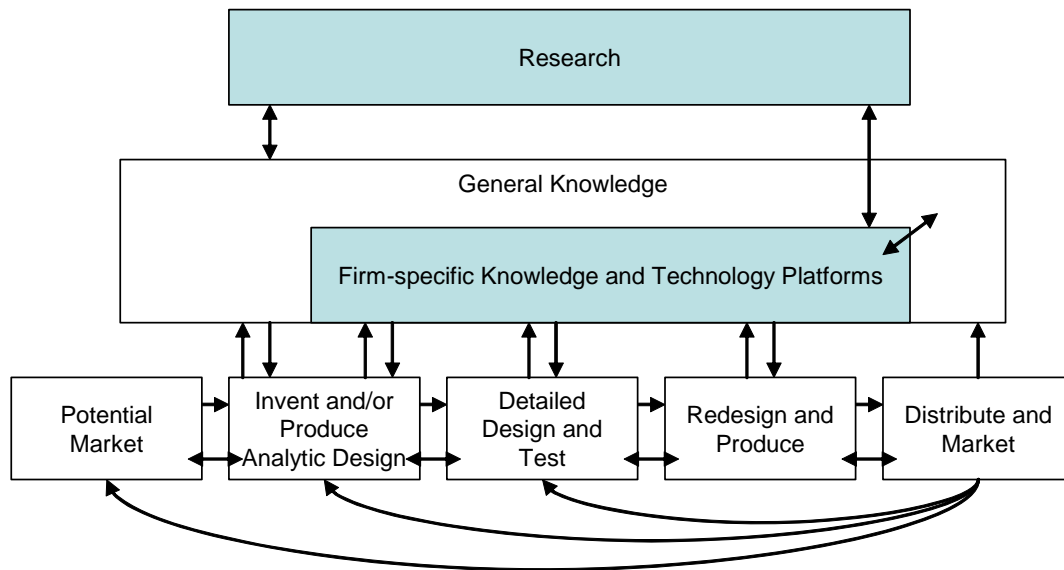
Most definitions of the term innovation, which are applied for empirical studies, do not require an innovation to be ‘new to the world’ but only to be ‘new to the firm’ (e.g. Ernst et al., 1998c, OECD, 1997a). Thereby, innovations are either technologically new or significantly improved products, including goods and services (**product innovation**), or new or significantly improved production methods, including organisational changes (**process innovation**). Since firms in late-industrialising countries rarely work at the technological frontier, but are rather concerned about the diffusion and adaptation of existing technologies from advanced countries (see 2.1.2), this thesis applies the OECD concept of ‘firm-only’ innovations (new to the firm). However, this definition blurs the distinction between the innovation of technology and its diffusion. Nevertheless, due to the assumption that companies in late-industrialising countries first have to adapt, use and improve existing technologies, the application of this definition seems justified.

A further distinction can be made between radical and incremental innovations. **Incremental innovations** happen more or less continuously due to ‘learning by doing’, i.e. in the production process, or to ‘learning by using’, i.e. improvements proposed by users. They are minor improvements to existing products or processes, which – in the sum – are very important for the growth of productivity. **Radical innovations** are discontinuous events, mainly produced by R&D, which bring about new products, processes or organisations (or a combination of these) and which might lead to severe structural change. However, their overall economic impact tends to be relatively small and localised (Freeman & Perez, 1988: pp. 45).

The understanding of the innovation process has changed fundamentally in the last decades. The notion of innovation as a linear process, starting with basic and applied research, feeding into product and process development, which is then realised in production and finally marketed and diffused is now obsolete. Rather, innovation is seen as a chain-linked process (see Figure 2.2), which encompasses a variety of feed-back-loops and interactions between ‘firm units’, where new

ideas from production or marketing feed-back into basic research etc., and between firms and their environment (Kline & Rosenberg, 1986, Malecki, 1997: pp. 52).

Figure 2.2: Chain-linked model of innovation



Source: Malecki, 1997: 53

In general, innovation processes are characterised by five distinctive criteria:

- The result of innovative activities is highly **uncertain**, in technological as well as economic terms;
- many opportunities for innovations rely on advances in scientific research, therefore innovations are highly **dependent on and bound to scientific progress**;
- search and innovation processes are increasingly **complex** (see Figure 2.2) and need to be formally organised (e.g. R&D-laboratories);
- and – at the same time – **learning by doing** and **by using** poses an important impetus for innovation activities, innovation therefore is closely connected to the production and marketing of products;
- innovations rely on previously accumulated knowledge and technology and at the same time are determined by these, therefore technical change takes place in an **cumulative** and **path-dependent** manner (Dosi, 1988: 222-223, Koschatzky, 2001: pp. 38).

Due to these characteristics, especially complexity, high costs, uncertainty and fragmented specialised knowledge, “firms almost never innovate in isolation ... they interact with other organizations to gain, develop, and exchange various kinds of knowledge, information, and other resources. These organizations might be other firms (suppliers, customers, competitors) but also universities, research institutes, investment banks, schools, government ministries, etc.” (Edquist, 1997: pp.1; for more see systems of innovation in chapter 2.2).

Because knowledge and technology are at least partly public goods, not all of the costly created new knowledge can be retained by a company. Knowledge diffuses easily to other actors, which do not or only partly compensate for the benefit. These externalities have been termed **knowledge or technology spillovers**. According to Griliches (1992): “knowledge spillover means working on similar things and hence benefiting much from each others’ research” (cited in Feldman, 2000: 377, see also Maier & Tödting, 2002: 132, Koschatzky, 2001: pp. 106). In general, positive spillovers or externalities are “benefits generated by an economic activity that are greater than those captured within the activity itself and greater than those captured by users of the activity’s output” (Moran, 2001: 24). For economic development and technical change these spillovers are very important. From the perspective of a firm, on the other hand, it is necessary to limit such spillovers as much as possible. Consequently, collaborations on innovation and knowledge generation have to rely on social attributes such as trust.

The next sections will deal with some key ‘ingredients’ for technological learning in late-industrialising countries, namely absorptive capacity and technology transfer. Finally a model by Kim (1999) will be presented that tries to integrate these different aspects.

2.1.3.2 Absorptive capacity

The term ‘absorptive capacity’ (henceforth ACAP) was coined by Cohen and Levinthal (1989, 1990). It builds upon studies in the field of cognitive and behavioural science at the individual level, which state that “accumulated prior knowledge increases both the ability to put new knowledge into memory, what we would refer to as the acquisition of knowledge, and the ability to recall and use it” (Cohen & Levinthal, 1990: 129). Accordingly, ACAP is seen as a necessary pre-requisite for effective technological learning (e.g. Kim, 1999).

ACAP describes a firm’s ability to “recognize the value of new, external knowledge⁵, assimilate it and apply it to commercial ends” (van den Bosch et al., 2003: 5). It therefore consists of three components or dimensions: a) recognizing the value b) assimilating and c) applying new external knowledge to commercial ends (ibid). Besides this most widely cited definition, two other slightly different constructions are used in empirical research (see Tab. 2.4, Zahra & George, 2002).

Re-conceptualising ACAP based on these three approaches, Zahra and George (2002) view ACAP “as a set of organizational routines and processes by which firms acquire, assimilate, transform and exploit knowledge to produce a dynamic organizational capability” (ibid.: 186). Thereby, they add three new perspectives to the theoretical discussion: First, ACAP is a dynamic capability. It does not contribute to a firm’s output like other capabilities. Rather it is a meta-capability that helps a company to cope with efficient organizational change. Because it “influences the firm’s ability to create and deploy the knowledge necessary to build other organizational capabilities (e.g. marketing, distribution and production)” (ibid.: 188). Consequently, companies with a significant amount of ACAP are able to adapt easier to a changing environment, as they can anticipate developments with their advanced information processing capabilities (van den Bosch et al., 1999).

⁵ In their original definition, Cohen and Levinthal used the word ‘information’ (1990: 128). As van den Bosch et al. (2003: 5) show, the term ‘knowledge’ is more appropriate, reflecting Cohen and Levinthal’s true intention.

Second, ACAP is made up of four capabilities (acquisition, assimilation, transformation and exploitation) that are combinative and build upon each other. Third, potential and realized ACAP can be distinguished. While potential ACAP encompasses the ability to value and acquire external knowledge, realized ACAP is determined by the transformation and exploitation aspect of absorptive capacity. The first describes how well a firm is organised to know about, assimilate and acquire external knowledge, the latter shows how well a company can use this knowledge to commercialize on it. The ratio between these two is termed the efficiency factor by Zahra and George (2002).

Tab. 2.4: Conceptualization of ACAP

Definition	Dimension
a) The ability to value, assimilate, and apply new knowledge (Cohen & Levinthal, 1990)	Ability to value knowledge through past experience and investment Ability to assimilate - based on knowledge characteristics - based on organizational or alliance dyad characteristics Ability to apply - based on technological opportunity (amount of external relevant knowledge) - based on appropriability (ability to protect innovation)
b) A broad array of skills, reflecting the need to deal with the tacit components of transferred technology, as well as the frequent need to modify a foreign-sourced technology for domestic application (Mowery & Oxley, 1995)	Human capital: - skill level of personnel - trained R&D-personnel as % of population - trained engineering graduates - R&D-spending
c) ACAP requires learning capability and develops problem-solving skills; learning capability is the capacity to assimilate knowledge – for imitation- and problem solving skills to create new knowledge for innovation (Kim, 1998)	Prior knowledge base; intensity of effort

Source: Zahra & George, 2002: 168

As can be seen by the different forms of dimensions (Tab. 2.4), research on absorptive capacity has been conducted at different levels: Ranging from the **sub-firm level**, i.e. department- or unit-level (e.g. Tsai, 2001, Gupta & Govindarajan, 2000), to the **firm level** (e.g. Cohen & Levinthal, 1990, van den Bosch et al., 1999, Zahra & George, 2002) and the **inter-firm level** (e.g. Lane & Lubatkin, 1998). Even **countries** have been objects of ACAP investigations, either in the context of technology transfer (e.g. Mowery & Oxley, 1995) or of systems of innovation (Carlsson & Jacobsson, 1994, Wegloop, 1995).

In combining these concepts it can be concluded that the development of ACAP is determined by the following factors:

- a) The level of **prior related knowledge**: Learning is a cumulative process, and becomes easier with an existing stock of related knowledge, such as basic skills, shared language and knowledge of recent scientific or technological developments. Additionally ‘meta-knowledge’ like knowledge of problem solving methods, as well as prior learning experiences and learning

skills foster the absorptive capacity. The stock of prior related knowledge does not only refer to specialised knowledge but also to the diversity or breadth of the knowledge base, since “knowledge diversity also facilitates the innovative process by enabling the individual to make novel associations and linkages” (Cohen & Levinthal, 1990: 131).

- b) **Organizational factors:** As van den Bosch et al. (1999) point out, the **organisational form** (how a company is structured, e.g. divisional form vs. functional form) as well as its **combinative capabilities** (formal or informal mechanisms/ procedures by which a company combines or integrates different pieces of external information) are important determinants of the knowledge absorption and therefore of ACAP. Also, organisational arrangements such as the structure of communication or the distribution of knowledge within the firm are essential pre-requisites for knowledge assimilation and utilization (van den Bosch et al., 2003). Furthermore, the managerial influence, especially human resource management practices, on ACAP has to be taken into account (Minbaeva et al., 2003).
- c) **Intensity of effort or commitment:** refers to “the amount of energy relinquished by organizational members to solve problems” (Kim, 1999: 115). Internalising external knowledge requires time and effort. This can be expressed in resource allocation to the development of absorptive capacity.
- d) **Human capital:** Employees are essential for the absorption of new information or knowledge. Even though the ACAP of a firm is more than the sum of its members (Cohen & Levinthal, 1990), the qualification of the human capital is an important proxy for its ACAP (Mowery & Oxley, 1995). Thereby, employees’ ability and motivation can be distinguished as key aspects (Minbaeva et al., 2003: 589).

According to Cohen and Levinthal (1990) ACAP at the **intra-firm or firm level** is by and large generated by a) own R&D, which not only fosters the development of new knowledge but also helps in using external knowledge; b) as a by-product of manufacturing operations and finally c) by internal or external personnel training.

Looking at the **inter-firm level**, Lane and Lubatkin (1998) suggest the concept of **relative absorptive capacity**, which considers the ability of a student firm to learn from a teacher firm. Key determinants for developing ACAP in this context are the similarities of both firms’ knowledge bases, organizational structures, compensation policies and dominant logics (ibid.). To recognize and value external knowledge, student and teacher must have a common basic knowledge base. Moreover, specialised but complementary knowledge is necessary both as an incentive for co-operation and in order to learn from each other efficiently. Thereby, external knowledge from the teacher firm is more easily assimilated by the student firm when the ‘knowledge-processing system’ is similar. Since this is unobservable, Lane et al. (2002) use the compensation practice and organizational structure as proxies. The dominant logic of a firm reflects its preference for new projects, products and ‘way of doing things’, which in turn determines its degree of commercialization.

Operationalisation of ACAP

Despite being very popular, the concept of ACAP suffers from a lack of indicators by which it can be measured in empirical studies. Traditionally, research on ACAP uses R&D-expenditure per sales as an indicator (e.g. Cohen & Levinthal, 1990, Tsai, 2001, Stock et al., 2001). The fact that only “few attempts have been made to measure it [ACAP] outside of the R&D context” (Lane et al., 2002: M4) is one of the main shortcomings of the concept. An overview of other indicators that have been either used or suggested for empirical research is given in Tab. 2.5.

Tab. 2.5: Measuring ACAP

ACAP determinant	Indicator
a) Knowledge acquisition/ Knowledge base	<ul style="list-style-type: none"> ▪ Years of experience of the R&D-department ▪ Amount of R&D-investment ▪ Bibliometrics (number of publications) ▪ Co-citations ▪ Share of R&D-personnel ▪ Share of employees in training ▪ Share of academics
b) Assimilation	<ul style="list-style-type: none"> ▪ Number of cross-firm patent citations ▪ Number of citations made in a firm's publications to research developed in other firms ▪ Number of strategic alliances/ collaborations engaged in earlier
c) Transformation	<ul style="list-style-type: none"> ▪ Number of new product ideas ▪ Number of new research projects initiated
d) Exploitation	<ul style="list-style-type: none"> ▪ Number of patents ▪ Number of new product announcements ▪ Length of product development cycle

Own compilation based on Knudsen (2001), Lane (1998) and Zahra and George (2002).

Zahra and George (2002) criticise these measures, because they are “rudimentary and do not fully reflect the richness of the concept” (ibid.: 191). To meet this critique some recent work tries to evaluate ACAP by measuring more encompassing factors such as employees’ motivation and managerial influence (Minbaeva et al., 2003), systems-, coordination- and socialisation- capabilities (van den Bosch et al., 1999) or knowledge and knowledge-processing similarities (for relative ACAP) (Lane & Lubatkin, 1998).

This thesis recognises that research of ACAP has in the past focused too much on R&D, which ignores the fact that firms in late-industrialising countries often improve without having designated R&D-departments (e.g. see Arocena & Sutz, 1999, 2002). However, it cannot allow for increased focus on managerial and organisational oriented factors, since their measurement is restricted to detailed case studies. Rather, chapter 5 will measure – potential – ACAP with a fairly comprehensive set of indicators, using qualification structure of the workforce, R&D and training expenditure.

It has been stated that ACAP is important for the acquisition and assimilation of knowledge. This is essentially a process of technology transfer and is considered in the next section.

2.1.3.3 Technology transfer

“The generation of new knowledge embodied in new products and processes and its diffusion throughout the economy is the main source of economic growth. This knowledge is only partly the result of endogenous technological effort. The more a country is lagging behind the technological frontier the more it has to rely on foreign knowledge and the import of technology through equipment, machinery, licenses or through copying (‘reverse engineering’)” (Radoésevic, 1999a: 2).

Despite being widely used in academia the term ‘technology transfer’ is difficult to define, due to the complex and multidimensional concepts of ‘technology’ and ‘transfer’ (Cohen, 2004: 103). The main problems arise by first, trying to put a boundary on the term ‘technology’, second, trying to outline the technology transfer (henceforth TT) process which contains numerous concurrent processes, and third, trying to measure the impacts of the transferred technology (Bozeman, 2000: 627).

Technology has been defined as “the theoretical and practical knowledge, skills, and artefacts that can be used to develop products and services as well as their production and delivery systems” (Burgelman et al., 1996 cited in Lin, 2003: 328). Consequently, ‘real’ **technology transfer** is considered to be more than just technology trade (Cohen, 2004: 103), since it does not only involve the product that is transferred but also know-how of its use and application (Bozeman, 2000: 629). Actually, the physical machinery is only a small part of the TT process (Cohen, 2004: 103), if that – using Burgelman et al.’s definition even pure knowledge transfer can be seen as TT. Therefore, technology and knowledge transfer are inseparable (ibid., Schmoch et al., 2000). Thus, TT can be defined as “the movement of know-how, technical knowledge, or technology from one organizational setting to another” (Roessner, 2000 cited in Bozeman, 2000: 629).

Because every technology is rooted or embedded in firm-specific arrangements it includes shares of tacit and codified knowledge that can not easily be reproduced by others: “No technique is the simple summation of its reproducible elements [...] Putting these elements into practice always involves a certain degree of tacit knowledge which is not machine embodied nor codifiable and easily transferable” (Radoésevic, 1999a: 15). The tacit component of technology is for example inherent in operations, fault findings, process control inspections, machine settings, equipment design, problem-solving and test equipment etc. (Radoésevic, 1999a: 17). Hence, TT requires costly and time consuming learning efforts by the recipient of the technology, i.e. investment and commitment (e.g. Enos et al., 1997). It is the task of receiving companies is to assimilate and internalise the technology and – essentially – to turn the external technology into an integral part of their competitive advantage (Lin, 2003: 329). Besides internal learning this often requires training by the transferee which consequently is considered a key component of TT (Enos et al., 1997: 62). Bozeman (2000) sees TT as a two-way process requiring a sender and receiver, who transfer a specific content (object) via a particular medium (mechanism that is used to transfer the content). Sometimes the process is mediated by an intermediary (Cohen, 2004: 105). Furthermore, it is not always a two-way process, since the sender can also be passive, as in reverse engineering. Sender

and receiver could be firms, research institutes/ universities or parts there of (e.g. TNC affiliates), in the same or different countries.

Basically, TT takes place in one of four broad contexts (Tab. 2.6): In the organisational dimension it can be either internal (within an organization) or external (between organizations). In the technology dimension it can be concerned with either the innovation or the diffusion process (Amesse & Cohendet, 2001: 1460). For late-industrialising countries the level of ‘reproducing and diffusing technology’ is essential. Because firms in these countries might exhibit difficulty in organising TT with other external organisations, the transfer within organisations, namely transnational corporations is of great relevance for accessing technology from advanced economies.

Tab. 2.6: Four types of technology transfer contexts

	Within organization	Between organizations
Creating technology	managing innovation	contracting out R&D and outsourcing
Reproducing and diffusing technology	transferring to divisions or subsidiaries	buying or selling proven technologies (licensing, turnkey etc.)

Source Amesse & Cohendet, 2001: 1460

According to Lall (1993) the choice for internal TT by TNCs depends on:

- **The nature of the technology:** the higher the degree of complexity, the faster the speed of technical change, the newer and more valuable the technology and the more centralised the R&D on which it is based the more likely will internalised TT occur.
- The **seller’s strategy:** which is determined e.g. by the firm size (larger firms use predominantly internalised TT), its product diversification (non-core technologies are more likely to be externalised), dependence on brand names, and the firm’s experience with different modes of TT.
- The **buyers’ capabilities:** More capable buyers/ receivers mean less effort and costs for the seller. However, a highly capable buyer could become a (future) competitor and this may encourage internalisation.
- **Government policies:** Many governments try to increase externalised TT in order to improve the capabilities of local companies. On the other hand certain governments attempt to attract FDI without taking into account possible TT to local firms.

For technology transfer different transfer-media or mechanisms can be utilised. For international TT the eight channels depicted in Tab. 2.7 are seen as the most important ones (based on Radoéšević, 1999a: pp.19, Mowery & Oxley, 1995: pp. 70, Enos et al., 1997). Each of these mechanisms has a specific character in terms of the embodiment of the technology (e.g. in capital goods), the mode of transfer (e.g. market mediated) and the role of the seller/partner in terms of involvement. Thereby, the different modes of technology transfer also place different demands on the absorptive capacity of the recipient firm (Mowery & Oxley, 1995: 70), e.g. reverse engineering of imported capital requires different capabilities than operating as a subcontractor for a TNC.

Tab. 2.7: Types and dimensions of technology transfer

Transfer mechanism	Type of embodiment			Mode of transfer			Role of seller/ partner		
	capital emb.	emb.	disemb.	market (explicit)	network (intermed)	hierarchies (implicit)	active	enabling	passive
FDI/ JV									
Licensing/ Blueprints									
Import of (capital) goods									
Co-operative alliances									
Subcontracting									
Export									
Transfer by people									
Development assistance									

Source: based on Radošević, 1999a: 21; minor changes

In general, FDI by TNCs are seen as the most important and cheapest channel of direct technology transfer to late-industrialising countries (Enos et al., 1997, Lall, 1993, Damijan et al., 2003). Host countries can reap benefits from this kind of inward technology transfer directly, for example through higher productivity. More importantly, new technologies may also benefit domestic firms indirectly, by diffusing in the host country via spillovers. Important sources of spillovers are reverse engineering and skill acquisition through ‘learning by using’. The extent of or opportunity for spillovers is determined by the age of the transferred technology, the channel of transfer and the level of indigenous technical capabilities (Mowery & Oxley, 1995: pp. 78). For example TNCs might use ‘inappropriate’ technology, which is “too modern for the needs of these countries and too capital intensive given the resource endowments” (Enos et al., 1997: 56). Moreover, the import of technology may hinder indigenous technological efforts and can prevent the development of core technologies in host countries, because TNCs perform R&D in their (advanced) home countries (Enos et al., 1997, for further impacts of TNCs on the host regions see chapter 2.3.4.).

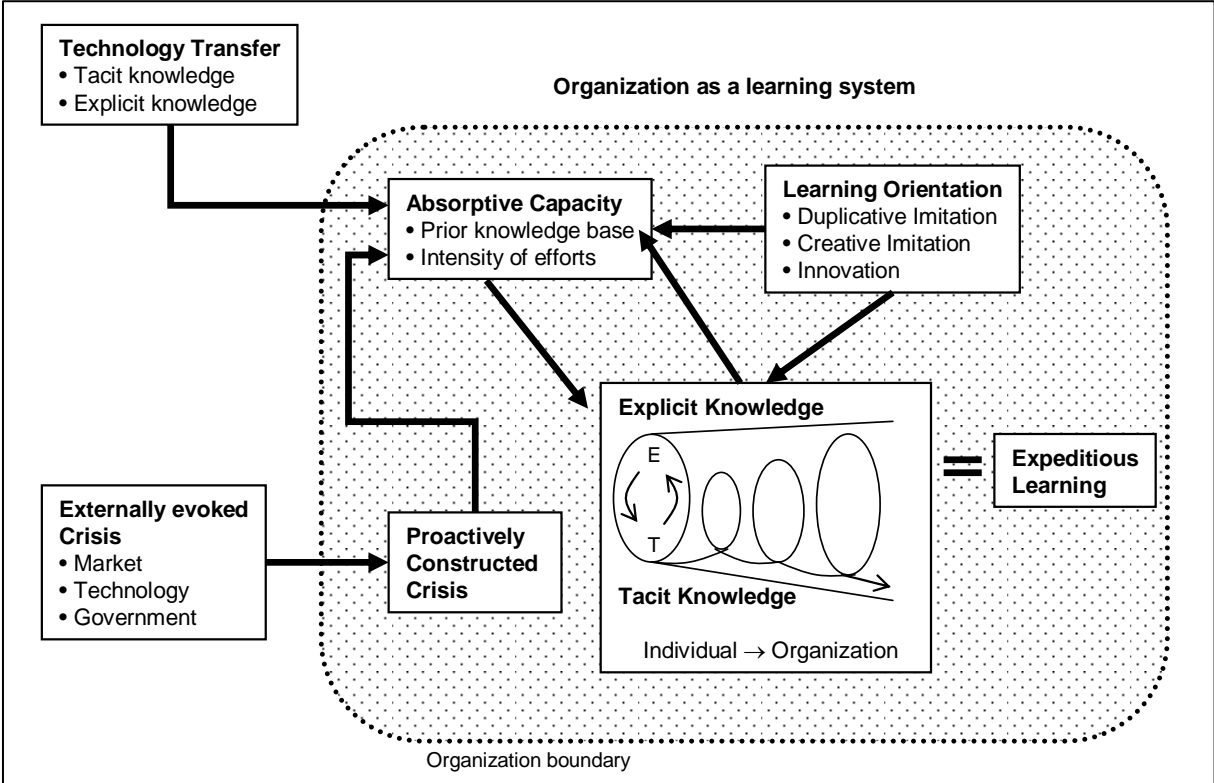
2.1.3.4 An integrative model of technological learning

Figure 2.3 shows an integrative model for technological capability building in firms located in late-industrialising countries developed by Kim (1999: 121). As shown in the previous chapters, firm-level learning constitutes the interplay between explicit and tacit knowledge, which is transferred in the form of the knowledge spiral from the individual to the organisational level. This learning process results in different levels of capabilities in several TC-groups (see chapter 2.1.2). Important determinants of the learning process are first the learning orientation and strategy of the firm, which relates to its present capabilities (see also chapter 2.1.4), and secondly the absorptive capacity within the firm, which is made up of the prior knowledge base and the intensity of effort by the firm itself and its members (see 2.1.3.2). This intensity of effort is influenced by a firm’s perception of its market position. If a firm feels that its competitive position is challenged, either by new entrants/ competitors, by new government policies or by the emergence of new technologies, it is urged to amplify its efforts. This kind of external crisis can also be constructed, for example, when TNCs

force their suppliers to decrease prices and increase quality. If companies manage to cope with this situation the crisis can be creative in the sense that it helps the company to increase its competitiveness. If the firm fails to meet the new demands the crisis can also be destructive (Kim, 1999). The management of a company might also construct a crisis-situation intentionally, feeling the need for intensified learning efforts from the members of the organisation.

An important factor in technological learning within the firm is the technology/ knowledge that is received from the outside via technology transfer (see chapter 2.1.3.3). This learning is a circular process: It builds up absorptive capacity and is eased by the stock of existing absorptive capacity. In this TNCs may also play a decisive role for firms in late-industrialising countries, because they can provide globally-available state-of-the-art knowledge and technology. Furthermore, since “firm-level learning tends to become faster and larger in scale as more actors in and around the firm with adequate existing knowledge intensify their efforts to convert knowledge within and between themselves” (Kim, 1999: 121), it is conducive to a firm’s learning efforts to have a sufficient and sophisticated knowledge base within reach (spatially as well as organisationally). Because spatial proximity can foster the exchange of (especially tacit) knowledge, the endowment of the firm’s environment with different actors can greatly influence its learning performance. Therefore, chapter 2.2 will focus upon the importance of innovations/ learning systems for technological learning and the role of proximity in collective learning and knowledge sharing.

Figure 2.3: An integrative framework of technological learning



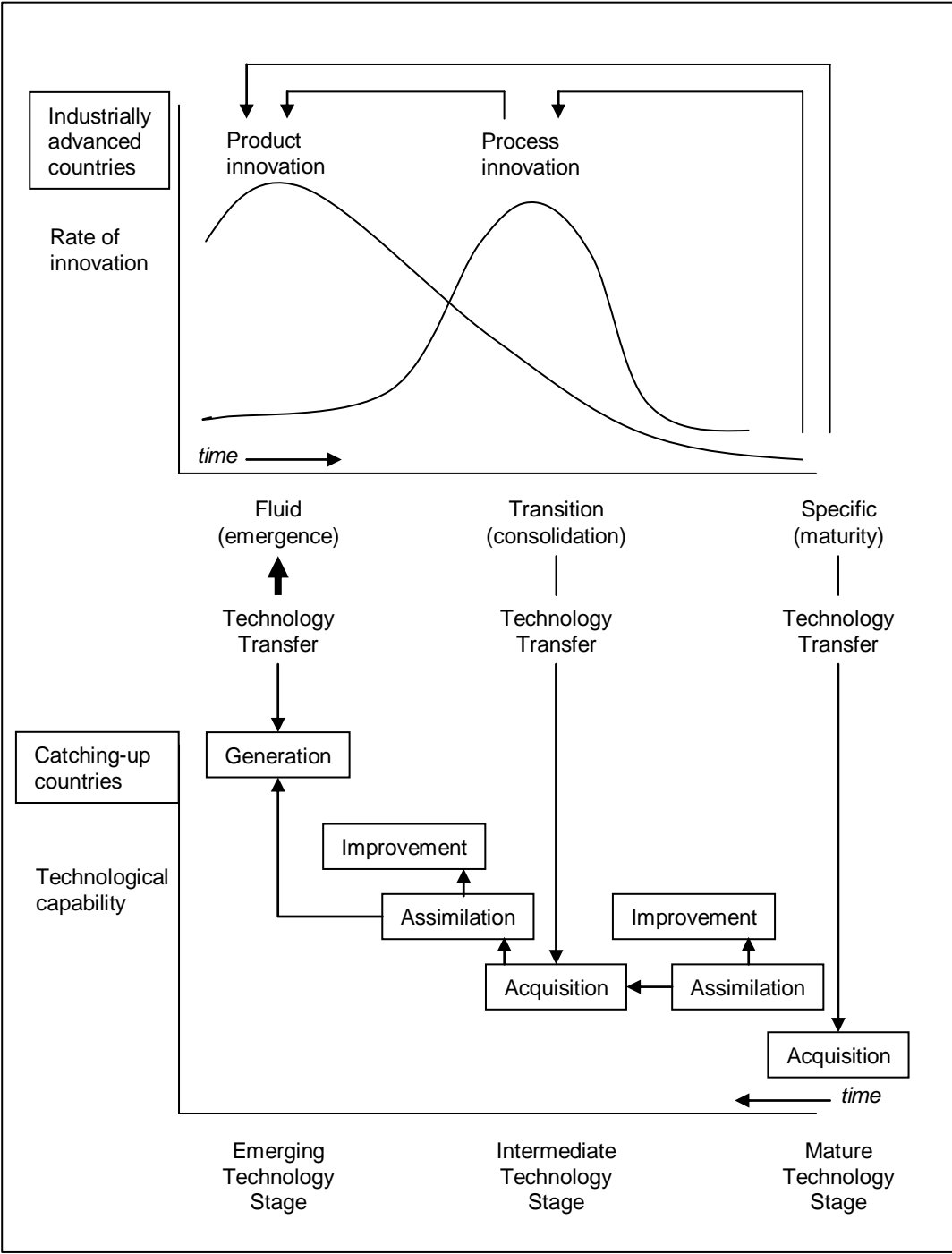
Source: Kim (1999: 121)

2.1.4 Technological trajectories

The empirical observation of different learning and development trajectories has led to the formulation of several trajectory frameworks. The first framework builds upon work by Utterback and Abernathy (1975) about the technology trajectory in advanced countries. It starts with a **fluid** stage, caused by a high rate of (radical) product innovation, frequent market and product changes, goes over into a **transition** stage, characterized by a change towards a dominant product design, mass production methods and price and quality competition. Finally, in a **specific** stage the market and product becomes more mature, price competition forces companies to enhance the efficiency of the production process, leading to automatisisation and (incremental) process improvements. This stage is typically characterised by relocation of production facilities into low-cost developing countries. This idea of technology trajectory has many parallels in the notion of the product-life-cycle (for an overview see Schätzl, 2001, Dicken, 2003a: 104), which distinguishes an initial development, growth, maturity, decline and obsolescence phase. Every phase depicts particular demand conditions, technology requirements and industry structure. Vernon (1966) extends the model by including spatial aspects. In his model, the manufacturing of products in the mature and declining phase is characterised by decreasing profits and strong price competition. In order to reduce costs, the production is relocated at first from its initial location in agglomerations of advanced countries to the respective hinterlands and subsequently to the periphery, i.e. developing countries.

The critique of the spatial extension of the product-life-cycle applies to the Utterback and Abernathy (1975) model as well. The relocation of production into the periphery is certainly not an automatic process and not all types of products can be moved on account of their resource, market or human capital orientations (Tichy, 1991). Despite its restrictions the model is seen as “still useful in analysing the process of building technological capability in developing countries” (Kim, 1999: 113). Kim (1980) extends the model by elaborating three additional phases that show the technology trajectory of industrialising countries: At an early stage these countries **acquire** mature ‘package foreign technologies’ (i.e. including assembly processes, product specifications, production know-how, technical personnel, and components and parts) and learn how to produce standardised, mature and undifferentiated goods. In a second phase, companies **assimilate** foreign technologies to manufacture differentiated products. Finally, enhanced capabilities and the need to compete in export markets lead to a process of gradual **improvement** of these mature technologies. By repeating this process of acquisition, assimilation and improvement, companies in late-industrialising countries develop technological capabilities and work their way towards technological stages closer to the emergence stage (Figure 2.4).

Figure 2.4: Technological trajectories



Source: Kim, 1999: 114

A special form of technological capability building trajectory has been identified by Hobday in his research about electronic companies in East Asia (e.g. 1995b, 1995a, 2000). He differentiates three technological capability phases of firms: Original equipment manufacture (OEM), original design and manufacture (ODM) and own brand manufacture (OBM) (see Tab. 2.8 and Figure 2.5).

Under an OEM agreement a TNC customer provides a latecomer-supplier with the precise specifications of a product. The product is manufactured by the supplier, sold to, marketed and distributed by the TNC under its own brand name. The advantage for the latecomer firm is that it gains access to highly competitive markets without having to invest into product development,

marketing and distribution. It can concentrate on the development of production capabilities and the mastery of process technology. Additionally, the TNC frequently supports the OEM-firm by assisting in the selection of appropriate capital equipment, training managers, engineers and technicians and giving advice on production, financing and management (Hobday, 1995b). Since the TNC buyer relies on the quality, delivery and the price of the components, OEM-agreements can become long-term commitments. The disadvantage for the OEM-supplier is that it is highly dependent on and subordinated to the TNC as (frequently) its only customer. Often the OEM-firm is prohibited from developing its own market access (ibid.). Furthermore, the value-adding involved can be very limited, since the buyer provides or recommends specific supplies, sometimes resulting in the OEM-firm as merely an ‘extended workbench’ that is solely responsible for the assembly.

Tab. 2.8: Transition of latecomer firms: OEM - ODM - OBM

	Technological transition	Market transition
OEM	Learns assembly process for standard, simple goods	Foreign TNC/ buyer designs, brands, and distributes
ODM	Local firm designs (or contributes to the design, alone or in partnership with the foreign company) and learns product innovation	TNC buys, brands, and distributes TNC gains post production value-added (PPVA)
OBM	Local firm designs and conducts R&D for new products	Local firm organizes distribution, uses own brand name, and captures PPVA

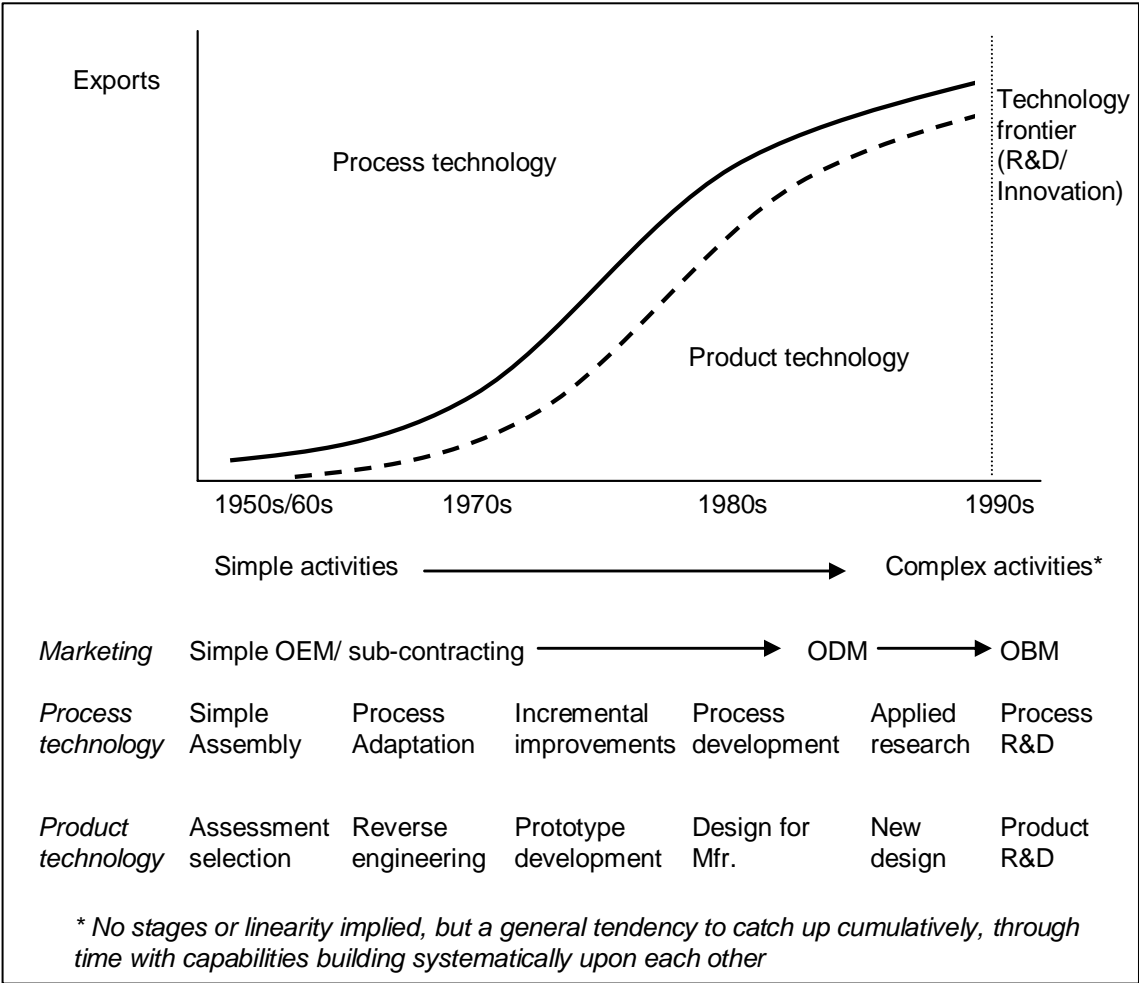
Source: Hobday, 2000:135; adapted

Under an ODM agreement a firm conducts some or all of the product-design and processes needed to manufacture a product according to the general design-layout provided by the buyer (Hobday, 1995b: 1178). Consequently, it requires more component- or product-design skills by the latecomer firm and frequently complex production technologies. The advantage is that the ODM-firm acquires a larger share of value-added activity, while avoiding the costs and risks connected to developing its own brand and distribution activities. “Although ODM indicates some advance in technological competence, it applies mainly to incremental or follower design, rather than leadership product innovations based on R&D” (Hobday, 2000: 134).

Finally, OBM stands for companies that develop their own products, which are marketed and distributed under their own brand. To become an OBM-firm a company needs at least basic capabilities in the fields of marketing, product development and R&D.

As Hobday (2000) points out, a shift from an OEM to an OBM system enables firms to reach into international markets, export large volumes of goods, realise economies of scale and invest in automation. Furthermore, by supplying demanding customers in the leading markets latecomer firms learn by doing, using and interacting (with the foreign partner), and become acquainted with product and process technology as well as end-user market requirements (Wong, 1999a). Therefore, the OEM-OBM system can be seen “as a training school for technological learning” (Hobday, 2000: 134).

Figure 2.5: Latecomer firms - export - led learning from behind the technology frontier



Source: Hobday, 1995b: 1184

However, Hobday’s framework neglects the fact that companies can choose to stay in a ‘minor’ TC-stage and enhance the quality of the required capabilities at this stage. For example an OEM-firm that decides to become a leader in process technology is not technologically ‘behind/ inferior’ to an OBM-company that operates with intermediate technology. That upgrading can take different forms must be taken into account. Firms can chose to carry out **product upgrading**, i.e. making more sophisticated products. On the other hand, they can also pursue **process upgrading**, striving to enhance production technology in order to become more efficient. Others might opt for **functional upgrading**, whereby they acquire new, higher value-creating functions such as product design, or follow an **inter-sectoral upgrading** strategy by moving into new production activities (Humphrey & Schmitz, 2002: 1020).

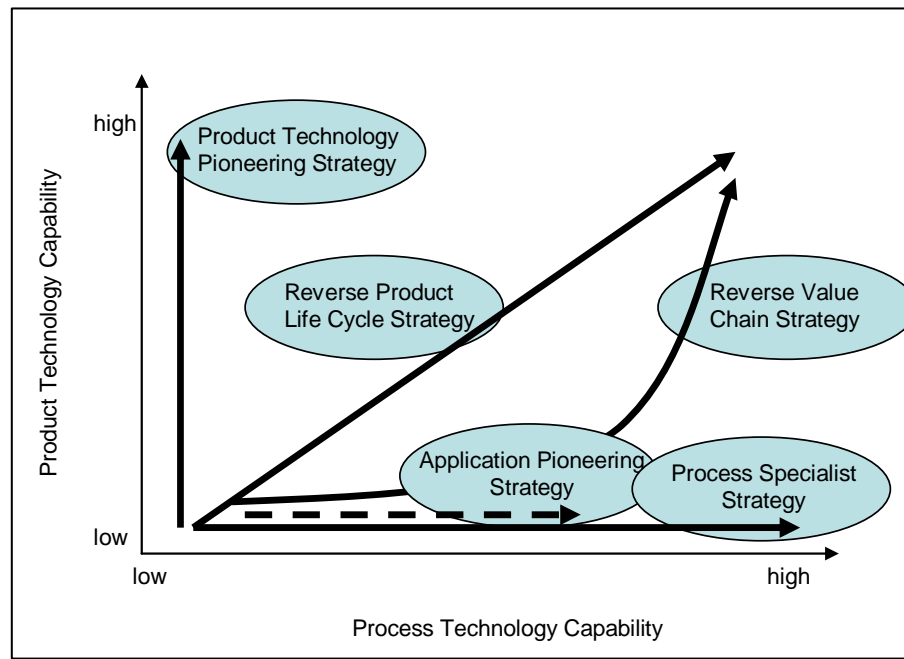
Similarly, Wong (1999a, 1999b) criticises Hobday’s migration strategy for being too simplistic and just one of several routes. He introduced five generic routes for rapid technological catch up, which are based on the experience of latecomer firms in newly industrialising countries (NICs) in Asia (ibid.). From a resource-based view, he argues that latecomer firms have to decide how to allocate their resources and that the development of technological capabilities is just one possibility. Other investments could include marketing, distribution channels or diversification. Furthermore, he argues that technological capabilities have two strategic dimensions and that consequently a firm

has the choice to invest in either of these: product or process technological capabilities. The different generic routes are (Figure 2.6):

- The **‘Reverse Value-Chain’ Strategy**: Basically Hobday’s OEM-ODM-OBM migration strategy: Companies start developing process capabilities and later build up product design and product creation/ brand competence. “This is a reversal of the normal sequence of value-chain activities pursued by large established high-tech firms in advanced countries” (Wong, 1999a: 8). By supplying sophisticated customers, the latecomer firm is learning about product technology and end-user market requirements at the same time.
- The **‘Reverse Product-Life-Cycle’ Innovation Strategy** (late-follower to fast-follower): The latecomer-firm starts producing mature products either by licensing technology from advanced companies or by imitative learning, e.g. through consultants. These products tend to be targeted at the low-price market segment and, therefore, are several generations away from the state-of-the-art; a strategy that becomes possible due to (labour) cost advantages. Over time, the firm moves up the technological ladder or approaches the beginning of the product-life-cycle by using more sophisticated, up-to-date technologies for its products and its production technology until it closes the gap to the technological leaders. This strategy is only feasible if the firm is (capable of) pursuing product and process technological learning at the same time and if it is able to compete with established companies directly. In order to close the gap to the technological leaders it is necessary for a firm to set up its own R&D-facilities.
- The **‘Process Capability Specialist’ Strategy**: Instead of migrating from OEM to ODM firms may also choose to strengthen their OEM capabilities by focusing all their resources and effort on the improvement of their production technology. The firm can become a ‘turnkey contract assembler’ or a specialised niche component or process-steps supplier. It constantly invests in the purchasing of the latest process technology or in in-house process R&D. This strategy makes very close interactions with the customers inevitable, because it is essential to anticipate future process requirements.
- The **‘Product Technology Pioneering’ Strategy**: Concentrating on product technology development, these latecomer firms seek to become true (radical) innovators, supplying global markets with new products. Common among leading firms from advanced countries, this is a very difficult strategy for latecomer firms from late-industrialising countries due to the distance from lead-user markets and sources of advanced S&T-knowledge (see 2.1.1). Wong has identified four approaches to overcome these disadvantages: First, establishment of a strong presence in the lead-user market; secondly, investment in or acquisition of high-tech start-ups in advanced countries; thirdly, recruitment of highly qualified personnel from lead-user markets and centres of advanced S&T-knowledge and finally large investment in R&D, either in-house, in collaboration with local S&T-institutes or in countries with abundant and cheap R&D-manpower (e.g. China, India, Russia). Notwithstanding, companies following this strategy still face the problem of market entry.

- **‘Applications Pioneering’ Strategy:** Instead of developing new products, the latecomer firm applies existing technologies in new innovative ways. This seems only possible in areas where the company possesses complementary skills and possesses good insight into the business sector and existing technology.

Figure 2.6: Generic technological capability development strategies of latecomer firms from late-industrialising economies



Source: Wong, 1999a

2.2 Systems of innovation

Obviously, the development of technological capabilities, i.e. technological learning, which has been described in the previous chapter, requires awareness, resources and commitment from the firm. This is of course strongly influenced by a set of factors external to the firm. This set of factors has been termed the **‘incentive system’** by Ernst et al. (1998a) and consists of three basic elements: policy dynamics, market forces and historical practices. Policy dynamics refer to the “impact of specific policies on particular types of economic actors” (ibid.: 26) and their innovation strategies, such as direct policy instruments like tax credits, subsidies for the purchase of equipment and R&D or indirect measures like the macroeconomic environment, patterns of competition etc. Market forces such as cost and availability of capital and labour, the size and structure of the domestic market as well as the industry structure and patterns of competition also have a fundamental impact on the technological capability building process. Finally, the social and cultural context and the traditional way of doing things is part of the incentive system as an historical practise (ibid.). This notion of an incentive system is closely related to the concept of **systems of innovation (SI)**, which takes into account framework conditions such as institutions and additionally contemplates the importance of system elements and their interaction. “A system of innovation can be thought of as consisting of a set of actors or entities such as firms, organisations and institutions that interact in

the generation, use and diffusion of new – and economically useful – knowledge” (Fischer & Fröhlich, 2001: 1). More generally, systems are made up of components, relationships, and attributes (Carlsson et al., 2002a: 234). Components are the operating parts of the system such as individuals, firms or universities. Relationships are the links between the components. Attributes are the properties of components and relationships (ibid.).

Since systems of innovations can be differentiated into sectoral or technological and localised systems (Fischer & Fröhlich, 2001, Carlsson et al., 2002a), the following sections will first reflect on national and regional systems of innovation as examples of localised SI and afterwards on sectoral SI and technological systems.

2.2.1 National systems of innovation

2.2.1.1 Basic concept

The founding fathers of the concept of systems of innovation are Chris Freeman (1987, 1988), Richard Nelson (1993) and Bengt-Ake Lundvall (1988, 1992b). While Nelson’s approach is more descriptive, comparing empirical analyses in fifteen countries, Lundvall is oriented more towards building a theoretical basis for the concept (Edquist, 1997). However, theoretical foundations such as interactive learning theories (see e.g. Lundvall, 1985), organisation theory (e.g. Penrose, 1959, Chandler, 1962, Chandler et al., 1998), institutional (e.g. Coase, 1937, Hodgson, 1988, 1999) and evolutionary economics (see e.g. Dosi et al., 1990, Nelson, 1995, Nelson & Winter, 1982) serve as common ground.

Furthermore, the NSI-concept synthesises the notion of a national system of production (based on List & Lloyd, 1909), which emphasises the production structure within a country, and the concept of national business systems (e.g. Whitley, 1994b, a), which accentuates the institutional set-up. Both are subject to national differentiation (Lundvall & Maskell, 2000: 362). Consequently, the NSI-approach takes the co-evolution of structural and institutional characteristics into account (Lundvall & Maskell, 2000: 359).

A first definition was proposed by Freeman (1987: 1), who defined a NSI as “the network of institutions in the public and private sector whose activities and interactions initiate, import, modify and diffuse technology”. Whereas Lundvall (1992b: 12, 2002: pp. 216) distinguishes a narrow – also termed US-approach (e.g. Mowery & Oxley, 1995) – and a broad – coined Aalborg-version – definition. While the first includes “organisations and institutions involved in searching and exploring – such as R&D-departments, technological institutes and universities” (ibid.: 12), the latter consists of “all parts and aspects of the economic structure and the institutional set-up affecting learning as well as searching and exploring – the production system, the marketing system and the system of finance” (ibid.: 12).

According to Lundvall and Maskell (2000: 360) the NSI-approach is based on three insights: First, the awareness that successful innovation is related to close interaction and long-term relationships (see e.g. chain linked model chapter 2.1.3.1). Second, the relationship and interaction between

agents is connected to non-market relationships, called ‘organized markets’, which involve aspects such as power, trust and loyalty. Finally, different country specific conditions (in respect to structure and institutions) exert a strong influence on how these organized markets develop (Lundvall & Maskell, 2000: 360). The fundamental assumption of the NSI-approach is that interactive learning is rooted in routine activities. “If institutions define how things are done and how learning takes place, it is the economic structure that affects what is done and therefore what is learnt” (Lundvall & Maskell, 2000: 362). The degree of matching between structures and institutions cause variation between countries (ibid.: 363).

In summary,

“The NSI concept emphasizes that firms cannot be viewed in isolation but must be viewed as part of a **network** of public and private sector institutions whose activities and interactions initiate, import, modify and diffuse new technologies. Second, it emphasizes the **linkages** (both formal and informal) between institutions. Third, it emphasizes the **flows of intellectual resources** that exist between institutions. Fourth, it emphasizes **learning** as a key economic resource. And fifth [...] it asserts that geography and **location** still matter”⁶ (DeLaMothe & Paquet, 2000:29).

Consequently, in what follows the main components of a NSI: organisations, institutions and the relations/ interactions among them, are briefly described and defined.

Organisations are defined as formal structures with an explicit purpose, which are consciously created (Edquist & Johnson, 1997). Important organisations are:

- manufacturing companies,
- business services, especially knowledge intensive ones that support manufacturing firms in knowledge and technology creation/ diffusion and financial services,
- public or private knowledge-producing and -diffusing organisations like R&D-institutes or universities,
- government/ governance organisations that set policy, regulatory, or social setting for innovations such as parliaments, ministries, trade unions etc.,
- public and private institutions, providing general education and vocational training,
- and bridging organisations, that facilitate technology transfer between science and business (Edquist & Johnson, 1997: 47, Fischer et al., 2001, Patel & Pavitt, 1994: pp. 84).

Of course, not only the existence of these actors is important but their performance and hence **internal** aspects such as organisation, R&D-intensity etc. are also core elements of the NSI-approach (Lundvall, 1992a: 13).

⁶ While providing a neat description of the NSI idea, DeLaMothe’s citation already hints towards a certain confusion in the literature between the terms ‘institution’ and ‘organisation’ (for a general critique of some fuzzy terms in the SI approach see e.g. Edquist, 1997).

Institutions are “sets of common habits, routines, established practices, rules, or laws that regulate the relations and interactions between individuals, groups and organisations” (Edquist & Johnson, 1997: 46). They can be either formal (laws) or informal (traditional way of doing business). While organisations are regarded as players of the game, institutions are seen as the rules of the game (North, 1990). Lundvall et al. (2002: 220, Lundvall & Maskell, 2000: pp. 360) view the following institutional dimensions as having a major impact on learning and innovation behaviour: First, the time horizon of the agents (short-term in Anglo-Saxon countries vs. long-term in Japan), second, trust between agents; third, the pre-dominating rationality (communicative rationality rather than instrumental rationality seems to support innovative behaviour) and fourth, the authority characteristic of master-apprenticeship learning. Together these institutions constitute part of the term ‘social capital’ (see Putnam, 1993).

Interaction between organisations can take place in either market or non-market relationships. The latter, especially, is said to be highly relevant for learning (Lundvall & Maskell, 2000, Edquist, 2001). Interactions can take not only the form of flows of knowledge and information (including human flows) as well as flows of investment and funding, but also informal arrangements like networks (Cooke et al., 1997: 478, Niosi, 2002: 292). A recent OECD report (Remoe, 2002: 15) defines three categories of interactions that are important within a NSI: **Competition** forces companies to innovate, **transaction** in which goods and services (including tacit knowledge and embodied technology) are traded between organisations and **networking** by which knowledge is transferred through collaboration, co-operation and long term relationships.

According to Carlsson et al. (2002a) the core activities in a SI are those interactions that involve technology transfer, either intentionally or unintentionally (technological spillovers; see 2.1.3.1). These knowledge flows basically include interactions among firms, universities and public research laboratories, the diffusion of knowledge and technology to firms and the movement of personnel (OECD, 1997b: 12). Cooke et al. (1997: 478) assert that these links are of a different nature: They can be strong or weak, regular or irregular, intense or relaxed etc.

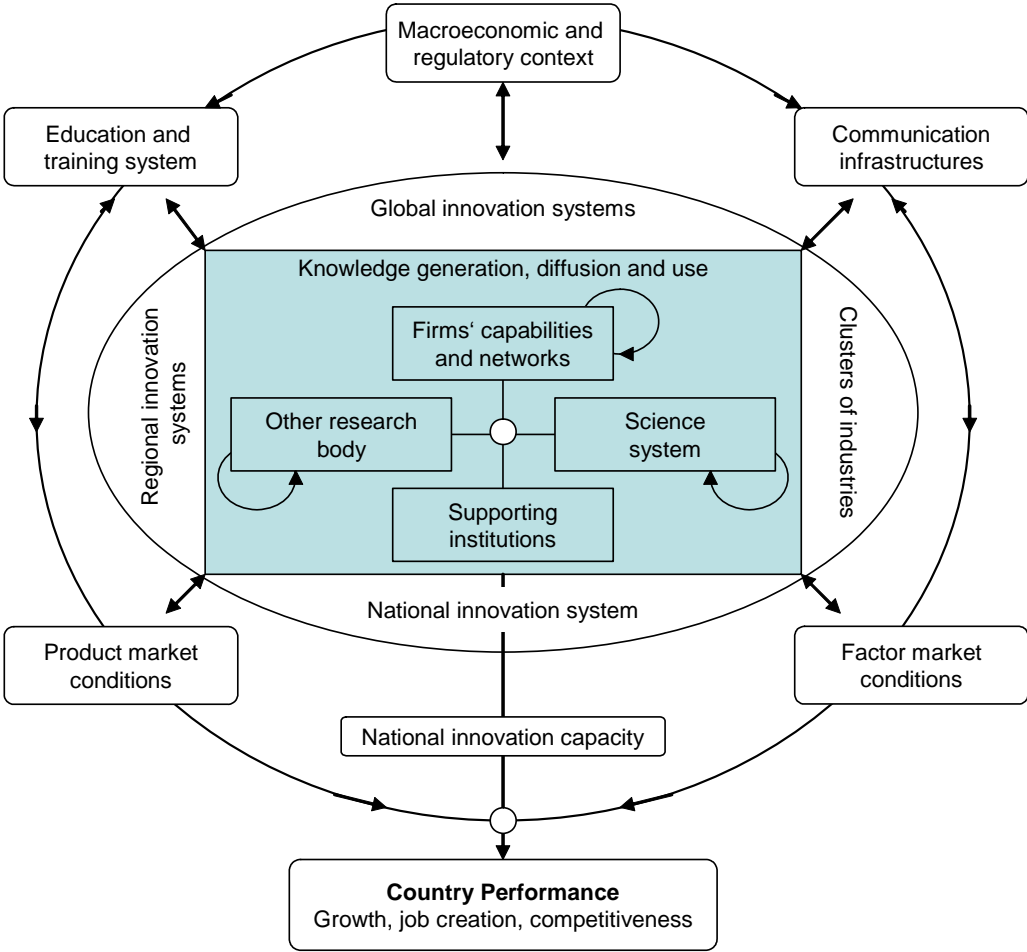
Additionally, these elements of the system are complemented by further crucial – mostly nationally determined – factors, such as the overall economic structure (firm sizes, industry, competition), the education and training system, the S&T specialisation of the research institutes and firms, government policies and regulations as well as the resulting incentive system, the financial system and the availability of (venture) capital, governance structures in a general sense and prevailing management practices, degree of labour mobility, cultural and behavioural particularities, the historical development of all these aspects over time etc. (see Archibugi & Michie, 1997, Koschatzky, 2001, Nelson, 2000, Ernst et al., 1998a, OECD, 1999).

Figure 2.7 shows a simplified model of a system of innovation with some of the main impact factors. It already depicts the essential interplay of different types of spatial systems of innovation, namely global, national and regional (see also 2.2.4).

Niosi (2002) argues that NSI can be x-efficient as well as x-effective. The first is defined as the “gap between observed performance and existing best performance”, while the latter is “the degree at which institutions attain their organizational missions” (ibid.: 293). Reasons for inefficiencies and ineffectiveness are grounded in path-dependence and lock-in situations. Main factors for system inefficiencies include inadequate system rules such as intellectual property legislations or restrictions on technology transfer, lack or limited number of key institutions, weak coordination among actors and a lack of information flows (Niosi, 2002: 296). The evaluation of the efficiency and effectiveness of NSI has to be based on benchmarking exercises between NSI, which hints towards the normative weight of ‘good’ and ‘bad’ practice that is inherent in the concept (Arocena & Sutz, 1999: pp. 5).

This kind of benchmarking is difficult given the country-specific and path dependent nature of each NSI (e.g. Gu, 1999) An aspect which poses a bottleneck in one country might not be relevant for the NSI improvement in another country. Therefore, policy recommendations that use the NSI concept need to avoid easy ‘one-size-fits-all’ solutions (Arocena & Sutz, 1999: 6).

Figure 2.7: Actors and linkages in the system of innovation



Source: OECD, 1999: 23

Currently, the scientific debate on NSI is characterised by three trends. First, there is an increase in policy-related studies. These reflect the growing interest of policy makers in ‘best or good practice’. Second, there are attempts to develop more formalized models for comparative studies of NSIs. And third, a stronger focus is laid on ‘low and medium-income countries’ (Balzat & Hanusch, 2004). For this thesis, the latter part is of particular interest.

At this point the main controversy is over the terms innovation and system. Does every country have a NSI or is this distinction dependant on some minimum requirements? While some authors like Radošević (1999) claim that while the “catching up and growth of CEECs [Central and Eastern European Countries] is closely related to the emergence of systems of innovation”, it is “not yet possible to talk about national or regional systems of innovation in CEECs” (Radošević, 1999b: 313). Others, like Arocena and Sutz (1999, 2002), detect NSI in developing countries as well.

The second debate is concerned with the term innovation. Authors like Viotti (2002) and Mathews (2001) prefer the term ‘national learning system’, which in their view is more appropriate to the situation in late-industrialising countries. This distinction, however, may be too harsh, considering the strong correlation between innovation and learning in advanced and late-industrialising countries. At least the Aalborg version of the NSI-concept takes learning explicitly into account. Nevertheless, even proponents of this research line acknowledge and demand a stronger inclusion of learning (Lundvall et al., 2002).

In the remainder of this chapter the topic of transferability of the NSI-concept to late-industrialising countries will be further elaborated upon.

2.2.1.2 Extending the concept to South East Asia

The NSI-concept is based on empirical work in developed countries. A simple transfer and implementation of the very same concept in developing countries, therefore, may not be appropriate. With this in mind, an analysis of the NSI in South-East Asian late-industrialising countries must take the following eight particularities into account:

Foremost, the modernisation and development of the economy in South-East Asian countries is driven to a stronger degree by transnational companies than in industrialised countries, because TNCs have the resources, technology and market access that local companies lack (Fromhold-Eisebith, 2001: pp. 48). Hence, TNC-affiliates are important actors within the NSI. However, these are – at least partly – externally steered, important decision-makers reside abroad, making them possibly less receptive to domestic policies.

Moreover, late-industrialising countries are subject to the ‘new division of labour’ (Fröbel et al., 1980, Ernst, 1980), which resulted into a split up of single production processes in the value-chain within global production networks. Since many late-industrialising countries offer low labour costs and an abundant labour force, they were mainly assigned to labour-intensive, low-skill production, often in the form of pure assembly sites. Especially in export processing zones, these kinds of ‘extended workbenches’ can be found, importing most of the components and exporting the assembled final or intermediate product. Even though the dichotomy between low skill, labour intensive production in developing, late-industrialising countries, and knowledge intensive, high

skill production in advanced countries is too simplistic, it is in essence correct and an essential aspect of the configuration of the developing NSI (Fromhold-Eisebith, 2001: pp. 48).

Secondly, companies in late-industrialising countries rarely work at the technological frontier. Rather, it is crucial for these companies to acquire, utilise, adopt and improve technologies that are already established in advanced countries (Wong, 1995, Lall, 2000). Hence, the focus should be laid on the distributive performance of the system, i.e. in which way it supports the diffusion of technologies. Furthermore, industrial innovation is for the most part conducted in-house and in an informal manner, where “R&D-activities are not clearly and formally articulated with the enterprise strategy” (Arocena & Sutz, 1999: 13).

Thirdly, human resource development is of major importance to the development of absorptive, learning and technological capabilities – especially in late-industrialising countries, which often lack a suitable human capital base for innovation. Nevertheless, human resources have so far been largely neglected in most NSI-research (Lundvall et al., 2002, Lundvall & Maskell, 2000, Wong, 2001).

Fourthly, although international links offer important learning opportunities for late-industrialising countries, they are not well accounted for in the NSI-concept. Due to a dualistic and inhomogeneous economic structure and a weak domestic knowledge base, interactions between national agents are seen as less important in emerging than in advanced countries (Wong, 2001, Ernst, 2002). Since the NSI in these countries is hardly developed, “international linkages need to prepare the way for the development of national innovation systems” (Ernst, 2002: 500). Hence most late-industrialising countries rely or even depend on international technology and knowledge transfer (see chapter 1.1.3.2). Linkages to foreign sources of innovation therefore predominate over domestic links (Fromhold-Eisebith, 2001: pp.48).

Fifth, for advanced countries the NSI-approach is an ex-post concept, which is based on empirical observations. It was utilised to describe, analyse and compare well-developed NSI with a strong institutional base and advanced infrastructure. For late-industrialising countries that have a fairly short history of industrial development, it is an ex-ante concept: Their NSI is less developed by order, in respect to the institutional set-up, the quality of S&T activities, and linkages between organizations, because the “technological and institutional attributes required for modern growth were not developed within their system” (Gu, 1999: 43). Gu argues that the NSI is development-level specific, which is linked to the structural and institutional development level (ibid.). Similar to the situation of latecomer firms (chapter 1.1), this implies several disadvantages, but might also hold some opportunities (see Fromhold-Eisebith, 2001: pp. 48): Since existing structures and path dependency can pose an obstacle to the development of new and efficient structures (e.g. lock-in symptom of old industrial regions; e.g. Grabher, 1993b), new industries might find favourable conditions in some late-industrialising countries for creating and manipulating the developing NSI in the sense of a ‘window of opportunity’ (cf. Storper & Walker, 1989: pp. 70). In conclusion, the

NSI in late-industrialising countries has to be built up alongside economic development. It is not a given asset but rather a political and economical objective (Arocena & Sutz, 1999, 2002). For this reason the focus of analysis in developing countries should be on ‘system construction’ and ‘system promotion’ (Lundvall et al., 2002: 226).

Sixth, as Gu (1999: pp. 43) argues, special attention should be paid to the role of the market in promoting learning and generating change in late-industrialising countries, because “market mechanisms are still under-developed” (ibid.). Moreover, learning to innovate is often associated with capital investment. Hence, while knowledge and learning is a prime source for growth in advanced countries, in developing countries capital investment is regarded as more important (ibid.).

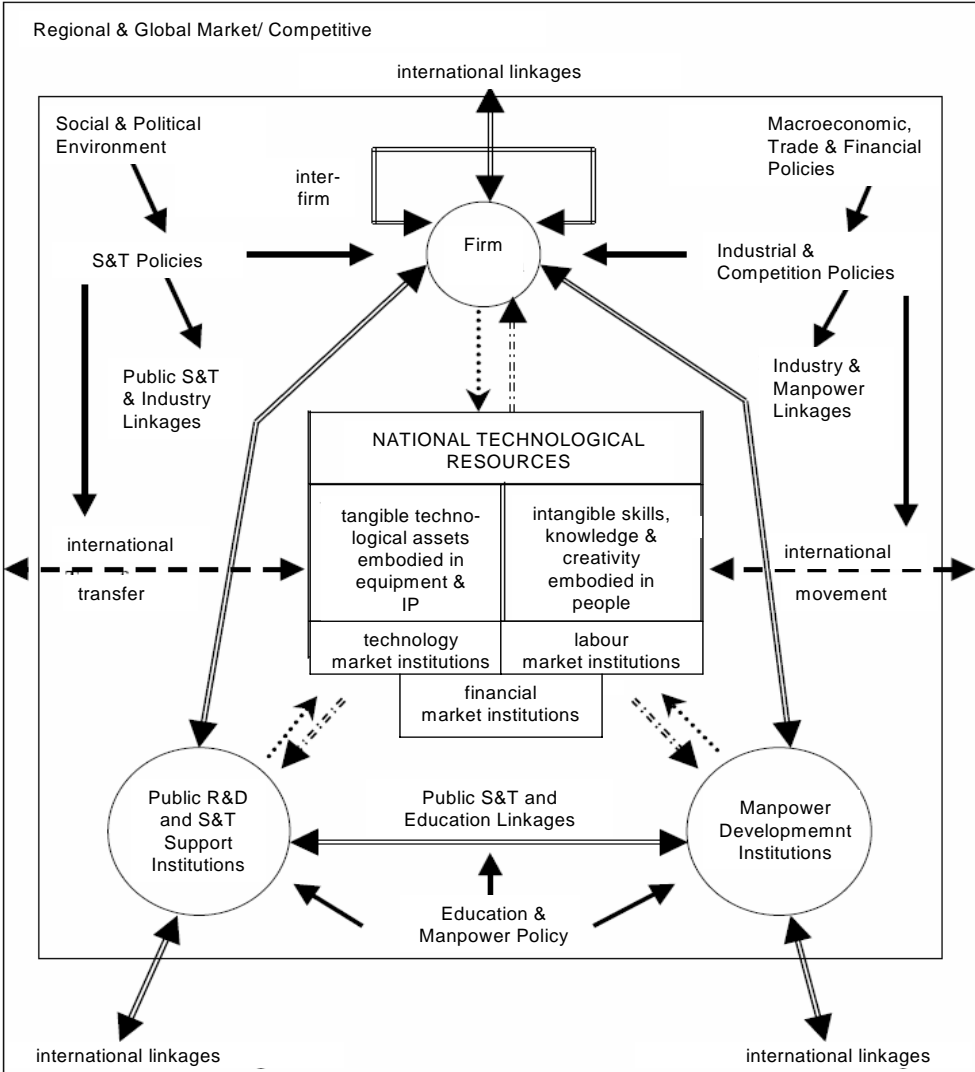
Seventh, many Asian states differ strongly from advanced economies in terms of policy (Fromhold-Eisebith, 2001: pp.48). Several could be considered ‘development states’, having a high degree of centralised political power, which intervenes in many spheres. Others, such as Thailand, are run by strong, ‘CEO-style’ politicians (The Economist, 2004b). Policies in these countries are often implemented in a sense of purposeful strategic management for catching up, fostering enhanced learning (Gu, 1999: pp. 43). Additional particularities of some late-industrialising Asian countries include inefficient or even corrupt bureaucracy, the prevailing strategy for economic development (esp. import substitution vs. market integration), the policies regarding education and S&T, the special role of state-owned companies and the institutional framework for regional policy (Fromhold-Eisebith, 2001: pp.48).

Finally, cultural aspects such as religion, social behaviour and ‘way of doing things’ result into differentiations between NSI. Even without over-generalising Asian cultures, there might be certain common characteristics which have a profound influence, for example on the type of interactions between different actors in the NSI (Fromhold-Eisebith, 2001: pp. 81).

Arguing from the point of transitional countries such as China, Liu and White (2001) criticise the NSI approach for merely describing the role and performance of particular actors, institutions and policies while neglecting system-level characteristics, such as “the distribution of these [fundamental innovation] activities, the organizational boundaries around them, coordination mechanisms, evolutionary processes, and the effectiveness of the system in introducing, diffusing and exploiting technological innovations” (ibid.: 1091). In their view, the focus on specific actors and institutions hinders comparisons with alternative systems. Hence, they concentrate on five fundamental activities: education, R&D, implementation (manufacturing), end-use (customer of products and processes) and linkage, i.e. combining complimentary knowledge. Furthermore, rather than using specific actor-categories (e.g. universities), they distinguish more generally between primary actors, performing one of the five fundamental activities, secondary actors, affecting the behaviour of or interplay between primary actors, and institutions. Consequently, instead of asking actor-centric questions like “what is the role of private firms in country X’s innovation system?”

(ibid.: 1095), they scrutinize the system with general questions concerning structure, dynamics and performance of the system.

Figure 2.8: NSI for small, late-industrialising countries



Source: Wong (2001): 544

Regarding some of these criticism, Wong (2001) has elaborated a modified NSI-concept especially for Asian newly-industrialised countries (see Figure 2.8). The main organisations in his NSI are companies, public R&D and Science and Technology (S&T) support institutions and manpower development institutions. By contemplating science and education separately, Wong brings human resource development to the forefront of his research. The key objectives of his NSI model are “to build up the stock of scientific and technological resources and to allocate and deploy these resources to the respective innovation actors” (Wong, 2001: 544). Hereby, he takes into account the diffusion of technology, which is crucial for developing countries. Moreover, he includes international technology linkages in order to overcome a limited focus on domestic interactions. As

a result of these changes and the widening of the concept, it is necessary to consider all direct and indirect policies affecting either the agents of the system or their interactions.

Several of the above cited particularities of NSI in late-industrialising Asian countries entwine themselves around the presence and influence of TNCs (see also Chenais, 1992). Consequently, these are the focused actors of this thesis. Even though this reflects an actor-centric investigation criticised by Liu and White (2001), it is justified because the regarded countries are not transitional states in terms of their policy systems. Consequently, chapter 2.3 deals with the characteristics of TNCs and their potential impact on host economies in late-industrialising countries in general and on their NSI in particular.

2.2.2 Regional systems of innovation and learning

In the course of the debate about globalisation, the end of nation states and the rise of regions as “natural economic zones” was proclaimed (Ohmae, 1993: 78). In innovation research this notion was mirrored by the concept of regional systems of innovation (RSI) (Braczyk et al., 1998, Cooke et al., 1997, DeLaMothe & Paquet, 1998). Taking on the basic ideas of the NSI-concept, the key notion of the RSI is that regions offer particular environmental conditions and opportunities for interactions that can either foster or hinder the co-operation between innovative actors in a region. Additionally, the amount and quality of regional actors influences the opportunities for learning by interacting (Cooke & Morgan, 1998).

Regions are viewed as “territories smaller than their state possessing significant supra-local governance capacity and cohesiveness differentiating them from their state and other regions” (Cooke et al., 1997: 480). Cooke et al. (1997: 479) distinguish between cultural and administrative regions, depending on the prevailing force of regional identity. Additionally, a region requires an identifiable homogeneity “in terms of criteria such as geography, political allegiance and cultural or industrial mix” (Cooke, 1998: 15).

The argument for setting the focus upon regions is twofold. Firstly, nations are not economically homogeneous but more often than not consist of different, to a certain degree specialised regions, offering particular organisational settings (e.g. highly specialised R&D-institutions, technical or financial services) and, therefore, show differences in institutional aspects such as routines, traditional behaviour, etc. (Howells, 1999: 74). Secondly, regions represent the spatial level at which (localised) interactive learning and tacit knowledge sharing is taking place (Howells, 1999, DeLaMothe & Paquet, 2000).

The main reason why the region is the locus of localised learning is

- the fact that “tacit knowledge is collective in nature and, because it is wedded to its human and social context, it is [...] territorially-specific” (Morgan, 1997: 495),
- that a distance decay function in communication can be observed (Howells, 1999),
- that a region offers specific untraded interdependencies (Storper, 1997, Storper & Scott, 1995), “which take the form of conventions, informal rules, and habits that coordinate economic actors under conditions of uncertainty” (Storper, 1997: 5),

- which together with other regional characteristics such as shared language, common cultural background, opportunities for face-to-face interaction and trust caused by long term social bonds enhance mutual understanding and collective learning (Lawson, 1999, Maskell & Malmberg, 1999, Keeble, 1999, Lawson & Lorenz, 1999, Capello, 1999).

Hence, geographical and socio-cultural proximity fosters collective information gathering and screening on markets and technologies. It supports collective learning through skilled labour mobility, customer-supplier linkages, exhibition of ‘good practice’, informal information exchange etc. Moreover, it facilitates collectively defined managerial practices, decision routines, and decision coordination (Camagni, 1991: 130; see also Ratti et al., 1997, Fromhold-Eisebith, 1999, 2000).

Breschi and Lissoni (2001), however, have questioned some of the underlying assumptions made in concepts of spatially bound knowledge flows and learning. They doubt that the tacitness of knowledge (for the scientific and technical, not for the craftsman-type) will necessarily result in regional ‘stickiness’ (Hippel, 1994). In their view, communication about specialised knowledge and technology requires specific technical language, which is rather bound to particular epistemic communities than to a locality. Furthermore, these communities have common ‘codebooks’ (i.e. language) which “may act as a powerful exclusionary device, even for local actors who live and work side by side with the community members, but cannot understand the messages (openly) exchanged by the latter” (Breschi & Lissoni, 2001: 989). At the same time communication of tacit knowledge within these communities seems possible even over long distances.

Nevertheless, “we recognize that there is hardly any doubt that innovation networks are often localized. However, the rationale for co-localization may have less to do with knowledge spillovers mediated by physical proximity, than with the need to access a pool of skilled workers and to establish transaction-intensive relationships with suppliers and customers” (Breschi & Lissoni, 2001: 998). A similar point is made by Amin (2000), who states that relational or organisational proximity (e.g. by epistemic communities or what he calls communities of practice) might be more important than geographical proximity. However, based on research exploring the impact of institutional and regulatory conditions on best-practice-learning, Gertler (1995, 2001) concludes: “The idea that organizational or relational proximity is sufficient to transcend the effects of distance (even when assisted by telecommunications and frequent travel) seems improbable” (ibid.: 19).

A necessary condition for an RSI is a region’s **governance power**, including “capacities to develop innovative support policies and organisations” (Cooke et al., 1997). This governance power requires a regional administration that has the legal and financial means to set up infrastructure and intermediary organisations, to pass laws, to create tax incentives and change regulations concerning the educational training system, etc. (Cooke, 1998, Cooke et al., 1997, Howells, 1999).

Similar to the NSI, a RSI consists of the number and properties of actors and their inter- and intra-regional linkages (Fritsch et al., 1998: 245, Fischer, 2002). Especially the importance of the knowledge infrastructure, universities and R&D-institutes, and training systems has been stressed (e.g. Asheim & Cooke, 1999), even though empirical results do not fully support these claims (e.g. Revilla Diez, 2000, Fritsch & Schwirten, 1998).

Hence, RSI could be seen as a smaller variant of the NSI consisting of mainly the same sort of organisations, institutions and linkages. Although, as was suggested, it is still subject to debate if an RSI is a subsystem or a reduced version of the NSI (Moulaert & Sekia, 2003: 293).

As for national systems, the question remains unresolved if every region constitutes an RSI or if it must fulfil a set of minimal standards (Thomi & Werner, 2001). Cooke (2001: 958) states that there are “few fully functioning RSIs”. In his view, a RSI is more than a ‘**regional learning system**’ (Cooke et al., 1997: 484). “A regional innovation system will thus have moved from a learning disposition of rapidly understanding and developing the competence to implement, apply and adapt innovations originating elsewhere to a ‘tutoring’ disposition where it displays the capability to innovate de novo” (Cooke et al., 1997: 484). Consequently, in his recent work Cooke (2003) tries to develop a regional innovation and learning system which contemplates the interaction between global value-chains and regional clusters for industrial upgrading in less favoured regions.

In order to provide a framework for empirical studies, certain attempts for the classification of RSI have been made (see e.g. Asheim and Isaksen 2000: pp. 179, Cooke, 1998). One example, which also includes less successful regions, was elaborated upon by Oinas and Malecki (2002) and is presented in Tab. 2.9. They distinguish RSI according to the degree of technological specialisation and advancement. Genuine innovator RSI are locations in which ‘new to the world’ innovations are developed and best practises emerge. Adapter RSI provide an environment for adopting new innovations from external sources quickly and improve them by incremental innovations, while adopter RSI are those into which innovations diffuse slowly and which rely on ‘imitator systems’.

Tab. 2.9: A typology of regional systems of innovation

Characterization of Region	Sectoral Diversity	Sectoral Specialisation
Genuine innovators (best practice places)	Stars (e.g. Silicon Valley)	Shooting stars (e.g. Detroit, US)
Adapters (relatively high levels of diverse competences)	Living room lamps (e.g. Hsinchu, Taiwan)	“Spotlights” (e.g. Bangalore, India)
Adopters (production oriented competences)	Chandeliers” (e.g. Bangkok, Thailand)	“Candles” (e.g. Dongguan, China)

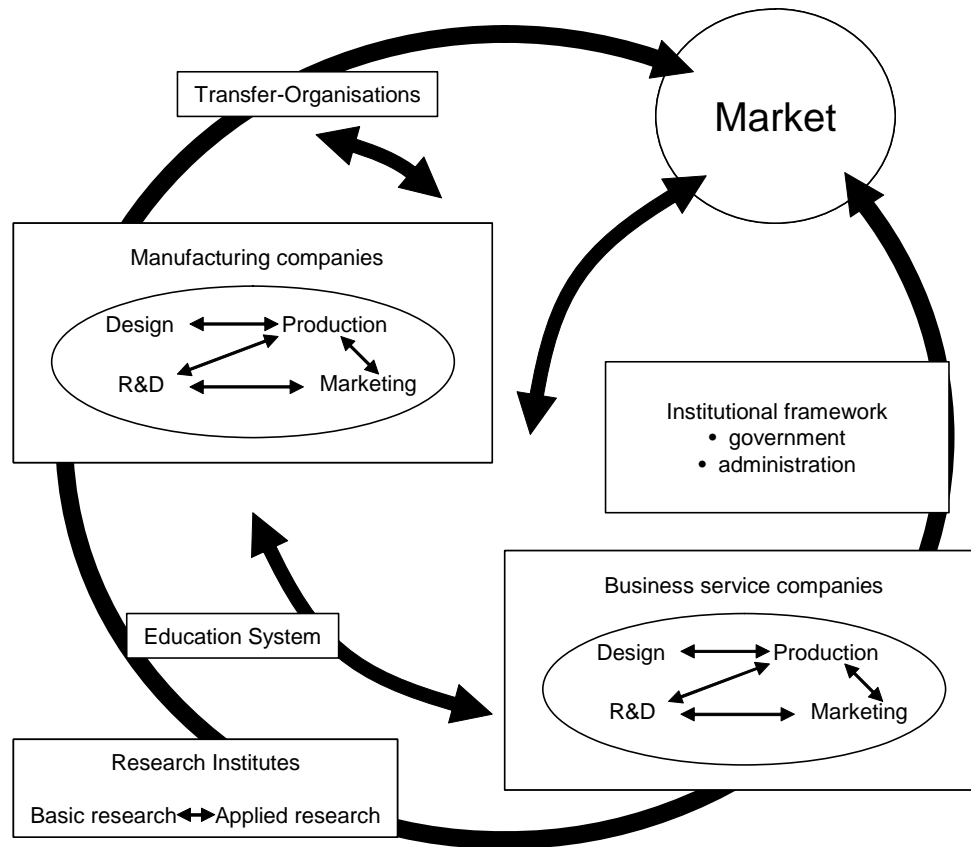
Source: Oinas & Malecki, 2002: 116, adapted

In conclusion, the endowment of a region with innovative actors and environmental conditions that favour co-operation and innovation activities constitute the extent and utilisation of the regional innovation potential. Bearing the positive effects of spatial proximity for innovation-related social capital building (trust) and knowledge spillover in mind, the regional scale provides an important research level. Figure 2.9 sketches the interactive model of an RSI.

Special cases in point are major metropolitan areas and their hinterland. Since these regions often encompass the major ‘growth engines’ of the national or global economy and offer a particular endowment of innovative actors and specific, favourable environmental conditions, they can be considered metropolitan innovation systems (Fischer et al., 2001, Revilla Diez, 2002b).

Despite the wide recognition of the RSI concept, some scholars like Bathelt and Depner (2003) and Bathelt (2003) question the existence of RSI. They argue that regions lack the necessary autonomy to develop independent accumulation- and regulation systems and are rather highly dependent on national institutions and external influences.

Figure 2.9: Regional system of innovation as an interactive model



Source: Revilla Diez, 2002a: 27

2.2.3 Sectoral Systems of innovation and technological systems

While protagonists of the spatial system of innovation concepts take the spatial extension of the system as given and analyse the conditions within these spatial boundaries, others emphasise the differences between industries within the same NSI. In their view, the conditions for innovation in, for example, the electronics industry in one country has much more in common with the electronics industry in another country than with the textile industry in the first country. Consequently, they endorse a given industry or technology as the point of origin for analysis and consider spatial aspects in a subsequent step. Among these concepts sectoral systems of innovation (Breschi & Malerba, 1997, Malerba, 2002, 2004) and technological systems (e.g. Carlsson & Stankiewicz, 1991, Carlsson, 1995, 1997, 2002) are prominent.

The main difference between both concepts is that the first considers **sectors** while the latter focuses on **technologies**. Therefore, the technological systems approach is more narrowly focused (Carlsson, 2004). While sectoral systems often use more than one technology, the same technology might be employed in different sectors (Malerba, 2004).

A **technological system** (TS) is defined as “a network of agents interacting in a specific economic/industrial area under a particular institutional infrastructure or set of infrastructures and involved in the generation, diffusion, and utilization of technology” (Carlsson & Stankiewicz, 1991:

111). A TS is, then, defined in terms of flows of knowledge and competence rather than flows of goods and services. It constitutes three dimensions (Carlsson et al., 2002b: pp. 10, Carlsson et al., 2002b: 13):

a) The **cognitive dimension** reflects upon the ‘design space’ (used as a synonym for technology), which is formed by complementary technical capabilities and evolves constantly.

b) The **organizational and institutional dimension**: Actors in the network are all individuals (researchers, managers, and critics), who participate in the growth and structuring of the design space. They are also referred to as technological communities. These actors are embedded in different organisations (e.g. companies, industry organisations, universities) and linked via professional or personal relationships. Like the design space, actor networks are subject to change over time.

c) The **economic dimension**, which includes the economic organisations that convert technological possibilities into business opportunities. These organisations influence the TS by shaping actors’ relationships through incentives and disincentives, by controlling the allocation of resources for knowledge creation and by determining the degrees to which business opportunities are exploited.

Consequently, a TS consists of knowledge and competence networks, which can become development blocs (“synergetic clusters of firms and technologies within an industry or a group of industries”; Carlsson et al., 2002a: 10) and competence blocs, responsible for the successful exploitation of the business opportunities. Interactions within a TS involve market as well as non-market transactions within buyer/supplier, problem-solving and informal networks (Carlsson, 1997: 5).

Carlsson (1997: 4) points out that the TS-approach is dynamic since it takes into account that systems evolve and vary over time. Moreover, the system as such is the unit of analysis, not its components. While the concept acknowledges the importance of the geographic location of the actors to the strength and density of the networks (Carlsson et al., 2002a: 14), it is not an explicitly spatial concept. TS “may be local, regional, or multinational, depending on the nature and extent of the networks involved” (Oinas & Malecki, 2002: 106).

Along a similar line of reasoning, a **sectoral system of innovation** (SSI) is defined as “a set of new and established products for specific uses and the set of agents carrying out market and non-market interactions for the creation, production and sale of those products. A sectoral system has a knowledge base, technologies, inputs and an existing, emergent and potential demand” (Malerba, 2002: 250). Like other systems of innovation a SSI consists of actors, interactions and institutions. Actors are either individuals like consumers, entrepreneurs and scientists or organisations such as firms, non-firm organisations (e.g. universities), sub-units of organisations (particularly R&D-departments) and groups of organisations (e.g. industry associations). Interactions include market as well as non-market relationships. Furthermore, these interactions are subject to institutions such as standards, regulations, labour markets, etc. (ibid.).

The forces that shape the dynamics of a SSI and its spatial boundaries have been compacted by Breschi and Malerba (1997: 132) into the term, technological regime. It is defined by the

opportunity conditions (likelihood for innovations), the appropriability conditions (possibilities of protecting innovations), the cumulateness of technological knowledge (“degree of serial correlation among innovations and [...] innovation activities”, *ibid.*: 135) and the relevant knowledge base. The latter encompasses the nature of the knowledge base (specificity, tacitness, complexity, independence) as well as the means of knowledge transmission and communication. Each sector operates under a different regime.

In respect to spatial aspects they emphasise the geographical concentration of innovators and their ‘knowledge spatial boundaries’, the search space for relevant knowledge that firms require for their innovation process (*ibid.*).

Carlsson et al. (2002a :12) see two major shortcomings in the SSI approach: First, it treats the concept of technological regime as largely static and unexplained. Second, it focuses on well-defined industries or branches, which is difficult since new technologies might form new systems of innovations across sectors.

From the point of view of an SSI-advocate, the differences between the TS- and SSI-approach are: First, the latter focuses strongly on private firms as central actors. Second, the SSI looks at competitive relationships among firms of the same branch whereas the TS concept considers networks of vertically and horizontally connected organisations that contribute to the development of specific technologies. Third, the SSI-concept takes the geographical boundaries of innovative activities into account, by considering the meaning of different spatial levels for particular sectors. And fourth, the SSI-approach uses some taxonomies and categories of the technical change literature (Breschi & Malerba, 1997: 131).

2.2.4 Common characteristics and problems: towards a multi-scale approach?

According to Edquist (1997) all different types of systems of innovation have a set of common characteristics, which are:

1. All of them place innovation and learning at their centre.
2. They try to include all determinants of innovations, considering political, economic, and historic as well as sociological and cultural aspects.
3. They are based in evolutionary economics and therefore share a historical perspective, which includes path dependencies and sequential transformations.
4. They are of a rather comparative nature, whereby they do not postulate an optimal system. However, they focus on evaluating different systems by comparison and learning from ‘good practice’.
5. The interdependence and interaction between the elements of the system is the most important characteristic in all approaches. Furthermore, these relations are “extremely complex and often characterised by reciprocity, interactivity, and feedback mechanisms in several loops” (Edquist, 1997: 21).
6. All types of innovations (product, process and organizational) are taken into account.

7. They emphasise the importance of institutions, despite no common understanding of the term ‘institutions’.
8. There are still ambiguities in all concepts: Some key elements are not commonly defined; the borders of the systems and the exact elements to be included are still fuzzy.
9. Finally, all these notions are sooner conceptual frameworks than formal theories.

Besides the merit of helping to improve understanding of the role that innovation plays in economic growth and towards setting technology policy in a broader framework, empirical SI-studies are faced with several shortcomings and methodological problems: the prevalence of snapshot studies and a lack of dynamic (longitudinal) studies, the concentration on invention and neglect of the innovation (economical exploitation) stage, the disregard of the role of financial institutions, the missing assessment of the performance of SI, a lack of formal modelling, difficulty in setting system boundaries and exact levels of analysis and finally, a bias towards industrialised countries (Carlsson, 2004, Carlsson et al., 2002a).

Although each SI-concept has a different focus, the “various system approaches are complements, not substitutes, each focusing on a particular domain with its own issues, problems and opportunities” (Carlsson, 2004: 16), since territorial and sectoral innovation systems overlap at a particular location. Therefore, it seems necessary to integrate the different approaches or at least try to clarify the interdependence among SI (Chang & Chen, 2004, see Tab.2.10).

Tab. 2.10: Comparing the NSI, TS/SSI and RSI approach

Approach	Major knowledge links	Knowledge transfer facilitating factors	Systemic boundaries
NSI	Triple-helix ⁷ interactions	Common language, social, cultural codes of communication	Nation-bound
TS/SSI	Inter-technological links	Technological complementarities and synergies; science and technology relation	Sector- or technology-bounded, not necessarily nation-bound
RSI	Tacit knowledge sharing; social networks	Geographical proximity, co-location learning; tacit knowledge spillover	Region-bounds

Source: Chang & Chen, 2004: 28

Contemplating empirical work at the global, national and sub-national scale, Bunnell and Coe (2001) make a case for a stronger focus on linkages and interrelationships between and across the different spatial levels. They assert that extra-local networks are critical but have received too little attention (for empirical evidence for the importance of intra- as well as interregional links for innovation see e.g. Sternberg, 2000). They demand a shift away from territorially restricted research towards a more network and key-actors oriented research⁸.

⁷ Triple helix is a synonym for the three main actors in the system: firms, universities and government (Chang & Chen, 2004: 27)

⁸ A line of reasoning that has found profound repercussion in the relatively new theoretical perspective of relational economic geography (e.g. Boggs & Rantisi, 2003, Bathelt & Glückler, 2002, 2003).

Taking on these criticisms, Oinas and Malecki (1999, 2002) have suggested a spatial innovation system (SIS), which “consists of overlapping and interlinked national, regional and sectoral systems of innovation” (Oinas & Malecki, 1999: 10). The starting point is a new technology that is developed within a technological system and creates a dynamic technological trajectory or path. The technological systems and its components evolve in space and time. Nevertheless, actors of the TS are spatially located within several RSI and RSI-characteristics (such as localised learning and creativity) are important for the further development of the TS. Consequently, it is not autonomous from the RSI in which its components operate. As a result a distinct spatial division of labour arises, with linkages between different RSI (for Oinas and Malecki's RSI classification see Tab. 2.9).

In the words of Oinas and Malecki (2002: 109):

“Key issues in discussing SIS are (1) the simultaneous and interdependent development of components of technological systems possibly in many places, utilizing spatial divisions of labour among several RSI specialised in different aspects of technologies, possibly in more than one NSI, and (2) the ‘travels’ that technologies make in space and over time as knowledge flows take place along the progress made in the frontiers of those components”.

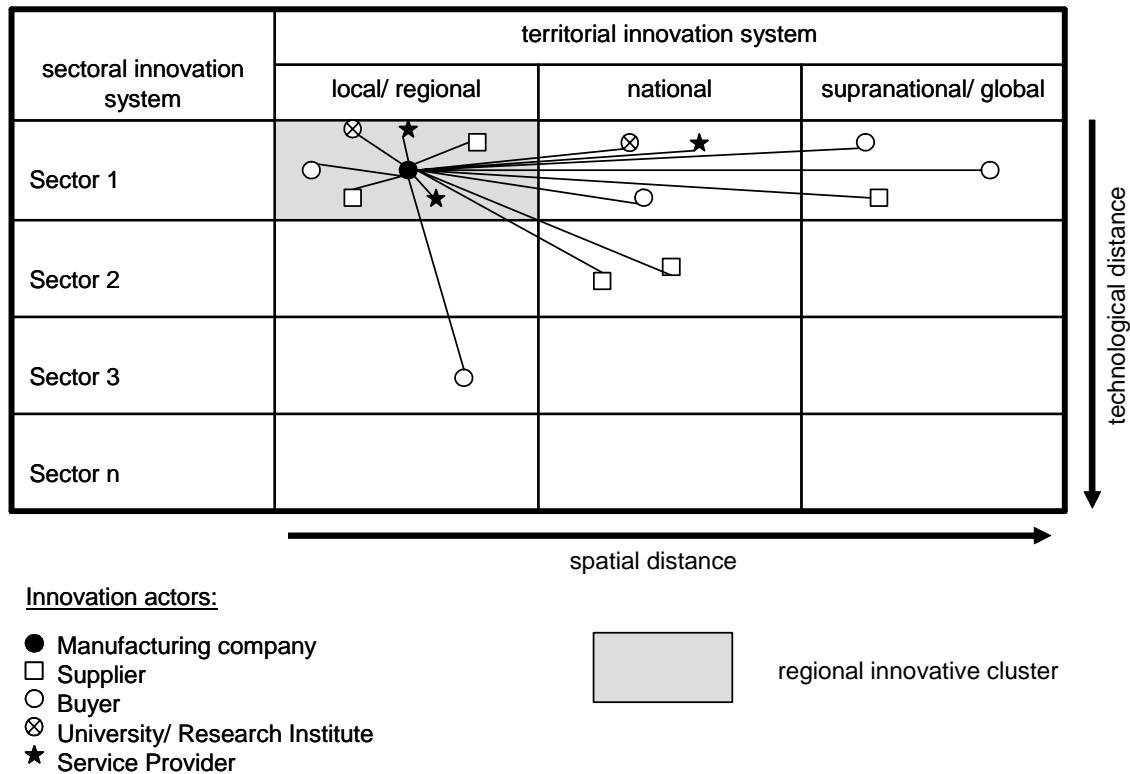
Key elements are the technological path itself, RSI, actors (individuals as well as organisations and firms), and their proximate or distant networks. Because distant networks cannot make use of spatial proximity, they are based rather on organisational, relational, institutional and temporal proximity.

The spatial innovation system approach is a useful attempt to merge the different SI-concepts, but it is still at a very early, conceptual stage, and has not resulted in any empirical investigations so far.

A similar line of reasoning leads to the notion of the “National Supersystem of Innovations” by Fromhold-Eisebith (2004), who tries to integrate RSI, NSI and an international system of innovation. In her view, each level executes a specific function: the RSI is the location where collaborative networking and collective learning takes place. The national level is responsible for regulation, setting policies and institutions, while the international innovation system links and combines different RSI, and offers a regulative framework for international co-operation.

Figure 2.10 presents a model of a hypothetical manufacturing company that is integrated into several sectoral and territorial systems of innovation at the same time (Kiese, 2004: pp 24). The model includes two propositions: first, the likelihood of interaction depends on the spatial and technological proximity of possible cooperation partners. Spatial proximity by itself is not sufficient; rather complementarities and the compatibility of the involved knowledge are essential. Second, territorial and sectoral innovation systems overlap within a region to form a regional innovative cluster (Cooke, 1998: 10) or a spatial innovation system (Oinas & Malecki, 1999, Oinas & Malecki, 2002, 2002).

Figure 2.10: Combining sectoral and territorial systems of innovation



Source: Kiese, 2004: 25, translated and redrawn

2.3 Transnational corporations and global production networks

It has been pointed out in the previous chapters that the economies and systems of innovation in late-industrialising countries are more strongly influenced by TNCs than those in advanced countries. Moreover, it has been stated that international linkages are needed to overcome weaknesses of the SI in these countries. Important actors for international linkages are transnational corporations (TNCs) and their foreign direct investments (FDI). FDI are a significant and efficient mechanism for international technology transfer (see 2.1.3.3). Consequently, this chapter takes a closer look at TNCs and their production networks. The remainder of the chapter gives an overview of definitions and characteristics of TNCs and different forms of FDI, before analysing the theoretical foundation of cross border investments in production and R&D. Subsequently, concepts of production networks are introduced. In the final part of the chapter the impact of TNC-activities on the host regions is described.

2.3.1 Definitions and characteristics

There is no clear and unified distinction between the term ‘**transnational corporation**’ (TNC) and ‘multinational corporation’. Dicken (2003a: 198) defines a TNC as “a firm that has the power to coordinate and control operations in more than one country, even if it does not own them”.

Furthermore, he uses the terms TNC and MNC synonymously, arguing that

“... the term 'transnational corporation' [is preferable] to the more widely used term 'multinational corporation', simply because it is a more general, less restrictive term. The

term 'multinational corporation' suggests operations in a substantial number of countries whereas 'transnational corporation' simply implies operations in at least two countries, including the firm's home country. In effect, all multinational corporations are transnational corporations but not all transnational corporations are multinational corporations” (Dicken, 1992:47).

Additionally, the term multinational enterprise (MNE) is applied, which is defined as “enterprises which own or control foreign-owned value-added activities, and which internalize cross-border intermediate product markets” (Dunning, 2000a: 30). This term is consequently similar to Dicken’s definition of a TNC.

Tab. 2.11: Some ideal-types of TNC-organisation: basic characteristics

Characteristics	Multinational	International	Global	Integrated network
Structural configuration	Decentralized federation; many key assets, responsibilities, decisions decentralized	Coordinated federation; many key assets, responsibilities, resources, decisions decentralized but controlled by HQ	Centralized hub; most strategic assets, resources responsibilities, decisions centralized	Distributed network of specialized resources and capabilities
Administrative control	Informal HQ-subsidary relationship; simple financial control	Formal management planning and control systems allow tighter HQ-subsidary linkage	Tight central control decisions, resources and information	Complex process of coordination and cooperation in an environment of shared decision-making
Management attitude towards overseas operations	Overseas operation sees as portfolio of independent businesses	Overseas operation sees as appendages to a central domestic corporation	Overseas operation treated as 'delivery pipelines' to a unified global market	Overseas operation sees as integral part of complex network of flows of components, products, resources, people, information among interdependent units
Role of overseas operations	Sensing and exploiting local opportunities	Adapting and leveraging parent company competencies	Implementing parent company strategies	Differentiated contributions by national units to integrated worldwide operations
Development and diffusion of knowledge	Knowledge developed and retained within each unit	Knowledge developed at the centre and transferred to overseas units	Knowledge developed and retained at the centre	Knowledge developed jointly and shared worldwide

Source: Dicken, 2003a: 215 based on Bartlett & Ghoshal, 1998

Some authors argue that there is a qualitative shift from multinational to transnational corporations. While MNCs are engaged in multi-country production operations with their headquarter (HQ) and R&D-departments in the country of origin, TNCs display a stronger global integration of their economic activities, including HQ- and R&D-functions, locating their function in whichever location suits them best (Allen, 1995: 61). A similar distinction is made by Bathelt and Glückler (2002: pp. 275), who differentiate between **international companies**, which concentrate all

functions in the home market and export their products; **multinational corporations**, which dispose of an international production network, but are still hierarchically governed by the HQ in the home country; and **transnational corporations** which are spatially diversified, having key coordination-, control- and R&D-functions positioned in several locations that interact intensely and frequently with each other. In contrast, Dicken (2003a) as well as Bartlett and Ghoshal (1998) see the term TNC as an umbrella term under which different organisation types can be summarised. These types include multinational-, international-, global- and integrated-network- firms. Tab. 2.11 presents some of the key characteristics.

Similar to Dicken and Dunning, the United Nations Conference on Trade and Development (UNCTAD) commonly defines TNCs as “incorporated or unincorporated enterprises comprising parent enterprises and their foreign affiliates” (UNCTAD, 2001: 275). A parent enterprise is described as an “enterprise that controls assets of other entities in countries other than its home country, usually by owning a certain equity capital stake” (ibid.). A foreign affiliate is an incorporated or unincorporated enterprise in which an investor who is resident in another economy owns a stake that permits a lasting interest in the management of that enterprise (UNCTAD, 2001: 275).

UNCTAD distinguishes three types of foreign affiliates:

- A subsidiary is an incorporated enterprise in the host country in which the parent enterprise owns more than 50% of the shareholder’s voting power and has the right to appoint or remove a majority of the members of the administrative, management or supervisory body.
- An associate is an incorporated enterprise in the host country in which the parent owns between 10% and 50% of the shareholders’ voting power.
- A branch is a wholly or jointly owned unincorporated enterprise in the host country. It can be a permanent establishment or office, a partnership or joint venture, land, structures and/or immovable or mobile equipment (UNCTAD, 2001: 275)

Consequently, a 10% capital stake is commonly considered as a threshold for the control of assets by UNCTAD. However, in some countries an equity stake of more than 10% is still used, e.g. the United Kingdom regarded a stake of 20% as a threshold until 1997 (UNCTAD, 2001: 289), China considers a 25% share as necessary for foreign control (Huang, 2003: 5) and in the USA the same limit of control is applied in the tax context (Kinney & Lawrence, 2000: 11). Similarly, early studies in the USA under the direction of Vernon used the 25% boundary (Vaupel & Curhan, 1969), which is still employed by Kumar (1990,na), in order to account for a variety of concepts even within one country, namely India, where different authorities apply 50%, 40% and 25% limits. Other authors, such as Ivarsson (2002b,2002a) analyse only majority-owned foreign affiliates and hence use a 50% criteria. In order to assess the influence of TNCs in Thailand, this thesis applies a capital stake of 30% as the threshold for external control (see chapter 5.1 for details).

Generally, a TNC can set up a foreign affiliate either by ‘greenfield investment’, by acquisition of existing facilities/ companies or by merger with local capital (joint venture) (Dicken, 2003a: 278).

The various organisation models of TNCs (see Tab. 2.11) naturally imply different relations between the HQ and the affiliate, which in turn exert a strong influence on the impact the affiliate has on the host economy and its innovation system. Dicken (2003a: 218) sees three different roles for affiliates. They are either **local implementers**, whose main task it is to adapt TNC-products for the local market and hence have limited geographical scope and function; or they are **specialized contributors**, which possess specific expertise and are therefore tightly integrated in the TNC-network. Moreover, affiliates can have a **world mandate**. These affiliates have a global or regional responsibility for a specific product or type of business (see also chapter 2.3.4).

In direct relation to the cross-border activities of TNCs stand **foreign direct investments (FDI)**. A direct investment is an “investment by one firm in another with the intention of gaining a degree of control over that firm’s operation” (Dicken, 2003a: 51). In the case of FDI the ‘other firm’ is simply located in another country. FDI is different from portfolio investments, because the latter are driven by pure financial interest (ibid.).

UNCTAD defines FDI as:

“an investment involving a long-term relationship and reflecting a lasting interest and control of a resident entity in one economy (foreign direct investor or parent enterprise) in an enterprise resident in an economy other than that of the foreign direct investor (FDI enterprise or affiliate enterprise or foreign affiliate). FDI implies that the investor exerts a significant degree of influence on the management of the enterprise resident in the other economy” (UNCTAD, 2001: 275).

These investments encompass initial as well as all subsequent transactions between the two entities (e.g. parent and foreign affiliate). They are essentially comprised of three components: equity capital, reinvested earnings and intra-company loans (ibid.).

The remainder of this chapter considers Dicken’s (2003a) definition of TNCs and contemplates upon the reasoning and modes of direct involvement via affiliates (2.3.2), as well as their indirect activities by exercising control or influence over companies which are involved in Global Production Networks or Commodity Chains (2.3.3). Finally, it considers the impact of TNC-affiliates on the host economy (2.3.4).

2.3.2 Internationalisation of production and R&D: why cross borders?

Traditionally, FDI and other forms of cross border investments were not treated separately. In neoclassical theory FDI-flows are simply seen as factor movements caused by differences in the factor prices (interest rates). These differences are constituted by different factor endowments (Mundell, 1957, Richardson, 1969, 1973). Consequently, capital would flow from capital rich countries with low interest rates to capital poor countries with higher rates, until factor equalization is achieved. Alternatively, international trade leads to factor equalization (see Heckscher & Ohlin, 1991; for theorising TNC-growth in the factor proportion theory cf. Krugman, 1995, Helpman, 1985, Helpman & Krugman, 1985).

This approach takes FDI-flows into account, but not the role of TNCs as the actors responsible for FDI. In the 1960s Vernon (1966) extended the notion of the product-life-cycle to accommodate

locational decisions made by companies at different stages in the product-life-cycle. In his model, companies would start to develop and produce new products first in their home base and export them to foreign markets. After some time firms may see the need to set up production facilities in these markets either in order to reduce production or distribution costs or to safeguard market shares. In due course, the product and the production technology would become more standardised and the need for cost reduction for the mature product would increase, such that the company is pressed to relocate production to a low-labour cost country to stay competitive.

Hence, these traditional approaches explain FDI flows between advanced and developing countries on the basis of comparative advantages (cf. Kleinert, 2004: pp.28). While they describe the initial FDI by US, European and Japanese companies quite well, they “can no longer explain the majority of international investment by TNCs” (Dicken, 2003a: 204).

In order to overcome these shortcomings Dunning proposed the OLI (ownership – location – internalization) or eclectic paradigm. This is rooted in Hymer’s pioneering work (1976), in which he argues that foreign companies need to have company-specific advantages over domestic rivals in order to conduct cross-border investment. Dunning asserts that TNC-activities are determined by a triad of variables: ownership advantage, internalisation advantage and location advantage (see Dunning, 1998, 2003). For cross border investment to occur all three have to be taken into account. The first variable describes the competitive advantage of a particular company over foreign rivals due to “privileged ownership of, or access to, a set of income-generating assets, or from their ability to coordinate these assets with other assets across national boundaries” (Dunning, 2003: 28). The second depicts the reasons why it is advantageous for the company to exploit these assets itself rather than selling them to other (domestic) companies. Finally, the latter is a proxy for the specific advantages of particular locations for asset exploitation, e.g. low labour cost, market access, etc. (ibid.).

Alternatively, the transaction cost approach (Coase, 1937, Williamson & Masten, 1995) has been used to explain internalisation by the associated costs. Accordingly, TNCs have the choice of market and intra-firm transactions for production and will only internalise transactions if this is cheaper than (cross-border) market dealings.

The decision about the location for an overseas-investment is influenced by a firm’s **motive** for this investment. These can be either:

- **Resource-seeking:** Companies look for location-specific resources, which are either tangible (e.g. natural resources or production factors such as labour) or intangible (expertise, specialised services etc.).
- **Market-seeking:** Firms seek market access by settling close to it, which reduces transaction costs and eases the gathering of information on market requirements.
- **Efficiency-seeking:** Companies might try to improve their efficiency by making use of economies of scale and scope, global sourcing etc. Typically, this motive leads to the specialisation of various affiliates in the TNC-network.

- **Strategic asset-seeking:** Firms use FDI to acquire strategic assets (either tangible or intangible) that may be critical to their long-term strategy. In contrast to the former motives, strategic assets seeking investment does not imply the exploitation of an existing ownership advantage of the firm. Instead, FDI may be a vehicle with which the firm can build ownership advantages that will support its long-term expansion at home and abroad, e.g. by tapping into new knowledge via joint ventures, joint research etc. (Dunning, 1998, 2000b, Rugman & Verbeke, 2003, Bathelt & Glückler, 2002).

TNCs pick locations very carefully, choosing not only a specific country but also the appropriate region/city for their investment. TNC-affiliates tend to cluster in the most suitable places, mostly agglomerations, because these places offer agglomeration benefits, such as urbanisation and localisation economies in terms of infrastructure, markets, production factors, specialised skills, suppliers and institutions (see e.g. Marshall, 1920, Schätzl, 2001: pp. 34; for empirical evidence see UNCTAD, 2001: pp. 59-88, Caves, 1996: 54). In late-industrialising countries with limited infrastructure and economic structure, most FDI will concentrate on the primate city. In general, the degree of affiliates' location in agglomeration depends on the sector, for example high-technology facilities are more concentrated than the food and beverage industry (UNCTAD, 2001: 68). The requirements on the location vary according to the motive of the investment (for details see Dunning, 1998: 53). These factors have been subject to change within the last three decades. The most prominent change relates to the reduction of spatial transactions costs through liberalisation, which has not only allowed for a spread of activities but also for bunching of related activities (ibid.).

The locational decision by TNCs is assumed to be less persistent than that of domestic firms. It is frequently argued that TNCs are 'footloose', in the sense that they can quickly shift production to other locations if the environment conditions in the host country deteriorate or other locations become significantly more attractive (see e.g. Caves, 1996). However, the notion of place- and boundary-less TNCs is rejected as a myth (see e.g. Dicken, 2003b), because on the one hand, TNCs bear a pretty strong imprint from their home country, i.e. they bring numerous inherent organisational and behavioural attributes with them to the host country (see also Gertler, 2001, Gertler, 2003), while on the other hand, they "invariably have to adapt some of their domestic practices to local conditions" (Dicken, 2003b: 41). Hence, TNC are neither completely placeless nor can they substitute locations without experiencing significant switching or sunken costs.

From the perspective of the geographical organisation of their **production** TNCs can basically follow four different strategies. They can operate **globally concentrated** by producing at a single location and exporting to world markets. Alternatively, they might follow a **host-market production** strategy, in which each production unit caters for the respective host market, or implement a **product specialisation** strategy, in which each production unit is specialised in one product, which is then marketed at a regional or global level. The most sophisticated organisation structure is **transnational vertical integration**, whereby each unit is responsible for either certain components or production steps (Dicken, 2003a: 246).

A significant change is taking place in the motives for FDI: The last two decades have witnessed a “rapid growth of strategic asset-seeking FDI, which is geared less to exploiting an existing owner specific advantage of an investing firm, and more to protecting, or augmenting, that advantage by acquisition of new assets, or by a partnering arrangement with a foreign firm” (Dunning, 1998: 55). Moreover, more traditional forms of FDI have also changed, and foreign subsidiaries are nowadays more embedded in their host economy, have deeper value-chains and perform higher order activities including R&D (ibid.).

Both processes resulted in a situation where “an increasing proportion of the total R&D-expenditure is accounted for by [...] foreign subsidiaries” (Dunning, 2000a: 16; see also Brockhoff, 1998: pp. 3). Consequently, the internationalisation of production is followed by **FDI in R&D-functions** (Hotz-Hart, 2000:442). However, it remains unclear how much late-industrialising countries like Thailand can benefit from this trend. Dunning (2002; cited in Nunnenkamp, 2002: 5) states that FDI in developing countries have shifted from market- and resource-seeking to efficiency-seeking motives, however, the former still dominate. Strategic-asset-seeking motives, on the other hand, play almost no role in FDI in developing countries (see Nunnenkamp, 2002).

Since the coordination of internationally dispersed R&D-facilities is not a simple task (Brockhoff, 1998: pp. 83), the question must be raised: why do firms internationalise their R&D-functions, which traditionally have been conducted at the home base of the TNC?

The main reasons for R&D-related FDI can be grouped in the following categories:

- **Market-related:** TNCs require local R&D units in order to adapt products to local needs, to keep track of customer demands and to provide technological back up for important production sites.
- **Technology-related:** TNCs try to tap into foreign science and technology (S&T) resources.
- **Cost-related:** R&D is a human capital intensive endeavour and TNCs may seek locations with low labour costs for engineers and scientists. Moreover, in some industries the supply of high-class scientists at the home base is simply not sufficient to sustain the TNC’s R&D-efforts.
- **Related to technology monitoring:** TNCs use R&D units to monitor new developments in S&T or to analyse competitors.
- **Non-R&D-related:** Some national governments require the establishment of R&D-facilities (e.g. in pharmaceuticals) before granting market access. Additionally, a TNC may aspire to improve its image by showing a level of commitment to the host region, for example, by transferring R&D-functions (Reddy, 2000, see also Brockhoff, 1998: pp. 28).

The variety of motives just described for R&D-related FDI is also reflected in the type of R&D-facility that a TNC might set up abroad.

Simplified, the R&D-process takes place in three phases: (1.) Applied scientific and marketing research that leads to (2.) a product design, which is then developed into a prototype and a product suitable for volume production. Before this production can start (3.) some ‘de-bugging’ and

adaptation to local conditions has to take place in order to run the new production line efficiently (Dicken, 2003a). Each of these phases is related to a certain type of R&D-facility. The most basic version is a 'support laboratory' to provide (3.) technical back-up for production and facilitate the transfer and adaptation of technology from the parent to the affiliate. A more ambitious endeavour involves the arrangement of a 'locally integrated R&D-laboratory', which engages in product design and development for the local market (2.). The highest order activity constitutes an 'international interdependent R&D-laboratory', which is more extensively integrated with other globally-based R&D-centres of the TNC than to the firm's production sites within the host country. Its objective is to develop new ideas for the global operations of the TNC (1.) (Dicken, 2003a, a complementary taxonomy is offered by Ronstadt (1977) who distinguishes technology transfer, indigenous-, global- and corporate-technology units).

Of course, the choice of a particular type of R&D-facility depends on the company's particular R&D-strategy. Traditionally, TNCs follow a centre-for-global strategy by developing new products at home for the global market. But especially in important markets TNC may desire R&D-units that develop products independently for the host market (local-for-local strategy) or even the global market (local-for-global strategy). Ambitious TNCs try to organise a network of globally dispersed R&D-units, which cooperate to develop new products for the global market (global-for-global strategy) (Ghoshal & Barlett, 1990). Frequently a TNC utilises different strategies for different products in order to reap the greatest benefits.

Considering the different types and motives attributed to foreign R&D-facilities, Kuemmerle (1999) distinguishes between R&D-units that are concerned with the exploitation of the firm's knowledge stock, which he labels 'home-base-exploiting' (HBE), and units that aim at augmenting that existing knowledge stock of the firm, named 'home-base-augmenting' (HBA) FDI. HBE is responsible for adapting existing products to local needs and transferring knowledge and prototypes from the firm's home location and therefore follows existing production abroad (see also Hotz-Hart, 2000). There is evidence that much of the technology that is developed by TNCs abroad is of the HBE-type, because it falls into the core areas of the firms' competence, "suggesting that adaptation and technical support to foreign manufacturing plants continues to be a major explanatory factor" (Cantwell & Iammarino, 2003: 4) for the dispersion of multinational R&D-activities.

In contrast, HBA has the task to extend existing core competencies and to broaden the knowledge base of the firm. Its locational requirements are fairly different from those of HBEs. In order to participate in innovative networks, to benefit from spillovers and to tap into local knowledge, they need to be located in metropolitan areas that host a high density of high-class R&D-facilities (public or private), service companies and institutions as well as a large pool of highly educated engineers and scientists (e.g. Ivarsson & Alvstam, 2004). Furthermore, different locations offer different specialisations, and it is necessary for TNC to 'be there' in order to make use of this localized knowledge. Reddy (2000: 27) evaluates this access to "a wide range of innovative stimuli and sources of scientific creativity" as the key driving force behind the globalization of R&D by TNCs. Even though this kind of localized knowledge is increasingly distributed internationally, it is predominately sited within the Triad of Europe, Japan, and North America (Hotz-Hart, 2000;

Dunning, 2000a). More than 90% of the world's industrial R&D is still carried out within the industrialised world (Reddy, 2000). Nevertheless, the distribution of locations of innovative stimuli, key knowledge and sources of creativity is patently uneven within the industrialized world, still there is "some suggestion that the major metropolitan areas and their surrounding hinterlands are becoming the loci of agglomerative knowledge enhancing activity" (Dunning, 2000a: 125). Furthermore, initial empirical results suggest that most of the R&D performed in late-industrialising countries such as Thailand, Malaysia and Singapore is of the HBE type (Revilla Diez & Berger, 2005).

There is almost no internalisation of **headquarters (HQ)** which are overwhelmingly located in the TNC home country (Dicken, 2003a: pp. 238). However, many TNCs pursue a regionalisation strategy and have established **regional headquarters (RHQ)**. Their main objective is to safeguard the HQ's influence. They coordinate and control the activities of the affiliates in a region (understood as a supranational entity) and mediate between the HQ and the affiliates. Furthermore, RHQ are part of the TNC's 'intelligence gathering' system, that perceives and understands changes in the host region (ibid., Yeung et al., 2001). RHQ are mainly located in world or global cities (Sassen, 1991) that offer agglomeration economies, excellent transport and communication infrastructure. In Asia RHQ are mainly situated in Singapore and Hong Kong (Yeung et al., 2001). Taken together, these changes have not diminished the explanatory power of the OLI framework, since FDI in R&D-facilities are also in line with this framework. Still, the dynamics between the three components have changed: Since the traditional hierarchical organisation has given way to more flexible integrated network organisation of innovative cross-border activities, the internalisation-advantage should be seen in a different light. Additionally, there is a stronger interaction between the ownership- and the location-advantage (Cantwell & Iammarino, 2003). It can be argued that a present firm's ownership-advantages are dependant on previous location-factors, while on the other hand a country's locational-advantage can benefit from locally based companies (local or foreign) with strong ownership-advantages (Narula, 1996).

2.3.3 TNCs in networks of externalised relationships

TNCs are not only involved in economic operations where they own stakes of an enterprise within the host country, but also influence domestic companies by including them in their production network or by forging alliances with them. This section briefly summarises the core conceptualisations, namely strategic alliances, production networks, global commodity chains and global production networks, because the interviews presented in chapter 6 will take account of these types of relationships in Thailand.

Strategic alliances

"Strategic alliances are formal agreements between firms to pursue a specific strategic objective" (Dicken, 2003a: 260). The objectives behind alliances can be related to research (e.g. cooperative R&D), technology (e.g. technology sharing or cross licensing) or market activities (e.g. joint distribution) (ibid.). The number of strategic alliances has increased rapidly in the last few decades

(Linden, 2000, Hagedoorn & Osborn, 2002, Dunning, 1997) and are forged mostly between competitors (Dicken, 2003a: 258). The share of international partnerships in newly established R&D-alliances is more or less constant at around 60%, with a strong focus on the Triad countries (North-America, Europe, Japan) (based on from 1960 to 1998 figures, Hagedoorn & Osborn, 2002, Narula, 2003). Consequently, strategic arrangements are not yet of significant importance in late-industrialising countries such as Thailand.

Production networks

A large and increasing proportion of inputs in the manufacturing process are purchased externally, either 'off-the-shelf' from independent suppliers or through long-term relationships with independent suppliers. The latter case, called subcontracting, is of increasing importance, and reflects a situation in between internalised production and arm's length market transaction. In industrial subcontracting the customer either procures certain components from the subcontractor or sources entire parts of the production process out.

Motivation for subcontracting can be threefold: either the subcontractor possesses sophisticated skills and equipment for specialised functions, or is able to produce components of the process at a lower price, or the subcontractor offers extra capacity in times of high demand (Dicken, 2003a). Frequently, subcontracting is connected with knowledge and technology transfer, because the customer does not only provide detailed design or specifications, but also gives assistance in choosing and purchasing the right equipment, materials and components. Additionally, the customer may offer training, technical advice or even financial assistance (*ibid.*). Hobday (1995a) has shown that for East Asia subcontracting (in the form of OEM, see 2.1.3.4) posed as an important means for technological upgrading.

Global Commodity Chain (GCC)

A GCC has been defined as "a network of labor and production processes whose end result is a finished commodity" (Hopkins & Wallerstein, 1986: 159) and consist of "sets of interorganizational networks clustered around one commodity or product, linking households, enterprises, and states to one another within the world economy" (Gereffi & Korzeniewicz, 1994: 2). GCC refer to all activities involved in design, production and marketing of a product. It can be either producer-driven, i.e. organised by a large manufacturing TNC, or buyer-driven, when for example a large retailer coordinates the network. It includes the input-output and governance structure as well as the geographical configuration with its social and institutional context (Gereffi & Korzeniewicz, 1994: pp. 96). As distinctive characteristics, the GCC framework includes an **international dimension**, regards the **power** exercised by the organiser of the chain, considers the **coordination** of the chain as a source of competitive advantage and takes into account **organisational learning** as the main mechanism by which firms establish their position within the chain (Gereffi, 1999: 34). The central hypothesis of the GCC concept states, "development requires linking-up with the most significant 'lead firms' in an industry" (*ibid.*).

Global Production Networks (GPN)

The concept behind GPNs is based partly on that of GCCs. It has been simultaneously elaborated by Ernst (e.g. Ernst, 2002, Ernst & Kim, 2002) and a group based around Peter Dicken, Henry Yeung and Jeffery Henderson (e.g. Henderson et al., 2002). In Ernst's perspective a GPN is dominated by and built around a 'flagship', i.e. a large TNC. It includes TNC-affiliates and joint ventures as well as its subcontractors, service providers and partners in strategic alliances. The purpose of the GPN is to provide the flagship "with quick and low-cost access to resources, capabilities and knowledge that are complementary to its core competencies" (Ernst & Kim, 2002: 1420). The flagship is able to control the GPN and exercise power and pressure upon its members because it controls resources and capabilities for innovation, transactions and knowledge exchange within the GPN (ibid.: 1422). The GPN concept elaborated by Henderson et al. (2002) provides a broader analytical framework which pays attention to the structure and power relations within networks of firms involved in the development, production and marketing of a product. It additionally includes aspects of value creation and transfer, of institutions which influence firm strategy and the implications of these for technology upgrading, value-adding and capturing (ibid.: 447). Basically, three conceptual categories are considered: a) value (creation, enhancement and capture), b) power (corporate, collective and institutional) and finally c) embeddedness (either territorial or network) (ibid.: pp. 448).

The merits of these approaches are that they try to break up a state-centric view, take international connections seriously, and include aspects of power in the analysis. Because empirical observations underline the importance of external relationships for technological learning in late-industrialising countries (see chapter 2.1.4), this is a central undertaking. Accordingly, aspects of power will be taken up to a certain extent in the analysis of the interviews (chapter 6). The analysis in chapter 5, however, is limited to TNC-affiliates that are located in Thailand. Consequently, the next section considers possible impacts TNC-affiliates may have on the host economy.

2.3.4 Impact of TNC-affiliates on host regions

Generally, the establishment of a TNC-affiliate is an investment, whose impact on the host economy can – as a first step – be analysed from a post-Keynesian growth-theory perspective. Keynes (1936) pointed towards the **income-effect** caused by the investment, which increases the national product. Moreover, extra production capacity is added to the local capital basis (**capacity-effect**) (Domar, 1946, Harrod, 1948). Once set up, a TNC-affiliates interacts with the host economy through various linkages: It might procure inputs and services from domestic sources (**backward linkages**) and sell to domestic customers for further processing (**forward linkages**, on both cf. Hirschman, 1958). Additionally, TNC-affiliates import and export goods and services contributing to a countries trade balance. Furthermore, the presence of a TNC-affiliate creates direct and indirect employment opportunities (labour market effects and additional income-effects) and demands in domestic capital markets. Moreover, TNC-affiliates may generate profits, which – despite the

frequent practice of transfer pricing⁹ – will raise local tax-revenues. In general, all of these local activities have multiplier effect and trigger further rounds of income generation within the local economy. Finally, TNC-affiliates can compete with local firms, which can in turn threaten the survival of existing firms and spur the formation of new ones (competitive effect) (see Dicken, 2003a: pp. 278, Blomström & Kokko, 2001, Schätzl, 2000: pp. 97, Schätzl, 2001: pp.143).

Dicken (2003a: pp. 278) identifies five potential impact areas, displayed in Tab. 2.12: capital, technology, linkages, industrial structure and employment (see also UNCTAD, 1999: pp.149), while this thesis concentrates primarily on technology and linkages. Given this, the impact of an affiliate is determined by its own characteristics: mode of entry, functions, operational attributes, and the characteristics of the host economy, for example, the dynamic of the local business environment (Holm et al., 2003) and the policies adopted towards the promotion of FDI.

Tab. 2.12: The major dimensions of the potential impact of TNCs on host economies

Nature of the foreign-controlled unit	Nature of the host economy	Major areas of potential TNC impact
<p>Mode of entry 1. establishment of new unit 2. acquisition of existing firm 3. joint venture with local firm</p> <p>Function 1. to utilise local resources 2. to serve host-country markets (import substitution) 3. to serve export markets (export platform)</p> <p>Attributes 1. industry type 2. technology 3. scale of operations 4. extent of integration within parent company</p>	<ul style="list-style-type: none"> - level of economic development - size of the economy - resource endowment - technological base - social, political, cultural characteristics, etc. 	<p>Capital and finance - initial inflow of capital - capital raised locally - profits retained locally - profits remitted to parent company - transfer pricing - cost to host country of obtaining plant</p> <p>Technology - extent of technology transfer - appropriateness of technology - cost to host country</p> <p>Trade and linkages - propensity to export - propensity to import materials and components - use of local suppliers (extent of local linkages)</p> <p>Industrial structure and entrepreneurship - effect on concentration of industry - effect on competitive position of existing indigenous firms - effect on formation of new indigenous firms</p> <p>Employment and labour issues - volume of employment - type of employment (skills, gender) - wage levels and recruitment - labour relations - stability</p>

Source: Dicken, 2003a: 280; adapted

⁹ Many cross-border transactions take place within the corporate network. The TNC is fixing the price for these intermediate products, allowing for adjustments in order to minimise taxes payable to national governments (cf. Dicken, 2003a: pp.282).

Most important for the development of technological capabilities in local firms are **productivity and technology spillovers** which “take place when the entry or presence of TNC-affiliates lead to productivity or efficiency benefits for the host country’s local firms, and the TNCs are not able to internalize the full value of these benefits” (Blomström & Kokko, 2001: 440). These spillovers are basically knowledge externalities (Breschi & Lissoni, 2001: 977, see chapter 2.1.3.1) that are bound to linkages between TNC-affiliates and domestic firms (Blomström & Kokko, 2001: 442; for a literature review of empirical studies on technological spillover from FDI see Fan, 2002).

In particular **backward linkages** are seen “as the main vehicle to promote technological spillovers from TNCs” (Altenburg, 2000: 9), because they are an efficient means for the exchange of information, technology and skills. This is especially true for “transactions that go beyond arm’s length, one-off relations (as in buying standardized products off the shelf) and involve longer-term relations between firms” (UNCTAD, 2001:127). Because these linkages can promote a domestic supplier’s production efficiency, productivity growth, technological and managerial capabilities as well as market diversification and export growth (UNCTAD, 2001: 129). However, local suppliers must first qualify for supplying TNC-affiliates on a long-term basis. For this, they have to meet a TNC’s requirements in respect to quality, price, and delivery. Otherwise, an affiliate may import inputs, produce them in-house or procure them from ‘follow-source suppliers’, i.e. firms that already supply the TNC at its home base and follow it to production sites worldwide (ibid., Ivarsson & Alvstam, 2004). If a locally-owned supplier wins recognition, the TNC-affiliate can also help it meet demands by providing assistance. This assistance includes transferring technology, providing training, sharing information and offering financial support (UNCTAD, 2001, see Tab. 2.13) Caves (1999) points out, that TNC-affiliates have a strong self-interest in improving the performance of domestic suppliers. In his view, the degree of assistance offered correlates to the degree at which benefits are recaptured from the spillover of the affiliate.

In terms of **forward linkages** customers benefit from the market entry of TNC-affiliates, since these tend to improve the quality and/or lower the prices for inputs. Additionally, TNCs often outsource their distribution activities to domestic service or trade firms (e.g. car dealer). This goes hand in hand with comprehensive training and technology transfer (e.g. marketing know-how, personnel training, raw material procurement etc.), given that these outlets represent the trademark to the customer. The franchise system is a special case in point.

For industrial buyers, TNC-affiliates often provide assistance during the sale of capital goods, e.g. they train the personnel on how to operate and maintain the equipment (often not only including know-how, but also a certain extent of know-why knowledge). Frequently, they also offer information on international quality standards and market trends (Altenburg, 2000: pp.13). Having said that, Blomström and Kokko emphasise, that there is much less evidence of forward than backward linkages (2001: 443).

Another frequent and important **link** exists between **TNC-affiliates and public institutions**, such as universities, public R&D-institutes or training institutions like tertiary education institutions.

These include collaboration on research as well as on training. The latter is especially common, seeing as “all new technologies need shop-floor, technical and managerial training” (UNCTAD, 1999: 214). TNCs offer attractive job opportunities, which create an incentive for prospective students e.g. to choose engineering or science courses (Blomström & Kokko, 2002: 16). Furthermore TNC-affiliates offer scholarships, sponsoring, advice on the curriculum, material, and access to relevant new technologies (ibid., UNCTAD, 1999 214 & pp. 273). However, “the existence of linkages does not prove that there are spillovers, although the two are probably closely related” (Blomström & Kokko, 2001: 442), because even if the TNC charges the domestic company for its support services, it is not always able to retrieve all of the value from the resulting productivity increase (ibid.).

Tab. 2.13: Possible assistance by TNC-affiliates to domestic suppliers

Area	Mechanisms
Transferring technology	
a) Product technology	
<ul style="list-style-type: none"> ▪ Provision of proprietary product know-how ▪ Transfer of product designs and technical specifications ▪ Technical consultations with suppliers to help them master new technologies ▪ Feedback on product performance to help suppliers improve performance ▪ Collaboration in R&D 	
b) Process technology	
<ul style="list-style-type: none"> ▪ Provision of machinery and equipment to suppliers ▪ Technical support on production planning, quality management, inspection and testing ▪ Visits to supplier facilities to advise on layout, operations and quality ▪ Formation of “cooperation clubs” for interacting with or among suppliers on technical issues ▪ Assistance to employees setting up their own firm 	
c) Organizational and managerial know-how	
<ul style="list-style-type: none"> ▪ Assistance with inventory management and the use of just-in-time and other systems ▪ Assistance in implementing quality assurance systems ▪ Introduction to new practices such as network management or financial, purchase and marketing techniques 	
Providing training	
<ul style="list-style-type: none"> ▪ Training courses in affiliates for suppliers’ personnel ▪ Offering access to internal training programmes in affiliates or abroad ▪ Sending teams of experts to suppliers to provide in-plant training ▪ Promotion of cooperative learning among suppliers 	
Sharing information	
<ul style="list-style-type: none"> ▪ Informal exchanges of information on business plans and future requirements ▪ Provision of annual purchase orders (for precocious planning) ▪ Provision of market information (particular on foreign markets) ▪ Encouraging suppliers to join business associations 	
Providing financial support	
<ul style="list-style-type: none"> ▪ Providing special or favourable pricing for suppliers’ products ▪ Helping suppliers’ cash flow (e.g. through advance purchase and payments etc.) ▪ Longer-term assistance through provision of capital, guarantees for bank loans, leasing, etc. 	

Source: UNCTAD, 2001: pp. 142

For the **competitive effect on local firms**, the impact can be mixed. On the one hand, increased competition might lead to enhanced efforts from domestic companies in terms of technological upgrading. Subsequently, these companies may even enter highly competitive export markets. On the other hand, if the technology gap between TNC-affiliates and domestic companies is too large, domestic firms might be driven out of the market (crowding out effect; see e.g. UNCTAD, 1999: 171). Additionally, TNCs may lead to spin-offs, i.e. when former employees of the TNC-affiliates use the acquired knowledge to set up their own enterprise. This enriches the economic structure of the host economy and contributes to the diffusion of technology and knowledge (UNCTAD, 2001: 131).

Other spillover effects include **demonstration effects**, i.e. technologies or organisational procedure applied by TNC-affiliates can be copied or adapted by local companies observing TNC-affiliates' practices. Moreover, knowledge and skill spillovers take place via **personnel mobility**: TNC-affiliates tend to use more advanced technologies and management practices and therefore place higher requirements on their personnel, which is as a consequence subject to more training. Due to labour mobility, knowledge and skills may spread through the host economy (Altenburg, 2000: pp. 17). However, the quality of technology and know-how transferred by TNCs to their affiliates in late-industrialising countries is not always state-of-the-art. The quality depends on host countries' institutional development, such as the protection of property (intellectual) rights, the rule of law, degree of corruption etc. (Nunnenkamp & Spatz, 2003b: 3).

The intensity of a TNC-affiliate's integration in a host region's networks can be termed '**embeddedness**'. Generally, embeddedness has been described as follows: "The more dependent the subsidiary is on its counterparts to pursue its activities and the more adapted it is to its counterparts, the more embedded it is" (Andersson & Forsgren, 2002: 346). Since embeddedness can relate to the integration in networks inside and outside the TNC, **corporate and external embeddedness** are distinguished from each other (Dicken et al., 1994, Andersson & Forsgren, 2002). External embeddedness can either be **local** or **non-local**. Important general indicators for embeddedness are flows of good and services between the counterparts (ibid.: 348). The "most important single indicator for local embeddedness relates to supplier relationships" (Dicken et al., 1994: 38). Local embeddedness therefore reflects the choice and autonomy of the TNC-affiliate and the existence of appropriate partners in the host region (ibid.: 39). Hence TNC-affiliates can be classified based on the intensity of their corporate and external embeddedness TNC (see Andersson & Forsgren, 2002, Kutschker & Schurig, 2002, Andersson et al., 2001, Andersson et al., 1999, Holm et al., 2003).

Moran (2001: 62) asserts that the strength of embeddedness in the TNC-sourcing-network (i.e. the corporate embeddedness) strongly influences the affiliates contribution to the host economy (see Tab. 2.14). He concludes that the "interaction with the parent [...] creates a particular dynamic channel for bringing new technology and best business practices into the host economy. The benefits extend from the affiliate itself to local suppliers, with a relatively strong likelihood of generating spillovers and externalities for the host economy more broadly" (ibid.: pp. 62).

Consequently, internal and external forms of embeddedness are important determinants for the successful transfer and diffusion of internationally available technology within the host economy.

Tab. 2.14: Schematic comparison of foreign affiliates closely integrated into the parent’s global sourcing network with foreign affiliates that are not

	Foreign affiliates closely integrated into parent’s global sourcing network	Foreign affiliates not closely integrated into parent’s global sourcing network
Predominant characteristics of foreign affiliate	wholly owned, few domestic-content or technology-sharing requirements, full-scale size, largely export-oriented	subject to joint-venture, domestic-content, technology-sharing requirements, often boutique or less than full-scale size, largely domestic oriented
Foreign affiliate’s position in relation to industry’s competitive frontier	cutting edge of technology, business practices, quality control; near real-time pace of upgrading	older technology (3 – 10 years older), less advanced business practices and quality control; lags in pace of upgrading
Backward linkages	highly variable, but often extensive with local suppliers enjoying economies of scale	specified by domestic-content and joint venture requirements, but limited by small scale
Local suppliers’ position in relation to industry’s competitive frontier	extensive assistance on the part of foreign affiliate in enhancing efficiency and quality control of local suppliers	less extensive assistance on the part of foreign affiliate in enhancing efficiency and quality control of local suppliers
Externalities	OEM and REM qualification and export coaching for local suppliers, movement of skilled workers and managers within host economy	some movement of skilled workers and managers within host economy

OEM = original equipment manufacturer; REM= replacement equipment manufacturer; Source: Moran, 2001: 62

Additional determinates for local embeddedness include (based on UNCTAD, 2001: pp. 137):

- **Investment motives and strategies:** domestic-market oriented affiliates source more locally, than export-market oriented. This is due to lower quality and price requirements of the domestic market and higher expertise of local suppliers on the demands of the domestic market . Moreover, TNC-affiliates try to avoid exchange rate risks. Another factor is the structure and embeddedness into (global) production networks;
- **Technology and market position:** standardised, mature technology is likely to be procured off- the shelf- while specialised, advanced products and technologies are sourced either in-house or in long-term relationships;
- **Role assigned to affiliates:** greater autonomy frequently leads to more local linkages;
- **Age of foreign affiliate:** local procurement by affiliates tends to increase over time;
- **Mode of entry:** mergers and acquisitions have stronger local linkages than greenfield investments, since they acquire existing linkages;
- **Size of affiliate:** large affiliates source less locally than small affiliates;
- **Sector:** different industries offer different opportunities for local suppliers to engage in supply chains of foreign affiliates.

The reduction of the term embeddedness to a simple synonym of external economic linkages is strongly criticised by Oinas (1997: 26). Together with Glückler (2001) and Hess (2004) he stresses that the original notion of embeddedness as introduced by Polanyi (1944) and Granovetter (1985) emphasises the importance of social relations, concrete personal relations as well as the structures or networks of these relation, for economic activities. The importance of embeddedness stems from its trust generating effect (Granovetter, 1985: 490) which reduces uncertainty and opportunistic behaviour in economic transactions. Embeddedness is seen as a four dimensional concept, including cognitive, cultural, political and structural embeddedness. The key element is structural embeddedness, which describes how an actor is integrated into networks fostering knowledge transfer and learning (Taylor & Leonard, 2002: 2, Boschma et al., 2002: 26). It is associated with four common features (Grabher, 1993a, Taylor & Leonard, 2002):

- **reciprocity:** transactions between firms occur frequently and while not reaching equivalence in every transaction do reach an approximate balance over time
- **interdependence:** trust and “mutual adaptation and orientation” (Grabher, 1993a: 9) in long-term relationships foster knowledge transfer between firms
- **loose couplings:** although firms change their cooperation partners frequently in order to access various sources of information, they are able to sustain a stable framework of interaction (see also Lundvall, 1993)
- **asymmetric power relations:** which takes into account that networks do not only consist of collaboration and partnership but also dominance and exploitation between unequal exchange partners (Hakansson & Johanson, 1993).

From a typical perspective in economic geography, embeddedness refers to the involvement in local social relations, even though this has not been stated in the original formulation by Granovetter (1985) (Oinas, 1997: 26). In economic geography the concept “has been widely adopted because it revives the idea that firms are firmly linked to their local production environment [...]” (Boschma et al., 2002: 22). Hence it includes popular notions in the subject such as untraded interdependencies (Storper & Scott, 1995, Storper, 1997), institutional thickness (Amin & Thrift, 1994b, a), institutional endowment (Maskell & Malmberg, 1999) or social capital (Putnam, 1993, Morgan, 1997, Boschma et al., 2002). All of which take account of the unique socio-cultural properties of a specific region, such as formal and informal institutions, that shape firms’ behaviour, inter-firm-cooperation and interactive learning (see chapter 2.1.3.1 and 2.2.2). However, the ‘all-inclusiveness’ reduces the usefulness of the concept, because “it encompasses too many things with the result of being ambiguous” (Oinas, 1997: 26).

Despite this criticism, chapter 5 and 6 will use the term embeddedness in order to describe input/output as well as external R&D, innovation and human resource development linkages within the host economy. For the objective of this thesis this ‘superficial’ usage of the term is sufficient, because it describes the sufficiently the local involvement that can be considered a pre-requisite for local learning opportunities.

However, concerning the involvement of TNCs in local learning networks Gertler (2003) concludes – based on empirical research – that “the tendency for TNCs to embed themselves in local learning relationships abroad seems still to be quite limited at best” (ibid.: 112).

In summary, the benefits of TNCs as enumerated above are that “they create an inflow of funds in the form of foreign exchange, helping to plug both the savings and the foreign exchange gaps. They are expected to create employment, increase exports, bring in new technology, managerial and marketing skills, and improve competition in relatively lethargic markets” (Kambhampati, 2004: 135).

Conversely, TNCs tend to receive criticism for the very same reasons. TNCs often raise credits within the country. Consequently, the capital transfer is not as high as assumed and domestic borrowing on tight financial markets can lead to crowding out effects, i.e. local companies might not be able to acquire funds. Tax and import duty exemptions as well as transfer pricing can result in meagre revenues for the state from the TNC-activity, while at the same time, states often need to invest in infrastructure, etc. in order to attract TNCs. When domestic firms are weak, TNCs can create monopolistic or oligopolistic market power, driving even fairly competitive local firms out of the market. This can result in a net-loss of jobs, since many local companies are more labour-intensive than modern TNC-affiliates. Above all, if TNCs use ‘inappropriate technology’ (e.g. highly automated production technology in countries with abundant unskilled labour) local employment effects as well as opportunities for technology spillovers (when the technology is simply not adequate for domestic companies) are sharply diminished. Some TNC-affiliates also use local employees on the shop floor level only, while all management positions are held by expatriates, reducing learning opportunities. Moreover, if the labour market for qualified personnel is tight, demand from TNC-affiliates might leave domestic companies without adequate staff. Furthermore, economically weak countries can become economically and politically dependent on large TNC-affiliates. Finally, TNC have been criticised for re-locating environmental harmful production into late-industrialising countries (see Kambhampati, 2004:pp. 135, Hemmer, 2002: pp. 337, Altenburg, 2001, Schätzl, 2000: pp. 198, Dicken, 2003a: pp. 278, Todaro & Smith, 2003: pp. 638, Caves, 1996: pp. 224). More generally, for example Nunnenkamp and Spatz (2003a) do not find empirical evidence for a significant correlation between FDI and economic growth in developing host countries.

National vs. regional impacts

Only some of these impacts are of truly national nature, such as tax revenues or competition effects. Most impacts are instead limited to a regional level. As has been stated in chapter 2.3.2, TNCs concentrate in the most conducive locations in a country, mostly in metropolitan regions that offer significant agglomeration benefits. Consequently, many of the impacts from TNC-affiliates are restricted to these agglomerations. For example, many TNC-affiliates apply a just-in-time sourcing that requires their suppliers to be located within a certain distance. As a result, backward linkages will not affect local firms in remote places. Another example is knowledge spillovers that are

facilitated by proximity (see 2.1.3.1, 2.2.2), therefore benefiting local firms in the vicinity of the spillover source.

Thus, by being part of an agglomeration TNC-affiliates may increase the agglomeration effects by inducing circular-caused cumulative processes (Myrdal, 1957), i.e. the attraction of even more production factors, which encourage further concentration of economic activity leading to spatial disparities in the host country. However, according to the polarization-reversal-hypothesis (Richardson, 1980) these concentration effects tend to decrease over time, as agglomeration costs will finally lead to re-location or new industry locations, first in the hinterland and later in sub-centres within the country, resulting in a more equal distribution of economic activity.

Nevertheless, the presence of TNC-affiliates in late-industrialising countries initially fosters a (simplified) dualistic industrial structure in terms of technological sophistication and market orientation (technologically advanced, foreign-owned, export oriented firms vs. technologically weaker, locally-owned, domestic oriented firms; e.g. Ernst, 2002: 500) as well as dualistic spatial structures (thriving agglomerations vs. backward periphery).

2.4 The potential contribution of TNCs to host regions' system of innovation – deducing working hypothesis

The previous sections state that the main challenge faced by (latecomer) firms in late-industrialising countries is to catch up with their competitors in industrialised countries. The main objective hereby is to develop technological capabilities in order to upgrade technological performance, to develop innovation capabilities and to capture a more generous piece of the value-chain. The development of technological capabilities requires technological learning, which is a time consuming and costly exercise. Important inputs for technological learning are learning opportunities (learning by interacting), the development of absorptive capacity (especially via personnel training) and the utilisation of advanced technology from abroad via channels of technology transfer.

These efforts have to be set within the context of the national, regional or sectoral system of innovation, which strongly influences firm behaviour and opportunities. The SI-approach describes learning and co-operation **opportunities** by evaluating **the stocks** of the system, the quantity and quality of suitable partners, and assesses **the flows** within the system by considering the linkages. Furthermore, it takes **determinants** of firm behaviour into account by looking at incentives and support for learning and innovation in regard to policies, market conditions, available funds, prevailing attitudes and norms, etc.

Within the innovation systems of late-industrialising countries transnational corporations are important actors because they possess several owner specific-advantages vis-à-vis domestic firms, such as sophisticated, modern technologies, advanced organisational and technological capabilities, market access, etc. Moreover, they are embedded in transnational corporate networks that can provide easier access to internationally available technology and knowledge. Hence, TNC-affiliates can have positive effects on the host economy, especially when they are the source of spillovers that enhance technological learning by local firms.

In the following the possible positive and negative impacts of TNC-affiliates on their host's innovation system are summarised. Since an SI consists of components (actors), their relations (links) and attributes (properties of components and links) (chapter 2.2), the impacts are categorised respectively. **Positive** impacts include:

Components (Actors):

- TNC-affiliates improve the SI by 'simply being there'. They are additional actors in the system and consequently additional potential network partners for domestic firms.
- TNC-affiliates tend to bring with them follow-source suppliers, adding new actors to the SI. Mostly, these follow source suppliers 'fill a gap' in the domestic economy, which improves the system.
- There may be spin-offs from TNC-affiliates adding actors to the SI.
- TNC-affiliates can participate in the creation of new organisations, such as industry lobby groups, specialised training facilities etc., which can in turn enhance linkages and/or quality of actors.
- TNCs may set up own training facilities or might donate or sponsor university chairs.

Attributes of actors

- TNCs operate on global markets and must be globally competitive. This requires them to apply the latest technology and management practises. TNC-affiliates bring these methods and technologies (mostly) with them to late-industrialising countries, offering domestic companies access to these technologies via conscious assistance or unintended spillover effects. Therefore, TNC-affiliates offer learning opportunities, which can lead to improved domestic company performance and, consequently, to improved domestic actors within the SI.
- Most TNC-affiliates source locally to a certain degree. If they do not bring in follow source suppliers they rely on locally owned suppliers, which they push and assist to meet their high requirements. Again, this increases the quality of actors within the SI.
- Some TNC-affiliates contribute to the quality of training/ university courses by giving advice on curricula, providing equipment and/or offering job opportunities.
- TNC-affiliates in late-industrialising countries are frequently in a strong political position, because these countries are to a certain degree dependent on TNC- investment. Therefore, they have influence on national politics and may try to improve the framework conditions for learning and innovation.
- TNC-affiliates employ people, who are subject to training on-the-job with its subtle indoctrination of modern organisation and working methods. If these employees move to other employers, they can transfer this knowledge to other companies or, in the least, other companies might benefit from further educated personnel.

Relations (Linkages) and their attributes

- Obviously, most TNC-affiliates have some local linkages, adding to the density of the knowledge and collaboration network in the SI. Moreover, they often organise or motivate supplier clubs, thus creating new linkages between actors of the SI.

- Some TNC-affiliates establish linkages to horizontal partners, esp. to training facilities and research institutions/ university.
- In most late-industrialising countries an SI is still developing rather than already of mature nature – TNC-affiliates with their experience of ‘full blown’ SI can contribute to the development of the SI, i.e. fostering linkages, if they conceive any benefit from doing so.

However, TNC-affiliates might also be **indifferent to** or even have **negative** impacts on the SI. In terms of **components** and **relations** TNCs may exclude themselves from local cooperation networks: With their follow-source suppliers they might simply replicate networks from their home base or solely rely on international networks that exclude local actors. Furthermore, they might exercise pressure on local suppliers or associated companies not to interact autonomously with third parties, but insist on being the interface for every kind of external collaboration, thereby restricting opportunities for interactive learning. Generally, local involvement in networks depends on the degree “commitment” TNC-affiliates show towards the host country. Some TNC-affiliates feel a certain responsibility to interact locally and improve local conditions, while others simply operate in isolation.

When TNCs seize local resources (e.g. human capital) this can have negative impacts on the **attributes** of other actors, as they might limit the development possibilities for local companies due to an absolute lack of these resources. Moreover, prominent TNC-affiliates might distract the attention and care of local policies/ regulations from the need of local companies, even though the latter might be even more important from an endogenous development strategy point of view (e.g. Maier & Tödting, 2002: pp. 192), and for network collaboration as well. Certainly, the degree of potential impacts from TNC-affiliates on the host SI depends strongly on the specific characteristics of the TNC-affiliates (see 2.3.4).

The subsequent analysis will be threefold:

- A Analysis of existing studies and secondary data on the Thai innovation system and its components (chapter 4).
- B Analysis of the quantitative survey data in Thailand, Singapore and Penang. The analysis will concentrate on the possible impact of manufacturing TNC-affiliates on the SI by questioning their suitability as collaboration partners and technology senders. This is achieved by evaluating their technological capabilities, absorptive capacity and collaboration activity vis-à-vis local firms. Additionally, advanced firms will be scrutinised to see if local firms find sophisticated counterparts in this group. Moreover, the analysis will pinpoint key characteristics of advanced and embedded firms and establish major bottlenecks in the innovation system (chapter 5).
- C Analysis of interviews by the author in the hard disk drive and automotive industry, to enquire into the state of technological capabilities, the degree of embeddedness, the mechanisms of product and process developments as well as the perception of bottlenecks in the system (chapter 6).

The key questions leading the analysis in part A, as stated in the introduction, are:

1. What is the current state of the Thai systems of innovation – which strengths and weaknesses can be identified?
2. What level of quality exists among the primary components of the system, namely firms, knowledge-related organisations and government?

In order to answer the questions brought up in the introduction, part B requires further elaboration. In the following, three sets of working hypotheses will be deduced and some further questions for explorative statistics raised.

First, TNCs can be assumed to be superior to locally owned firms, because the status of being a TNC implies that it possesses some owner specific-advantages, has a good resource base, operates successful in the highly competitive world market and has access to knowledge and technology in advanced markets due to its global presence. Hence, TNCs are supposed to have higher capabilities than domestic firms. Therefore, the first set of hypotheses is:

H1: TNC-affiliates are actors with higher capabilities than local firms. Consequently, they are suitable contributors to the upgrading of the host countries' SI.

H1a: TNC-affiliates possess higher TCs than local firms.

H1b: TNC-affiliates have a higher absorptive capacity than local firms.

If these hypotheses find support in the empirical data, it can be stated that TNC-affiliates in Thailand, Penang and Singapore exhibit the necessary pre-conditions for being suitable technology transfer senders and useful collaboration partners for domestic firms. However, it inquires into neither if (or how) TNC-affiliates interact with other actors nor what contents are transferred in these interactions.

Second, late-industrialising economies are typically characterised by an inhomogeneous and dichotomised economy of advanced and backward firms. The first set of hypotheses looks at **all** firms, hence considers whether TNC-affiliates are generally appropriate learning partners for local firms or not. The second set of hypotheses focuses on the group of **advanced firms** (i.e. firms that are either product or process innovators or carry out R&D; for details see chapter 5.3). What is the situation like within this group, can advanced local firms also benefit from advanced TNC-affiliates? Or do the capabilities of advanced local firms' actually exceed those of the advanced TNC-affiliates? It therefore enquires, if TNC-affiliates are sophisticated enough to be suitable transfer and collaboration partners for local firms at different stages of the catching-up process. Hence, the second set of hypotheses is:

H2: Even within the group of advanced firms, TNCs have higher capabilities than local firms.

H2a: Advanced TNC-affiliates possess higher TCs than advanced local firms.

H2b: Advanced TNC-affiliates have a higher absorptive capacity than advanced local firms.

Third, chapter 2.3.4 states that TNC-affiliates are embedded in local and international networks to different degrees. Thereby, strongly embedded firms can foster a SI by transferring internationally available knowledge and technology to the Thai NSI. Again, it is not possible to measure real flows in this section, but to gauge the level of opportunity for these flows to take place. Due to the available information, this analysis will again change the focus group. After having analysed first all and secondly only advanced firms, this hypothesis will take account of **R&D-performing** and **potentially innovating** (i.e. other innovation activities than R&D conducting; see chapter 5.3) firms. Consequently, the third hypothesis is:

H3: R&D performing and potentially innovating TNC-affiliates are suitable technology transfer partners for local firms, since they are strongly embedded in the host economy and have access to foreign/ external technology.

Additionally, there are two further explorative questions, which are of great interest in terms of scientific insight and policy recommendations in respect to key characteristics of beneficial TNC-affiliates:

Q1: What are key characteristics of advanced TNC-affiliates in Thailand?

Q2: What are main determinants of embedded TNC-affiliates?

Q2a: Considering general embeddedness in R&D and innovation networks.

Q2b: Considering the embeddedness in the Thai system of innovation.

The final explorative question relates to external factors of the SI that hinder technological learning and upgrading in firms.

Q3: What are major bottlenecks within the Thai innovations system according to the perception of local and foreign firms?

Part C takes a more detailed, qualitative look at the case study sectors. Questions are:

1. What is the state of technological capabilities in the firms?
2. How strongly are the firms embedded into the local economy in terms of inputs, outputs and external collaborations?
3. To what extent do the firms carry out process and product innovations? And how is the innovation process organised between TNC-affiliates in Thailand and their headquarters abroad?
4. What is the firm's perspective on the human capital base and how are they trying to improve it?

3 Research design: indicators, data and methodology

In order to answer the previously raised questions and to test the stated hypotheses, it is first necessary to lay the foundation for the analysis of the empirical quantitative and qualitative data. First, this chapter gives an overview of available indicators for measuring technological and innovation capabilities and activities. Secondly, it introduces the sampling strategy of the quantitative survey and presents information on the representativeness of the data. This section also contains information on the benchmark studies in Singapore, Penang and Europe. Thirdly, the chapter gives insight into the in-depth interview approach including a custom-tailored matrix on technological capabilities.

3.1 *Measuring systems of innovation and technical change at the firm level*

In order to measure a **NSI**, Niosi et al. (1993: pp. 222) propose that the units (organisations), flows and performance of the system be measured. With regard to the **units**, they suggest taking the number and relative size of firms, universities, government laboratories etc., the ownership and control of these units as well as their regional distribution into account.

In respect to **flows**, the authors distinguish the following: **financial flows** can be measured as the shares of publicly and privately funded R&D at GDP (termed gross domestic expenditure on R&D (GERD) and business enterprise expenditure on R&D (BERD)). **Technology or knowledge flows** are appraised via scientific quotations in patents, analysis of co-citations, publications and patent records, as well as the analysis of input-output statistics (for embodied technology diffusion) (ibid.). Moreover, they take account of **interactions initiating knowledge flows**. These are difficult to quantify and can only be investigated in detailed firm surveys that shed light on co-operation or strategic alliances behaviour. The same is true for the **spread of social innovations** like the use of certain organizational innovations such as Kanban, JIT or TQM-systems¹⁰. Finally, **personal flows** might as well be accounted for in labour market statistics or gathered from firm surveys (see ibid., OECD, 1997b: pp. 7 and 45).

Indicators for the **performance** of the system could include patents granted per expenditure or per researcher (direct) or figures on the international flows of technologically intensive goods, services and payments (indirect) (Niosi et al., 1993: 224). However, these performance indicators cater very much to a narrow understanding of a NSI. For late-industrialising countries especially, a wider set of indicators is appropriate, including, in particular, information on the education system.

The European Innovation Scoreboard is a good example of a framework that elaborates upon a set of indicators, thus offering a means to evaluate NSIs (EU, 2005). It includes indicators related to human resources, knowledge creation, transmission and application as well as finance and output

¹⁰ Kanban: tool for a just-in-time system, maintains an orderly and efficient flow of materials throughout the manufacturing process; JIT: a material requirement planning system for a manufacturing process in which there is little or no manufacturing material inventory; TQM: Total quality management, an management approach to long-term success through customer satisfaction by constant quality improvement (American Society for Quality, 2005).

(see Tab. 3.1, also indicating the data source). Hereby, it draws heavily from firm-level surveys, namely the Community Innovation Survey (CIS). Even though these indicators focus on high-performing countries, some are also available for late-industrialising countries, such as Thailand, and will be presented in chapter 4.

Tab. 3.1: NSI indicators and data source used in the European Innovation Scoreboard 2004

<p>1. Human resources</p> <ul style="list-style-type: none"> ▪ S&E graduates (% of 20 – 29 years age class) / EUROSTAT (Education statistics) ▪ Population with tertiary education (% of 25 – 64 years age class) / EUROSTAT (LFS) ▪ Participation in life-long learning (% of 25 – 64 years age class) / EUROSTAT (LFS) ▪ Employment in medium-high and high-tech manufacturing (% of total workforce)/ EUROSTAT (LFS) ▪ Employment in high-tech services (% of total workforce) / EUROSTAT (LFS) <p>2. Knowledge creation</p> <ul style="list-style-type: none"> ▪ Public R&D expenditures (% of GDP) / EUROSTAT (R&D statistics); OECD ▪ Business expenditures on R&D (% of GDP) / EUROSTAT (R&D statistics); OECD <ul style="list-style-type: none"> ○ EPO high-tech patent applications (per million population) / EUROSTAT ○ USPTO high-tech patents granted (per million population) / EUROSTAT ○ EPO patent applications (per million population) / EUROSTAT ○ USPTO patents granted (per million population) / EUROSTAT <p>3. Transmission and application of knowledge</p> <ul style="list-style-type: none"> ▪ SMEs innovating in-house (% of all SMEs) / EUROSTAT (CIS) ▪ SMEs involved in innovation co-operation (% of all SMEs) / EUROSTAT (CIS) ▪ Innovation expenditures (% of total turnover) / EUROSTAT (CIS) ▪ SMEs using non-technological change (% of all SMEs)/ EUROSTAT (CIS) <p>4. Innovation finance, output and markets</p> <ul style="list-style-type: none"> ▪ Share of high-tech venture capital investment / EVCA ▪ Share of early stage venture capital in GDP / EUROSTAT <ul style="list-style-type: none"> ○ Sales of 'new to market' products (% of total turnover) / EUROSTAT (CIS) ○ Sales of 'new to the firm but not new to the market' products (% of total turnover) / EUROSTAT (CIS) ▪ Internet access / EUROSTAT ▪ ICT expenditures (% of GDP) / EUROSTAT ▪ Share of manufacturing value-added in high-tech sectors / EUROSTAT (SBS)
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S&E: Science and Engineering, EPO: European Patent Office; USPO: U.S: Patent Office, SME: Small and Medium Sized Enterprises, LFS: Labour Force Survey, CIS: Community Innovation Survey; Source: EU, 2005

Moreover, innovation related indicators have been differentiated into input-, throughput- and output indicators (Grupp, 1997: pp. 143, OECD, 2002, OECD, 1997a, Revilla Diez, 2002a: pp. 40). These indicators can, in principle, be applied at the country, as well as the firm level. In the following, indicators pertaining to the **firm level** are presented.

Firstly, due to methodological reasons one must make a distinction between the key terms **R&D** and **other innovation activities**. The leading guide for R&D-surveys, the OECD's Frascati manual (OECD, 2002: 30) defines that "research and experimental development (R&D) comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications". In this case, the term R&D subsumes basic research, applied research and experimental developments (for examples see OECD, 2002: 81). However, it excludes many activities related to innovation which are essential for a firm's innovation performance, such as education and training, acquisition of technology (embodied and disembodied), tooling up and

industrial engineering, industrial design, production start-up and marketing for new and improved products, etc. (ibid.: pp. 30). For surveying these type of innovation-related activities the OECD published the Oslo Manual (OECD, 1997a), which covers technological product and process innovations. These are defined as new or significantly improved products (ibid.: pp. 31; see chapter 2.1.3.1). Above all, the activities covered by the Oslo Manual are of relevance to firms in late-industrialising countries, as these rarely perform clearly articulated R&D (see 2.2.1.2). Moreover, the covered activities are related closely to the existence of technological capabilities (see 2.1.2).

Input indicators measure the resources devoted to the innovation process. Traditionally, the main indicators are the R&D-intensity (R&D-expenditure per sales) and R&D-personnel intensity (R&D-personnel in % of total workforce). Since R&D is only one source of new knowledge it is appropriate to consider license fees and royalties for the acquisition of external technology in addition (Grupp, 1997: 153). Hence, an additionally broad definition of innovation expenditure is used (OECD, 1997a), even though this is difficult for firms to report, given that firms do not keep separate records of this expenditure (Kleinknecht et al., 2002: 114). Moreover, the qualification structure of the R&D-personnel or the workforce can be seen more generally as an input indicator (OECD, 2002; Revilla Diez, 2002a). Nevertheless, input indicators have a significant weakness, because they can be “used more or less efficiently” (Kleinknecht et al., 2002: 110). For this reason indicators capable of measuring further steps in the innovation process must complement them.

Throughput indicators are the result of research activities that have not yet been developed into marketable products. The most important indicator is the number of patents, either in relation to the R&D-personnel or total employees. Nevertheless, this indicator clearly misses a number of innovations, as some innovations are simply not patentable or firms are reluctant to patent innovations due to costs, the requirement of disclosure, the limited life-time of the product or the perceived time-lead over competitors (e.g. Kleinknecht et al., 2002, Giese & Stoutz, 1998). Further throughput indicators are e.g. prototypes, pilot lines or the commercialisation of new knowledge via licences (Revilla Diez, 2002a: 43).

The final set of indicators relates to the primary objective of the innovation process, namely the development of new, marketable products or processes. Since it is difficult to measure the true innovativeness of new products (e.g. Revilla Diez, 2002a: 44), these **output indicators** are mostly related to the number of newly introduced products or processes within a certain period of time (Grupp, 1997: pp. 195, OECD, 1997a). A problem with such a tally of innovations lies in the complex character of many products, which can consist of several new components that may have been developed in collaboration with suppliers (Revilla Diez, 2002a: 44). Moreover, a simple count of innovations ignores how substantial each single innovation is. A product undergoing minor improvement will be counted at the same intensity as a path-breaking new invention. Hence, the contribution of new products/ processes to total turnover/ production is often required to alleviate these concerns (Grupp, 1997: pp. 195, OECD, 1997a). Finally, this kind of information is gathered in questionnaire-based surveys. Firms have the capacity to give biased answers about their

innovativeness. To avoid this bias, it is possible to analyse new product announcements in trade and technical journals (Kleinknecht et al., 2002). However, similar concerns exist regarding the validity of this indicator (ibid.).

In chapter 5, a set of input, throughput and output indicators will be analysed. Moreover, some indicators of technological capabilities and activities are used, which are either self-explanatory or will be defined prior to the analysis. Beforehand, however, the next section will take account of data gathering methodology.

3.2 Data gathering process

Two different approaches to data gathering were used in this thesis. First, quantitative survey data from both the first and second R&D/ Innovation Surveys in Thailand is used. Chapter 3.2.1 gives an overview of the methodology and sample in both Thailand and the benchmarking regions. Moreover, it provides a brief critique of the methodology. Secondly, qualitative data was collected in 20 in-depth firm interviews in the automotive and hard disk drive industry. Background information is presented in chapter 3.2.2.

3.2.1 Quantitative data: questionnaire based survey

The subsequent sections will provide information on the questionnaire, the sampling procedure, the response rates, and the representativeness of the sample in Thailand and the benchmarking regions. Moreover, some questions will be contemplated regarding possible problems with the quantitative survey methodology.

3.2.1.1 Thailand R&D and innovation survey

The presented work is based on two unique and original datasets that were retrieved in the first (2000) and second (2002) R&D/ Innovation Surveys. These were commissioned by the Thailand National Science and Technology Development Agency (NSTDA), and conducted by the Brooker Group plc.

The first survey concentrated on manufacturing companies, whereas the second survey included service companies as well. The questionnaire (see Appendix A3) is based on definitions from OECD's Oslo and Frascati manuals (OECD, 2002, OECD, 1997a), taking into account previous innovation surveys, such as the European Regional Innovation Survey (ERIS, see Fritsch et al., 1998, Sternberg, 2000), the Penang State Innovation Survey (PSIS) (Stracke, 2003) and the Singapore National Innovation Survey (SNIS) (Kiese, 2004). The first survey was conducted from January to April 2001 (Virasa & Brimble, 2001), the second from October 2002 until February 2003 (Brimble, 2002).

Both the 2000 and 2002 questionnaires are comprised of the following parts:

- Section A: General information on companies including type of products, year of establishment, number of employees, etc.
- Section B: R&D activities including types of activities, expenditure and personnel, etc.
- Section C: Innovation activities other than R&D

- Section D: External collaboration for R&D and innovation
- Section E: R&D and innovation environment in Thailand

The 2002 questionnaire was, however, slightly modified with some questions being erased (Brooker Group, 2001, Brooker Group, 2003). Both questionnaires were subject to pre-tests with a sub-sample (ibid.).

Sampling Strategy

For the 1st RD/ Innovation Survey the ‘Business On-line Database’¹¹ was used, which includes comprehensive information on around 35,000 manufacturing establishments registered with the Commercial Registration Department at the Ministry of Commerce (Brooker Group, 2001).

Thereby, the survey concentrated on medium- and large-sized manufacturing firms, with a minimum annual revenue of 12 million Bhat in 1999 (Brooker Group, 2001: 2-2)¹².

From a total sampling frame of 13,415 companies, 2,166 firms were selected (16.2%) using a three-stage sampling procedure consisting of stratified random sampling, probability proportional to size (PPS) and systematic random sampling within each industrial sector in each stratum (Brooker Group, 2001: 1-2). The three strata were created according to firm size (measured in 1999 turnover). Then, for each sector (Tab. 3.2), all firms from the first stratum (200 largest companies), 20% from the second stratum (next 2000 medium to large companies) and 3.3% from the third stratum (remaining 11,215 small firms) were selected by applying a systematic random sampling technique.

Tab. 3.2: Manufacturing Sectors by two-digit Thai Standard Industry Classification

31	Manufacture of food, beverages and tobacco
32	Manufacture of textiles, wearing apparel, leather and leather products
33	Manufacture of wood and wood products, including furniture
34	Manufacture of paper and paper products, printing and publishing
35	Manufacture of chemicals and chemical products, petroleum, coal, rubber and plastic products
36	Manufacture of non-metallic mineral products
37	Basic metal industries
38	Manufacture of fabricated metal products, machinery and equipment
39	Jewellery, diamond, gem and ornaments

Source: Brooker Group, 2003: 3; for TSIC see Department of Labour, 1972)

Of the 2,166 firms sampled, a total of 1,019 completed questionnaires were received representing a response rate of 47%. Unfortunately, the Brooker Group presents no information on the industry-specific response rate.

For the 2nd RD/ Innovation Survey the ‘Business On-Line Database’ was once again queried, this time containing information from roughly 50,000 establishments (Brooker Group, 2003).

The sampling methodology used in the first survey was replicated in order to ensure consistency. The sampling frame consists of 14,870 manufacturing companies, including the 1,019 manufacturing firms interviewed during the first survey.

¹¹ An information service by the Business Online Company Limited, Thailand, under the consent of Department of Commercial Registration the Ministry of Commerce.

¹² The boundary of 12 million Bhat was retrieved from a SME study by the Department of Industrial Promotion, that found that small firms had average annual sales of 12 million Bhat in 1999 (Brooker Group, 2001: 2-2).

Again, this group was divided into three strata according to revenue (2001), with the first stratum including the top 200 firms, the second stratum the following 2,000 firms and the third stratum the remaining firms. The same probabilities for selection were also assigned: first stratum 100%, second stratum 25% and third stratum 3.3% (Brooker Group, 2003: pp.3).

From the sample frame, 3,945 firms (26.5%) were selected. Of these, 1,449 firms responded, equalling a response rate of 36.7%. Tab. 3.3 presents the industry-specific response rates of the second survey (manufacturing only). Even the lowest response rates of wood products (31.1%) are satisfying upon comparison to benchmark surveys in Europe, Singapore and Penang (see Tab. 3.7).

Tab. 3.3: Industry-specific sampling frame and response rate for the 2nd survey (manufacturing)

Sector		Sampling Frame	Approached	Received	Response Rate %
31	Food, beverages and tobacco	1,950	500	176	35.20
32	Textiles, leather, leather products	2,511	676	221	32.69
33	Wood, wood products	926	193	60	31.09
34	Paper, printing, publishing	1,312	212	85	40.09
35	Chemicals, petroleum, coal, rubber, plastic	2,689	835	317	37.96
36	Non-metallic, glass, ceramic, clay	625	134	46	34.33
37	Basic metal	603	174	67	38.51
38	Fabricated metal products, machinery, equipment	3,882	1,137	446	39.23
39	Other manufacturing	372	84	31	36.90
Total		14,870	3,945	1,449	36.73

Source: Brooker Group, 2003: pp. 4

It is important to point out that the two surveys do not form a consistent time series, but rather two snapshots. The surveys differ in terms of sample size and structure. Despite these limitations, chapter 5 will make cautious comparisons between the two surveys, comparing patterns rather than absolute figures.

Representativeness

In order to evaluate the quality of the sample, data on the population is compulsory. The National Statistics Office of Thailand conducted its latest industrial census in 1997. More current information is available in the manufacturing industry surveys from 2000 and 2001, which are based on samples and only include enterprises with ten employees or more (see National Statistical Office, 2004).

For the 1st R&D/ Innovation Survey, Schiller (2003: 47), based on the R&D/innovation survey data and the manufacturing survey from 2000, asserts that the sample is a good representation of the population. While Schiller based his assertion on Pearson's product-moment correlation coefficient, an application of the more appropriate Pearson's Chi-Square test for homogeneity results in the rejection of H_0 and therefore does not support the finding that both distributions are founded in the same population. However, this is also true for the comparison between the 1997 census and the 2000 manufacturing survey. Furthermore, the comparison between the manufacturing survey 2001 and the R&D/innovation survey data 2002 rejects the nil hypothesis.

Tab. 3.4: Structure of the sample and the population for the 1st R&D/ Innovation Survey¹³

TSIC-2		Number of establishments			Number of employees		
		Pop.	Sample	Sample/ Pop. (%)	Pop.	Sample	Sample/ Pop. (%)
31	Food, beverages, tobacco	3,470	146	4.21	402,760	94,060	23.4
32	Textiles, leather products	3,728	140	3.76	489,858	97,789	20.0
33	Wood, wood products	865	38	4.39	56,967	13,935	24.5
34	Paper, printing, publishing	1,256	55	4.38	84,759	11,753	13.9
35	Chemicals, rubber, plastic	2,661	235	8.83	259,202	67,000	25.8
36	Non-metallic, glass, clay	1,825	35	1.92	111,350	21,662	19.5
37	Basic metal	465	19	4.09	38,758	12,317	31.8
38	Metal products, machinery, equip.	4,942	327	6.62	549,847	247,608	45.0
39	Other manufacturing	1,639	24	1.46	177,799	5,810	3.3

Source: R&D/ Innovation Survey 2000; National Statistical Office & Office of the Prime Minister, 2000, own calculations

Tab. 3.4 and 3.5 depict the size of the population, the sample and the relation between sample and population for the first and second survey. Additionally, the share of employees in the R&D/innovation surveys is compared with that in the manufacturing surveys.

In terms of number of establishments, sectors 31-34 are fairly equally represented in both surveys. Sector 35 and 38 are over- whereas sector 36 and 39 are underrepresented. TSIC 37 is overrepresented only in 2002. The number of employees represented by the sample is much higher than for the number of establishments. The sampling procedure is the primary cause for this, as it favours large firms (see below). As with the number of establishments, the sample displays an uneven composition. Both surveys include a similar share of employees in sectors 31-33 and 35. Sector 34 (2002), 37 and 38 are over-, while sector 34 (2000), 36 (2002) and especially 39 are underrepresented.

The overrepresentation of some sectors is likely a result of the sampling procedure, since turnover was a criterion for both the strata and the probability of selection. Sectors 35 and 38 are among those with the highest sales per establishment, whereas firms in sectors 36 and 39 show lower sales per establishment (based on National Statistical Office & Office of the Prime Minister, 2001; own calculations). This assumption is supported by the comparison between the size of the sample frame and the population for the second survey (cf. Tab. 3.3 and Tab. 3.5).

Moreover, the chemicals and machinery/ equipment industries can be considered more innovation-affined than the primarily raw material-oriented sectors of non-metallic, glass, clay, and others

¹³ Figures for the population of manufacturing firms were retrieved from the Manufacturing Survey 2000 (National Statistical Office & Office of the Prime Minister, 2000) which uses the 3rd revision of the ISIC-classification (see UN Statistics Division, 2004). Since the R&D/Innovation survey classifies according to the TSIC 1972 (Department of Labour, 1972), which is based on the ISIC Revision 2 (see UN Statistics Division, 2004), the classes can be only approximately matched.

(including e.g. jewellery, gem etc.). Hence, the response-propensity for an R&D/ innovation survey can be supposed to be higher in the first group.

Tab. 3.5: Structure of the sample and the population for the 2nd R&D/ Innovation Survey¹⁴

TSIC-2		Number of establishments			Number of employees		
		Pop.	Sample	Sample/ Pop. (%)	Pop.	Sample	Sample/ Pop. (%)
31	Food, beverages, tobacco	3,300	176	5.33	404,247	99,843	24.7
32	Textiles, leather products	3,695	221	5.98	485,536	134,258	27.7
33	Wood, wood products	797	60	7.53	52,482	17,272	32.9
34	Paper, printing, publishing	1,283	85	6.63	44,543	25,473	57.2
35	Chemicals, rubber, plastic	2,635	317	12.03	276,239	92,263	33.4
36	Non-metallic, glass, clay	1,802	46	2.55	130,524	18,594	14.2
37	Basic metal	476	67	14.08	38,591	17,730	45.9
38	Metal products, machinery, equip.	4,932	446	9.04	669,718	266,730	39.8
39	Other manufacturing	1,687	31	1.84	164,610	14,549	8.8

Source: R&D/ Innovation Survey 2002; National Statistical Office & Office of the Prime Minister, 2001, own calculations

Tab. 3.6: Number of establishments by size: manufacturing 2002 sample and population

Size (employees)	Population	Sample	Relation Sample to Population (%)
1-4	33,814	1	0.00
5-9	21,177	7	0.03
10-19	15,209	15	0.10
20-49	12,075	133	1.10
50-99	4,548	180	3.96
100-299	4,397	505	11.49
300-499	1,156	198	17.13
500-999	793	168	21.19
>1,000	494	166	33.60

based on Year Book of Labour Statistics 2000 (Alpha Research, 2003:162)

In terms of firm size, the distribution of the sample reveals a strong bias towards larger companies (see Tab. 3.6 for the 2002 survey). This is the result of a sampling procedure which applies a threshold of 12 million Bhat annual revenue and designates a higher probability to larger companies, causing the R&D/Innovation Survey to be aimed primarily at medium to large-sized companies.

In conclusion, it is not possible to get a current and comprehensive picture of the population, because the latest industrial census is outdated (being conducted in the crisis year of 1997) and the current manufacturing survey is based on a restricted sample used for estimations about the population. However, comparing the sectoral distribution of 'firms with foreign investment'

¹⁴ see 13

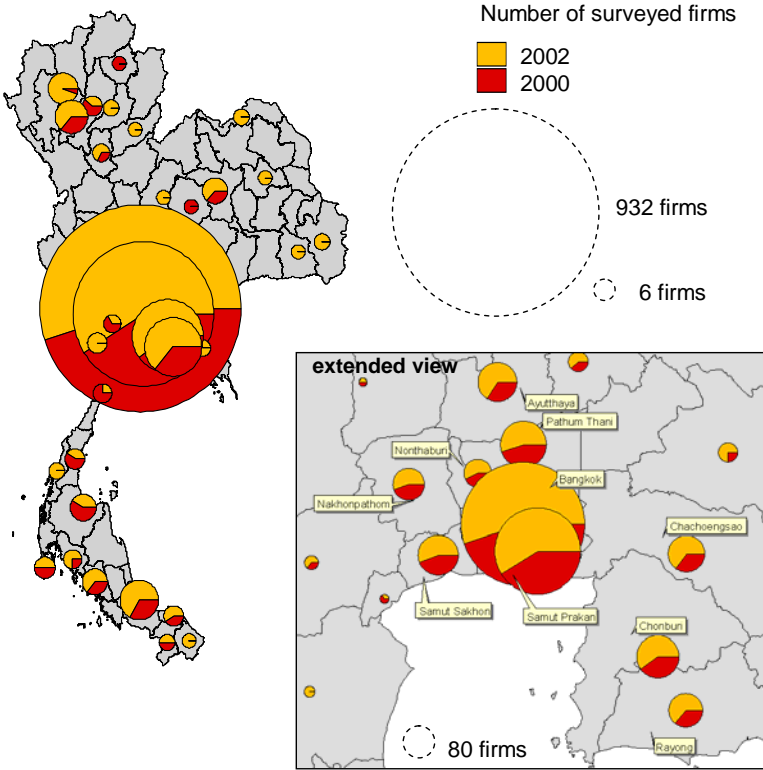
according to the manufacturing survey 2001 with the distribution in TNCs¹⁵ in the Thailand R&D/ Innovation Survey 2002 (for more details see 5.1) reveals a suspicious similarity (see table 3.7), even though the Chi-Square test of homogeneity rejects H_0 . Consequently, the sample is not weighted, because there is no reliable, current information about the population, and the sectoral composition of TNCs seems to be sufficiently similar to the estimated population to conduct a first analysis.

Tab. 3.7: Sectoral Distribution of foreign firms in the manufacturing survey 2001 and the Thailand R&D/Innovation Survey 2002

TSIC-2		Manufacturing Survey 2001	R&D/Innovation Survey 2002
31	Food, beverages, tobacco	8.3	7.6
32	Textiles, leather products	12.8	10.2
33	Wood, wood products	1.2	1.0
34	Paper, printing, publishing	4.4	3.0
35	Chemicals, rubber, plastic	22.5	22.9
36	Non-metallic, glass, clay	3.6	1.8
37	Basic metal	3.3	5.8
38	Metal products, machinery, equip.	35.3	45.4
39	Other manufacturing	8.6	2.2

Source: R&D/ Innovation Survey 2002; National Statistical Office & Office of the Prime Minister, 2001, own calculations

Figure 3.1: Regional distribution of the surveyed companies of the first and second R&D/ Innovation survey



Source: R&D/ Innovation Survey 2000/2002, own graphic

¹⁵ Please note the different definition, since in this work TNCs are defined as firms with at least 30% foreign ownership (see 5.1).

Figure 3.1 displays the regional distribution of the firms surveyed in the first and second R&D/Innovation survey in Thailand. It exhibits, and quite impressively, a very strong concentration in the Bangkok Metropolitan Region (BMR consists of the provinces of Bangkok, Samut Prakan, Samut Sakhon, Nonthaburi, Phatum Thani and Nakhonpathom), Ayutthaya and the Eastern Seaboard Region (ESR encompassing the provinces Rayong, Chonburi and Chachoengsao). In total, these core regions account for 91% (2000) and 88% (2002) of the sample. This mirrors the strong concentration of Thailand's economic activity in Bangkok (see chapter 4.1.2). However, compared to the population of manufacturing establishments, one can recognise a bias in the sample towards this core region. Based on the labour statistics 2000, only 58% (Alpha Research, 2003) of all establishments are located in these provinces. According to the manufacturing census 2001 (National Statistical Office & Office of the Prime Minister, 2001), the BMR accounts for 62% of all manufacturing establishments. No separate data for ESR and Ayutthaya are available from this source.

Presumably, this bias is in part due to the sampling procedure's tendency to favour large enterprises. Since this thesis focuses on TNC-affiliates, which are strongly concentrated in the core region (see chapter 4.1.3.2), the bias does not need to be corrected for.

3.2.1.2 Benchmarking surveys

In order to benchmark the results of the 1st and 2nd Thailand R&D/Innovation Survey the subsequent sections will make use of original data from the European Regional Innovation Survey (ERIS), the Singapore National Innovation Survey (SNIS) and the Penang State Innovation Survey (PSIS). This section will briefly reflect upon methods of data gathering in the benchmarking studies.

a) European Regional Innovation Survey (ERIS)

A research consortia from the University of Hanover, Cologne, Freiberg and from the Fraunhofer Institute for Systems and Innovation Research, Karlsruhe conducted the ERIS project in two phases from 1995-1997 and 1997-1999, surveying manufacturing and service companies as well as research institutes in eleven European regions (Sternberg, 2000). A total of more than 8,600 questionnaires were gathered, with around 4,200 from manufacturing, 2,500 from service companies and 1,900 from research institutions. The selected case study regions range from agglomerations such as Barcelona, Vienna and Stockholm to peripheral regions such as South Wales and Saxony (ibid.). For more information on the project's key findings, see special issues of *Raumforschung und Raumordnung* (e.g. Fritsch et al., 1998) and *European Planning Studies* (e.g. Sternberg, 2000) as well as a number of monographs (e.g. Fischer et al., 2001, Revilla Diez, 2002a).

b) Singapore National Innovation Survey (SNIS)

In cooperation with the Economic Development Board (EDB) and the Centre for Management of Innovation and Technopreneurship at the National University of Singapore, the University of Hanover conducted the SNIS in 1999/2000. The SNIS concentrated on the four key industries for

innovation in Singapore, namely the electronics, chemicals, engineering and life sciences sectors, which in 1999 account for 67.8% of all manufacturing companies, 83.2% of all manufacturing employees and 93.1% of all manufacturing production (Kiese, 2004). The sample frame contained 1,869 companies (70.1% of the companies in the named sectors according to the industry census), from which 374 utilisable questionnaires were returned, achieving a response rate of 20% (ibid.). While the sample displays a bias towards larger companies (measured in number of employees), it offers an appropriate representation of the population in terms of the sectoral structure (ibid.).

c) Penang State Innovation Survey (PSIS)

In 2000 the University of Hanover, in cooperation with the Socio-Economic and Environmental Research Institute (SERI) and the State Executive Councillor for Economic Planning, Education, and Human Resource Development, carried out the PSIS. On the basis of a non-official database provided by the Penang Development Corporation, 921 questionnaires were sent out to manufacturing companies, of which 192 usable questionnaires could be reclaimed (equalling a response rate of 20.2%) (Stracke, 2003). The sample shows a structural bias towards the chemical, electrical engineering and fabricated metal products sectors. Due to insufficient statistics for the distribution of establishments in terms of size, no judgement of representativeness could be reached (ibid.).

Tab. 3.8 gives an overview of the case study regions, their launch-years, the number of responses as well as the response rates (only for manufacturing which is the focus of this thesis), while Tab. 3.9 displays the sectoral structure of the considered surveys.

Tab. 3.8: Innovation Surveys in Europe (ERIS) and South East Asia (manufacturing only)

Region	Country	Year (1)	Realised Sample	Response Rate
Baden	Germany	1995	430	15.8%
Hannover-Brunswick-Göttingen	Germany	1995	372	20.6%
Saxony	Germany	1995	1,004	26.7%
Alsace	France	1997	263	15.0%
Barcelona	Spain	1997	395	15.3%
Gironde	France	1997	101	12.7%
Slovenia	Slovenia	1997	416	31.2%
South Holland	Netherlands	1997	261	13.7%
South Wales	UK	1997	280	17.6%
Stockholm	Sweden	1997	451	24.0%
Vienna	Austria	1997	204	19.9%
Total ERIS			4,177	19.7%
Singapore	Singapore	1999	373	20.0%
Penang	Malaysia	2000	191	20.7%
Thailand (1)	Thailand	2000	1,019	47.0%
Thailand (2)	Thailand	2002	1,449	36.7%

(1) **launch**; Source: ERIS database, EDB/NUS-CMIT National Innovation Survey, Penang State Innovation Survey; Thailand R&D/ Innovation Survey 2000/ 2002

Tab. 3.9: Sectoral Structure (in %) of the comparative surveys (grouped according to TSIC 2-digit classes)

	TSIC	TIS (1)	TIS (2)	PSIS	SNIS	ERIS
31	Food, Beverage, Tobacco	14.3	12.1	9.9	0.0	7.3
32	Textiles, leather, leather products	13.7	15.3	1.6	0.0	6.0
33	Wood, wood products	3.7	4.1	1.6	0.0	3.8
34	Paper, printing, publishing	5.4	5.9	6.3	0.0	9.1
35	Chemicals, petroleum, coal, rubber, plastic	23.1	21.9	23.4	20.8	11.2
36	Non-metallic, glass, ceramic, clay	3.4	3.2	0.5	5.9	5.0
37	Basic metal	1.9	4.6	5.7	1.4	3.4
38	Fab. metal products, machinery, equipment	32.1	30.8	47.4	71.7	49.0
39	Other manufacturing	2.4	2.1	3.7	0.3	5.2
	Total (n)	1,019	1,449	192	371	4,079

TIS= Thailand Innovation Survey; PSIS= Penang State Innovation Survey; SNIS = Singapore National Innovation Survey; ERIS = European Regional Innovation Survey

NB Sectors of PSIS, SNIS and ERIS had to be aggregated for comparison. Furthermore, ERIS and SNIS data is classified according to ISIC Rev. 3, while PSIS and TIS are classified according to ISISC Rev. 2. (UN Statistics Division, 2004).

3.2.1.3 Critique of the methodology

Written questionnaires offer the advantage of allowing one to survey large samples. Furthermore, they preserve the anonymity of respondents and reduce time pressures for answering the questionnaire (see e.g. Wessel, 1996: pp. 104). Nevertheless, they also contain some inherent disadvantages. First of all, written standardised questionnaires pose a clear restriction to the amount of information gathered. Individual or sectoral particularities cannot be accounted for (ibid.). Secondly, there is the question **of reliability of the data**: written surveys rely on self-assessment and, consequently, conscious or unconscious manipulation and mistakes. Even though all surveyed firms were assured anonymity, there might be a tendency to present one's firm in a positive light. Moreover, it may lead to strategic behaviour: for example knowledge that the survey is commissioned by the national S&T development agency could cause some firms to cast public policy towards innovation in a darker light, hoping that a negative assessment would trigger increased benefits. In addition, a single person usually answers questionnaires. Depending on his or her position within the enterprise, their insight into different functional areas may be limited. Additionally, even the most carefully designed and pre-tested questionnaires can often sound 'too scientific' for business people, leading to misunderstandings.

Thirdly, many **terms are not or cannot be clearly defined** within the questionnaire. Some terms might be understood differently according to the respondent's background. For example, the terms applied research and experimental development are comprehensively explained in the questionnaire. Nevertheless, the head of an R&D-department interpret them differently than the General Manager. Other terms are ambivalent: What is the difference between intense and very intense cooperation? Again, respondents with different experience, cultural or professional backgrounds may possess different 'mental yardsticks'. Furthermore, some categories are formulated in a way that can include many different things, e.g. acquisition of external technology might relate to the purchasing of a generator, to custom-tailored production lines, blueprints, licenses as well as patents. Such broad categories reveal only limited clues to highly differentiated processes and capabilities (cf. ibid.).

A second set of problems relates to the transfer of a methodology developed for advanced economies, such as OECD's Frascati and Oslo Manual (OECD, 2002, OECD, 1997a), the European Union's Community Innovation Survey (CIS) or the European Regional Innovation Survey (ERIS), to late-industrialising countries.

Innovation in late-industrialising countries is predominantly taking place incrementally within the production process rather than in formally assigned R&D-departments. This informality and individuality of the innovation process causes difficulty when applying a set of standardised questions to it. Furthermore, these activities are not easy, even for the firm itself, to account for. While R&D-expenditure is treated separately, there is most often no clearly expressed 'innovation-related activity budget', hence many firms simply do not know what they spend on innovation activities (Kleinknecht et al., 2002:114). This is also true for organisational change, which is independent from product and process innovations, but prepares the ground for these innovations and should, as a consequence, be considered (see Ellis & Polcuch, 2005).

Moreover, most questionnaires emphasise the output of the innovation process (e.g. in the Penang and Singapore questionnaire, only firms that successfully adopted a new process or introduced a new product were asked about their innovation process). However, many firms in late-industrialising countries carry out innovation activities other than R&D without achieving an output (ibid.). Since capability building and technological learning are essential in these countries, surveys should take these processes into account despite their outcome. For example, the R&D/Innovation Survey in Thailand distinguishes explicitly between the performance of R&D, other innovation activities and the output of these activities. Its results reveal a considerable amount of firms performing innovation activities without creating an output. Hence, the Thailand questionnaire is a first attempt towards allowing for these activities. Unfortunately, the questionnaire has – at least from a regional science point of view – the drawback of not including questions regarding the locations of collaboration partners.

All these considerations show the need to supplement written questionnaires with personal interviews in order to first, double-check answers and to identify possible inconsistencies and second, gain further insights into complex processes. Consequently, the presented research has pursued both methodologies (cf. Wessel, 1996. pp. 103, Schätzl, 2000: pp. 40). The subsequent section delivers basic information on the qualitative interviews.

3.2.2 Qualitative data: in-depth interviews

In addition to the questionnaire based data, the author conducted semi-structured interviews with General Managers, R&D and Production Managers of ten automotive and eleven hard disk drive (HDD) companies in September and October 2003.

These sectors were chosen because they account for a significant share of GDP and exports (see 4.1.2). Moreover, they are among the largest recipients of FDI (see 4.1.4.2) and are dominated by TNCs. They are highly competitive on a global scale and are industries targeted by the Thai government (Office of the Prime Minister Thailand, 2004). For example Thailand's government promotes the country as the "Detroit of Asia" (e.g. Prais, 2004b), because it has the highest

concentration of vehicle manufacturers in South-East Asia, with ten major car companies operating local assembly plants (Brooker Group, 2002b, Bangkok Post, 2003). In the HDD-industry, four out of seven global assemblers operate in Thailand, which makes the country the second largest HDD-producer in the world (Wiriyapong, 2003a, b; for more information on both industries refer to chapter 6.1.1 and 6.2.1.). Consequently, both sectors are of particular interest in regards to the influence of TNCs on the Thai innovation system.

Appendix A4 gives an overview of the interviews that were conducted, while appendix A5 and A6 present the semi-structured interview guides for each industry. The guides include general information on the company including the location of suppliers and customers, the self-assessment of technological capabilities and external collaborations. The self-assessment of technological capabilities was implemented using a modified Bell and Pavitt-type (1995) framework (see 2.1.2), which has been designed specifically for the project by Dr. Nitin Afzulpurkar of the Industrial Systems Engineering Program at the School of Advanced Technologies at the Asian Institute of Technology (see Tab. 3.10). The framework tries to simplify the identification of capabilities for the interviewees by using industry-compliant keywords in the fields of investment, manufacturing (process, product and industrial engineering), innovation and linkages.

The interviews in the HDD-industry were conducted together with Dr. Peter Brimble of Asia Policy Research and Dr. Nitin Afzulpurkar of the Asian Institute of Technology. This team was commissioned by NSTDA to conduct an HDD-cluster survey. As a first step in the research, all key actors within the HDD-cluster were identified. Afterwards, most of the known actors were approached with support from the Thailand division of the International Disk Drive Equipment and Materials Association (IDEMA), an industry interest group, in order to arrange interviews. During the interviews additional actors were identified and, subsequently, asked to meet with the research team. Finally, eleven companies and several surrounding actors agreed to take part in the survey.

The interviews in the automotive industry were arranged by the author with support of the Science, Technology and Innovation Policy Research Department at NSTDA. Based on information from the 1st and 2nd Thailand R&D/Innovation Survey, several companies in the automotive industry were chosen and then contacted by phone and fax, including a letter of reference from the vice-president of NSTDA, Dr. Chatri Sripaipan (see Appendix A7). Ten companies and a few surrounding actors agreed to interview appointments. On several occasions Preeda Youngsuksathaporn and Sittirat Tapahudee of NSTDA supported the author.

Additionally, the author took part in a number of interviews with the frozen seafood industry, which were conducted by NSTDA staff in order to examine this cluster. The cooperation partners offered the author an opportunity to pre-test the semi-structured interview guide during these interviews. Accordingly, the findings of these interviews are not part of the presented thesis.

All interviews took about one hour. The interviewers took notes during the interview, and most interviews were followed by a guided tour through the plant, which offered the opportunity to enquire further into certain aspects and to enhance the understanding of the particular production process.

Critique of the methodology

Similar to the problems encountered in written surveys (see 3.2.1.3) interviews might suffer from a lack of reliable data. Interviewees might give consciously or unconsciously ‘wrong’ or biased answers. Additionally, interviewees might misunderstand questions, especially since all interviews were conducted not in the mother tongue of the interviewees, but in English. On the other hand, one benefit of interviewing is precisely this opportunity to repeat and explain questions, or to ask additional ones. Still the ad-hoc nature of the answers given might cause the interviewee to forget details. However, all interviewees were prepared for the interviews with a letter outlining the key aspects of the interview (e.g. see Annex A7).

Basically, the presented approach treats data from interviews as a resource, i.e. the data is supposed to reflect the interviewees’ reality, and not as a topic, i.e. reflecting a reality that is jointly constructed by the interviewee and the interviewer (see Rapley, 2004: 16). Consequently, the gathered data is treated as fact. This assertion is based on the objective of the interviews, which was to retrieve relatively easy to communicate, factual information, such as main customers and suppliers and their location, descriptions of collaboration processes etc. Therefore, an individual’s emotions, attitudes, behaviour, etc are intended to be of minimal influence on this information. However, the behaviour and manner with which an interview is conducted by the interviewer can also influence how the interviewee formulates answers.

It is the strength of this method to have gathered much in-depth information about collaborations, which are additionally illuminated with some exemplary cases and anecdotal evidence. Consequently, the interplay between quantitative and qualitative information offers the greatest balance between information and data reliability.

Tab. 3.10: Technological Capabilities – a unified framework for the firm interviews

	Investment	Manufacturing			Innovation	Linkages
		Process Engineering	Product Engineering	Industrial Engineering		
Basic	<ul style="list-style-type: none"> • Feasibility Studies • Site selection • Project preparation 	<ul style="list-style-type: none"> • Scheduling • Maintenance • Quality management 	<ul style="list-style-type: none"> • Understanding basic product design • Adapting minor product changes 	<ul style="list-style-type: none"> • Optimization based scheduling • Basic skill upgrading programs 	<ul style="list-style-type: none"> • Process improvement • Local parts development 	<ul style="list-style-type: none"> • Local supplier base development • Subcontracting to technological service providers
Inter-mediate	<ul style="list-style-type: none"> • Technology selection • Contract negotiation • Technology transfer agreements • Recruitment and initial training project execution 	<ul style="list-style-type: none"> • Process optimization • Process adaptation for product variations • Introduction of TQM/Kanban techniques 	<ul style="list-style-type: none"> • Technology transfer for new products 	<ul style="list-style-type: none"> • Productivity analysis • Benchmarking • Advanced inventory control (JIT etc) • Advanced skill development • Logistics management • Supply chain management 	<ul style="list-style-type: none"> • Product support improvement (packaging, testing) • R&D transfer • New process design 	<ul style="list-style-type: none"> • Process/product upgrading in collaboration with supplies and R&D institutes • Reverse system engineering in collaboration with external partners • Industry networking and collaboration for re-competitive development
Advanced	<ul style="list-style-type: none"> • Organization management using ISO and BS standards • Ability to develop own turn-key projects • Export of project know-how. 	<ul style="list-style-type: none"> • Implementation of MRP ERP systems • Process standardization using ISO and BS standards 	<ul style="list-style-type: none"> • Tracking global product changes • New product design 	<ul style="list-style-type: none"> • Long term HR development programs • Supply chain development (cluster based) 	<ul style="list-style-type: none"> • New product innovation • Organization set up for innovation 	<ul style="list-style-type: none"> • Long term linking with R&D institutions and universities • Licensing new technology to partners and suppliers • Strategic alliances with academic institutes and R&D agencies to open new product markets and services

Source: Elaborated for the HDD- cluster research project by Dr. N. Afzulpurkar, Industrial Systems Engineering Program at the School of Advanced Technologies, Asian Institute of Technology, Bangkok, Thailand

ISO International Standard Organisation
 BS British Standard
 TQM Total Quality Management

MRP Material Requirements Planning
 ERP Enterprise Resource Planning
 JIT Just in time

4 Development and the state of the Thai system of innovation

The purpose of this chapter is to provide a brief overview of the Thai NSI. Since the NSI-concept is based on evolutionary economics, both path dependency and history matter. Accordingly, it seems necessary to provide a brief summary of economic development in Thailand (4.1), with an emphasis on exports and FDI. Moreover, sectoral and regional destinations of FDI are considered and a first assessment of the impact of FDI – based on a literature review – is made. Additionally, policies concerning FDI are taken into account. Chapter 4.2 contemplates briefly the quality of the three main components of the Thai NSI, namely firms, knowledge-related organisations and government, in order to assess the current state of the NSI.

4.1 *The Thai economy and FDI: development, structure, impacts, and policies*

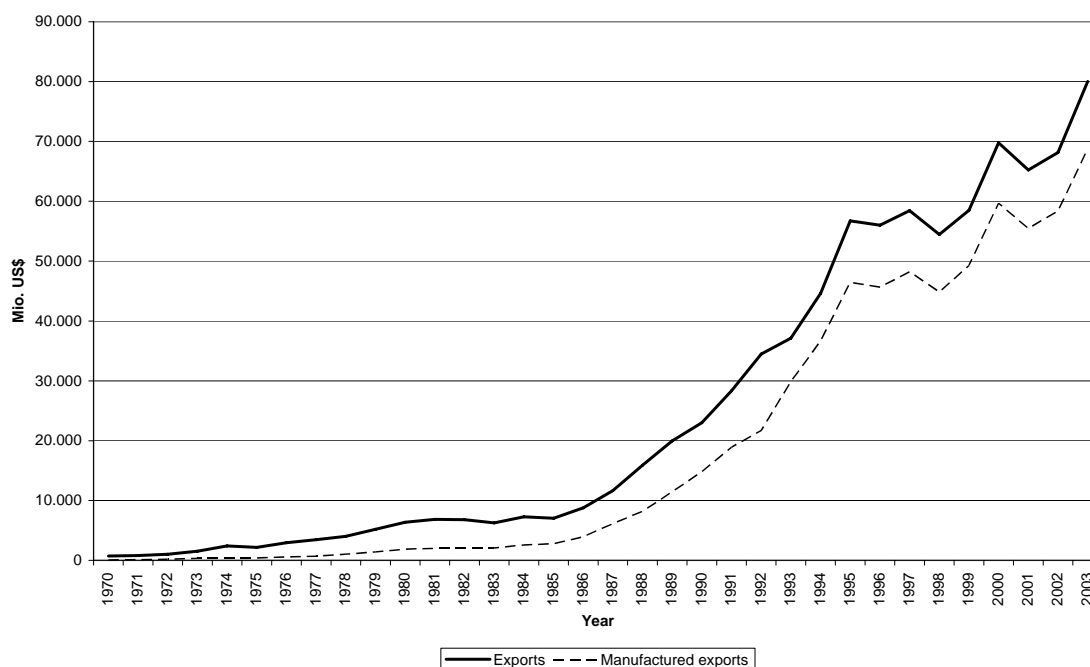
4.1.1 Historic development

Thailand has been an agricultural society for centuries. It can therefore, be assumed that GDP growth was very moderate, almost insignificant, from the mid 19th century to the 1950s. It began to accelerate within the period between 1950 and 1960, reaching an annual growth rate of about 4.5%. This was caused primarily by an export ‘boom’ of agricultural products during the Korean War and an increase in manufacturing (Dixon, 1999: pp. 74). However, the economy remained strongly dependent on a fairly narrow range of primary products, mainly agricultural goods such as teak, rubber and rice, which accounted for two-third of all exports in 1960 alone. Agricultural products made up almost four-fifth of total exports (Phongpaichit & Baker, 1998: 22). The end of the Korean War boom resulted in a slow-down, forcing the government to implement new policies. Consequently, the first National Economic Development Plan was introduced in 1960 (Dixon, 1999: 80). The first phase of industrialisation was dedicated to **import substitution** (see chapter 2.1.1) (Poapongsakorn & Tonguthai, 1998: 159). The government introduced high levels of import tariffs on consumer goods and low levels for intermediate and capital goods in order to foster the establishment of a domestic industry. Furthermore, the Board of Investment (BOI) was established in 1959 for the promotion of enterprises (Jomo, 1997: 61). The BOI could make use of several instruments, e.g. guarantees that the government would neither nationalise promoted companies nor create competition through state enterprises, licenses for hiring foreign staff, ‘tax holidays’ for up to eight years and the adoption of protective tariffs reaching up to 50% of the goods’ value (Dixon, 1999: 87). Despite favourable GDP annual growth rates of about 8% from 1960 to 1969 and 7% from 1970 to 1979 the Thai economy remained “remarkably low key” (ibid.: 93), depending strongly on the export of primary products and an import-substituting industry. Nevertheless, firms soon began to export their products. Generally, the industrial sector was based on “a handful of big [Thai owned] conglomerates” (Phongpaichit & Baker, 1998: pp. 22) and a quantity of foreign capital. From a sectoral perspective, the major growth areas were agro-processing, textiles and certain assembly activities for the domestic consumer goods market (Dixon, 1999: 102). Due to a

worsening balance of payments in 1969-70, Thailand slowly adopted an **export oriented industrialisation** approach by giving greater incentives to export industries from 1972 onwards (Poapongsakorn & Tonguthai, 1998: 160). Triggered by a severe economic and political crisis in the late 1970s caused by the oil price rise and a fall in the returns on Thailand's main export products, the World Bank entered the stage and was to determine that economic growth was hampered by long-term structural problems. As a consequence, the World Bank recommended a **structural adjustment program**, which included a clearer shift from import substitution to export oriented industrialisation, which had proved highly successful in the South-East Asian tiger states of Korea, Taiwan, Singapore and Hong Kong (Dixon, 1999: pp. 111). Subsequently, the government would promote export industries by offering tax rebates to firms not promoted by the BOI, the establishment of bonded warehouses and export processing zones, as well as by streamlining customs procedures (Poapongsakorn & Tonguthai, 1998: pp. 160).

Nonetheless, in the early 1980s the Thai government was still struggling to implement real reforms, such as reforming the taxation system, removing export restrictions and export taxes, reducing import taxes, privatisation and simplifying investment regulations etc. (Dixon, 1999: pp. 115). Suddenly, with only a minimal number of reforms in place, the economy took off. Beginning in 1987, fuelled by the devaluation of the Thai Bhat in 1984 and 1985 and fostered by a saturation of the domestic market and large over-capacities, export of manufactured products increased sharply (initially textiles and later electronic products, Figure 4.1) as did GDP growth (Figure 4.2).

Figure 4.1: Exports and manufactured exports in US\$ 1970 - 2003

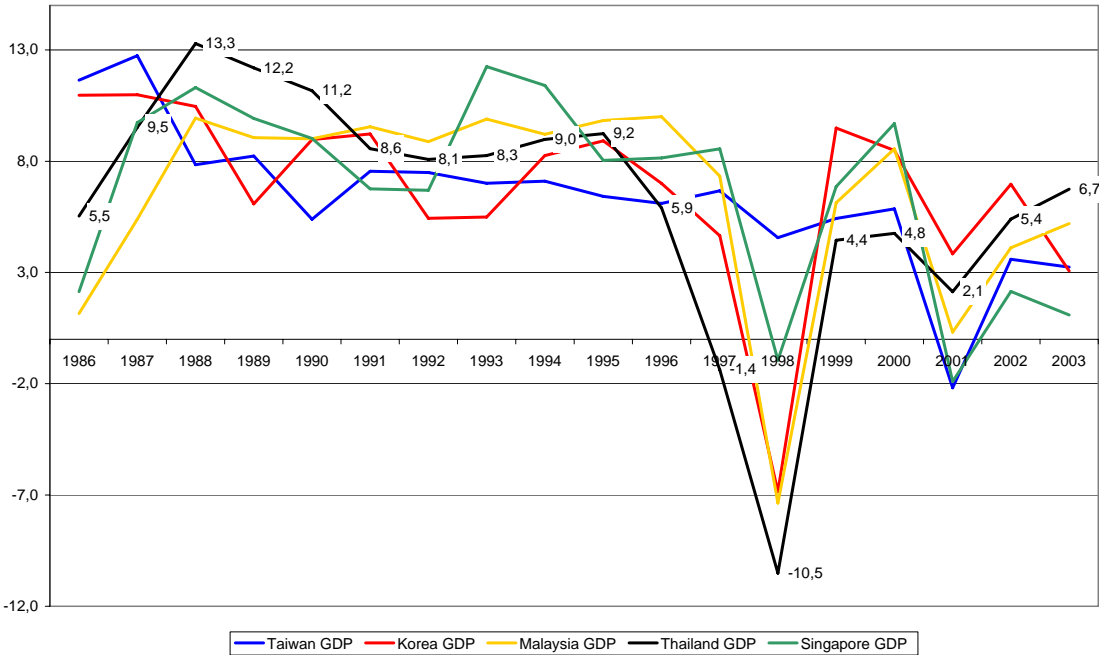


Source: Bank of Thailand; 1970-1994: cited in Dixon, 1999: 114; 1995-2003 Bank of Thailand, 2004a

This growth was driven further by a massive inflow of FDI beginning in 1987 (Figure 4.3): It was predominantly Japanese firms that invested in Thailand, after the Japanese central bank was forced to revalue the yen in 1985. From 1985 till 1989 the yen rose 89% against the dollar and manufacturing firms were literally fleeing Japan. Since the tiger states of Taiwan, South Korea,

Singapore and Hong Kong were also facing rising currencies and costs, the bulk of investments went to Malaysia, Indonesia and Thailand (Phongpaichit & Baker, 1998: pp.2, see also Kraas, 1996). Moreover, these NICs acted as additional sources of investment, which flowed into the Thai economy. Such a development led to the ‘flying geese’ paradigm, which saw Japan as the leading goose initially pulling the first tier NICs and later countries like Indonesia, Malaysia and Thailand with it as it relocates labour-intensive production (Akamatsu, 1962; for critical aspects in respect to knowledge transfer see Hayter & Edington, 2004).

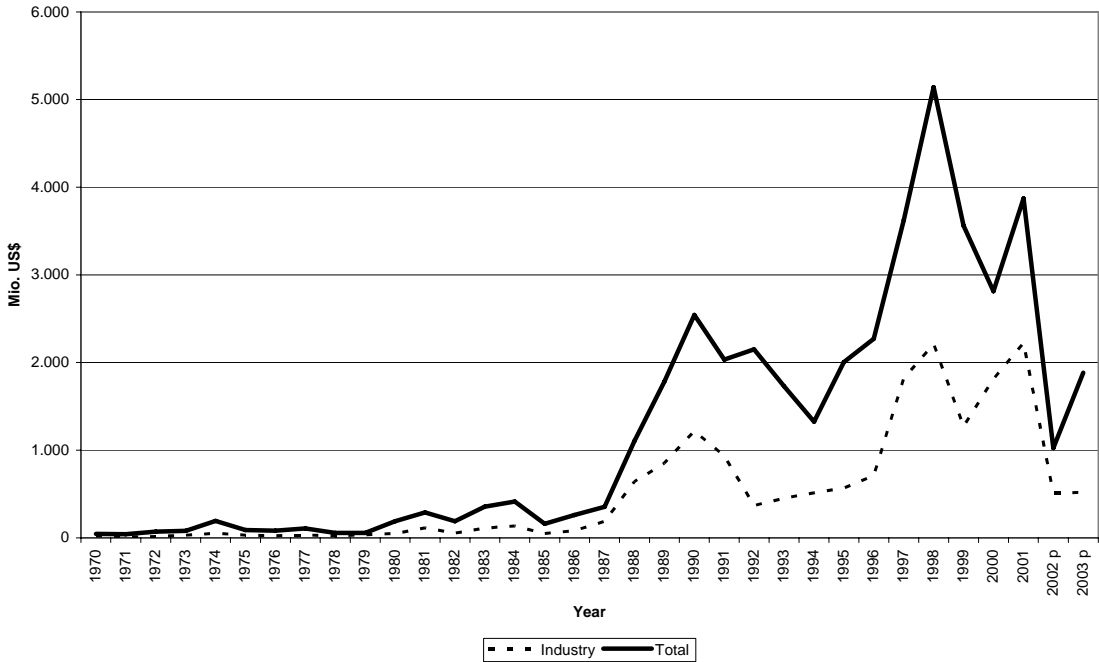
Figure 4.2: GDP growth rate in % (annual) in Thailand and other Asian NICs



N.B. Figures given for Thailand;

Source: Asian Development Bank, 2004

Figure 4.3: Net flows of foreign direct investment to Thailand 1970 – 2003



Source: Bank of Thailand, 2004a

The majority of the money was invested in labour-intensive export-oriented industries, like textiles and electronics (Phongpaichit & Baker, 1998). Dixon (1999: pp. 124) asserts that four reasons spoke in favour of Thailand: a) **Price advantage**: Thailand had the lowest labour costs in ASEAN and the devaluation of the Bhat increased its price competitiveness; b) **Political advantage**: Thailand was considered the only politically stable ASEAN country; c) **Strategic advantage**: production in Thailand allowed Japanese firms to avoid restrictions imposed by the EU and North America on Japanese exports and finally d) **Local knowledge**: due to a comparatively long history of investment Japanese firms could make use of existing linkages, contacts and expertise. The following years witnessed remarkable economic and export growth. Manufacturing exports grew at an annual rate of almost 23% from 1990 to 1995 (Lall, 1998) and the economy grew at an annual rate of 8.5% (EIU, 2004: 30). A projection from *The Economist* predicted that Thailand would become the world's seventh largest economy by 2020 (Phongpaichit & Baker, 1998: 100). However, Thai exports still consist more of 'simple' manufacturing, e.g. food processing and textiles, than in the tiger economies and Malaysia (Lall, 1998; for more on export see below).

In 1996 the export growth rate declined sharply from around 21% in 1995 to 8% by the end of 1996¹⁶ (Phongpaichit and Baker, 1998: 95). What were the reasons?

First, new export competitors from 'even lower cost' countries like China, Vietnam, Indonesia and India entered the market following free market reforms in the late 1980s. This made it more difficult for Thai based firms to compete on prices, because real wages were increasing from 1991 onwards at 8% per year, due to a shortage of labour. In the past, additional labour from the countryside could be activated without additional cost, now the labour market had tightened. Second, the recession in Japan caused a devaluation of the yen beginning in 1995. Within two years the cost of Thai imports increased by 40% for Japanese customers (Phongpaichit & Baker, 1998: pp.96). Since the Bhat was pegged to the strengthening US\$, Thai low-cost exports lost their competitiveness and the import-dependent high-technology exports could not fill the gap (EIU, 2004). Third, the Thai economy had invested too little in the upgrading of export industries in order to stay competitive. Rather, investment went into more lucrative property businesses or service industry (Phongpaichit & Baker, 1998: pp. 96).

Moreover, the Thai economy with its remarkable growth had attracted large foreign (portfolio) investments. These investments went mostly into the domestic market, i.e. heavy industry, infrastructure, services (including real estates), consumer finance and stock speculations (Phongpaichit & Baker, 2000: 2). However, the massive inflow "obscured the export slowdown and produced a bubble economy of inflated assets, overbuilt property, excess spending, and incautious investment" (Phongpaichit & Baker, 1998: 126). Overinvestment, in turn, resulted in both over-capacity and declining returns. First, property firms could not repay their credits. The bubble then burst, when finance firms went bankrupt in light of 'non-performing loans', which were guaranteed with overvalued property or assets. Shocked foreign investors began to sell their holdings in the

¹⁶ NB official statistics exaggerate the decline: export figures were not reflecting real exports, since VAT refund fraud was a wide spread problem; see Phongpaichit and Baker, 1998: 95

stock market, and international currency brokers speculated against the Bhat, which was finally floated on the 2nd of July 1997. As a consequence, foreign funds rushed out of Thailand; Within the “next twelve months, the private capital outflows and net of foreign direct investment were equivalent to almost a fifth of GDP” (Phongpaichit & Baker, 2000: 3). The financial crises became an economic one, as firms with foreign loans lost liquidity, inflated liabilities or went out of business, as many did in the end. Demand and consumption declined sharply: more firms went bankrupt and many people became unemployed (Phongpaichit & Baker, 1998, 2000; for more see also Kraas, 1998, 2000).

In recent years there are clear signs of recovery (hampered by non favourable condition of the world economy), but the Asian crisis still hints towards a need for restructuring, addressing the problems detected at the outset of the crises: eroding international competitiveness (e.g. Poapongsakorn & Tangkitvanich, 2001). Despite this remarkable growth (and decline), Thailand’s GNP/GNI¹⁷ per capita is significantly lower than in first tier NICs (Singapore, Korea and Taiwan), but also lower than in neighbouring Malaysia (Tab. 4.1).

Tab. 4.1: Per capita GNP/GNI (US\$) for South East Asian countries 1996, 1999, 2002

Country	1996	1999	2002
Thailand	2,000	1,980	2,930
Malaysia	3,540	3,370	4,330
Singapore	20,690	22,930	30,590
Korea	9,930	8,530	10,590
Taiwan	12,930	13,110	13,230
Philippines	1,030	1,040	1,160

Source: Asian Development Bank, 2000, 2003, 2004

4.1.2 Structure of GDP and exports

Another problem brought to light during the crisis was the limited sectoral change during the period of economic growth. The share of GDP achieved by the primary sector declined from about 50% in 1950 to about 10% in 2003, whereas manufacturing rose from 10% to 35%, and services increased from about 35% to 45% in the same period (Dixon, 1999: 10, Office of The National Economic and Social Development Board, 2003, Asian Development Bank, 2004: 72). However, these figures show that Thailand is, without doubt, still an agricultural country and that the shift towards a service economy is less intense than in other countries. In 2003, Korea (agriculture: 3.2%; industry: 34.6%, service: 62.2%) or Taiwan (1.8%; 30.4%; 67.8%) were oriented towards the tertiary sector to a much higher degree, whereas Malaysia shares a similar structure (9.5%; 48.6%; 45.5%) (ibid.). Within the manufacturing sector machinery and equipment accounts for the lion’s share of GDP (29%), followed by food and beverages (21%), textiles (18%) and chemicals (15%). Within TSIC-sector 38, manufacturing of motor vehicles (7%), radio and TV (6%), office and computing machinery (5%) and machinery and equipment (4%) are the most important industries (National Economic and Social Development Board, 2002, Tab. 4.2).

¹⁷ Gross National Income (GNI) is the new term for gross national product (GNP). It is GDP plus net receipts of primary income (compensation of employees and property income) from abroad. GNI, calculated in national currency, is usually converted to U.S. dollars at official exchange rates for comparisons across economies. Per Capita GNI (US\$), formerly per capita GNP, is the gross national income, converted to U.S. dollars using the World Bank Atlas method, divided by the midyear population (Asian Development Bank, 2004: 387).

Tab. 4.2: Contribution of sectors to total manufacturing GDP (2002)

TSIC-2		%	TSIC-3 sectors within TSIC-2 sector 38		%
31	Food, beverages and tobacco	20.58			
32	Textiles, leather, leather products	18.31			
33	Wood, wood products	0.45	Machinery and Equipment		4.02
34	Paper, printing, publishing	2.96	Office, Accounting and Computing Machinery		5.29
35	Chemicals, petroleum, coal, rubber, plastic	14.94	Electrical Machinery and Apparatus		1.55
36	Non-metallic, glass, ceramic, clay	4.25	Radio, Television and Communication Equipment and Apparatus		5.87
37	Basic metal	1.07	Medical, Precision and Optical Instruments, Watches and Clocks		1.16
38	Fab. metal products, machinery, equipment	28.95	Motor Vehicles		7.39
39	Other manufacturing	8.50	Other Transport Equipment		0.89
		100.00			

NB Figures for the GDP share are based on the 3rd revision of the ISIC classification (see UN Statistics Division, 2004). Since the R&D/Innovation survey classifies according to the TSIC 1972 (Department of Labour, 1972), which is based on the ISIC Revision 2 (see UN Statistics Division, 2004), the classes can be only approximately matched.
Source: National Economic and Social Development Board, 2002

Sectoral change in terms of employment is even more limited: an over-proportional share of the labour force is still employed in the primary sector (about 49% in 2000), with much less in industry (17%) and services (34%) (Jomo, 1997: 84, Asian Development Bank, 2004: 64). Once again, this contrasts markedly with countries like Korea (ca. 9%, 19%, 72%), Taiwan (ca. 8%, 35%, 57%) and also Malaysia (ca. 15%, 36%, 50%), which have shifted decisively towards industry and/ or services (ibid.).

This overview of the economic development in Thailand has emphasised the importance of exports. Tab. 4.3 presents Thailand's top 10 export items (ranked by value) in 2001. These products account for more than 40% of all export revenue. Computer related products such as 'automatic data processing machines and parts thereof' and 'electronic integrated circuits' represent about 18% of total exports alone.

According to the Bank of Thailand (2004a), the share of high-tech exports to total manufactured exports rose from 53.3% in 1993 to 69.2% in 2003, whereas labour intensive exports (27.8% to 11.9%) as well as resource based exports (11.4% to 9.6%) declined.

Tab. 4.3: Thailand's top ten export items in 2001

Product	Share of total exports in 2001
Automatic data processing machines and parts thereof	12.2
Electronic integrated circuits	5.4
Garments	4.5
Motor cars, motor vehicles, parts and accessories	4.1
Canned fish	3.1
Precious stones and jewellery	2.8
Radio-broadcast receivers, television receiver and parts thereof	2.6
Polymers of ethylene, propylene, etc. in primary forms	2.5
Rice	2.4
Rubber	2.0

Source: Bureau of Commercial Information Administration; cited in Tambunlertchai, 2002: 51

This positive evaluation is challenged by the International Institute for Management Development (IMD), which asserts that Thailand's high-technology exports in 2001 only accounted for 31.4% of all manufactured exports (IMD, 2004: 703). In total, the country exported high-tech products worth US\$ 15,234m in 2001 and earned a rank of 18 in the IMD listing (ibid.). In both terms Thailand ranks behind Singapore, Taiwan, Korea and Malaysia (ibid.).

Another ranking sees Thailand ranked 7th in the top 25 developing economy exporters of high-technology manufactures (by export values 1997) as compiled by UNCTD (1999: 440). Using the UN Comtrade Database for a slightly more differentiated analysis, Brimble (2003a: 341) presents Tab. 4.4. It shows that Thai exports are still fairly labour-intensive, but that its science-based export share is higher than Korea's and close to Taiwan's, whereas Singapore is still far more advanced. Brimble asserts that the observed increase in science-based exports is more "in the labour-intensive end of science-based production" (ibid.: 339).

Tab. 4.4: Distribution of manufactured exports by technology categories (%)¹⁸

	Korea			Singapore			Taiwan			Thailand		
	1980	1990	1999	1980	1990	1999	1980	1990	1999	1980	1990	1999
Resource-based	9.0	6.8	11.6	44.4	26.9	13.2	9.8	8.2	9.2	21.7	13.8	10.7
Labour-intensive	49.2	40.8	23.2	10.6	10.3	7.6	54.3	41.2	31.0	47.0	45.5	35.8
Scale-intensive	23.6	19.3	21.0	9.9	5.9	5.5	9.1	10.3	10.6	7.8	6.3	7.7
Differentiated	11.3	15.6	18.7	20.5	22.3	21.2	12.4	20.6	20.4	22.2	14.1	19.5
Science-based	6.9	17.4	25.5	15.1	34.6	52.5	14.5	19.8	28.9	1.2	20.2	26.4

Source: Brimble, 2003a: 341

Similarly, Lall (2001) cautions against misinterpreting the high figures for high-technology exports, which:

"may conceal large differences in the underlying capabilities of manufacturing industry. On the one hand, they can reflect high levels of local physical and technological content (as in Korea and Taiwan); on the other, they can reflect low local content and simple assembly activity under the aegis of MNCs. Much of 'technology-intensive' production in Thailand falls in the second category"

(Lall, 2001: 349).

This assertion is supported by data from a 1997 study by the Siam Commercial Bank Research Institute (cited in Tambunlertchai, 2002: 79), in which the import content of high-technology exports, such as computer (64%) or integrated circuit boards (72%) is found to be fairly high. Medium- to low-technology products such as vehicles, parts and accessories (53%) or garments

¹⁸ N.B. Classification is based on OECD (1987). Resource-based refers to access to natural resources, e.g. for oil refining or food processing; labour intensive to un- and semi-skilled labour for e.g. textiles and garments; scale-intensive to length of production runs, e.g. for steel, auto or paper industry; differentiated means the ability for tailored products for varied demands such as advanced machinery and TVs; science based confers to the rapid application of science and technology as e.g. in electronics and biotechnology (Lall, 1998).

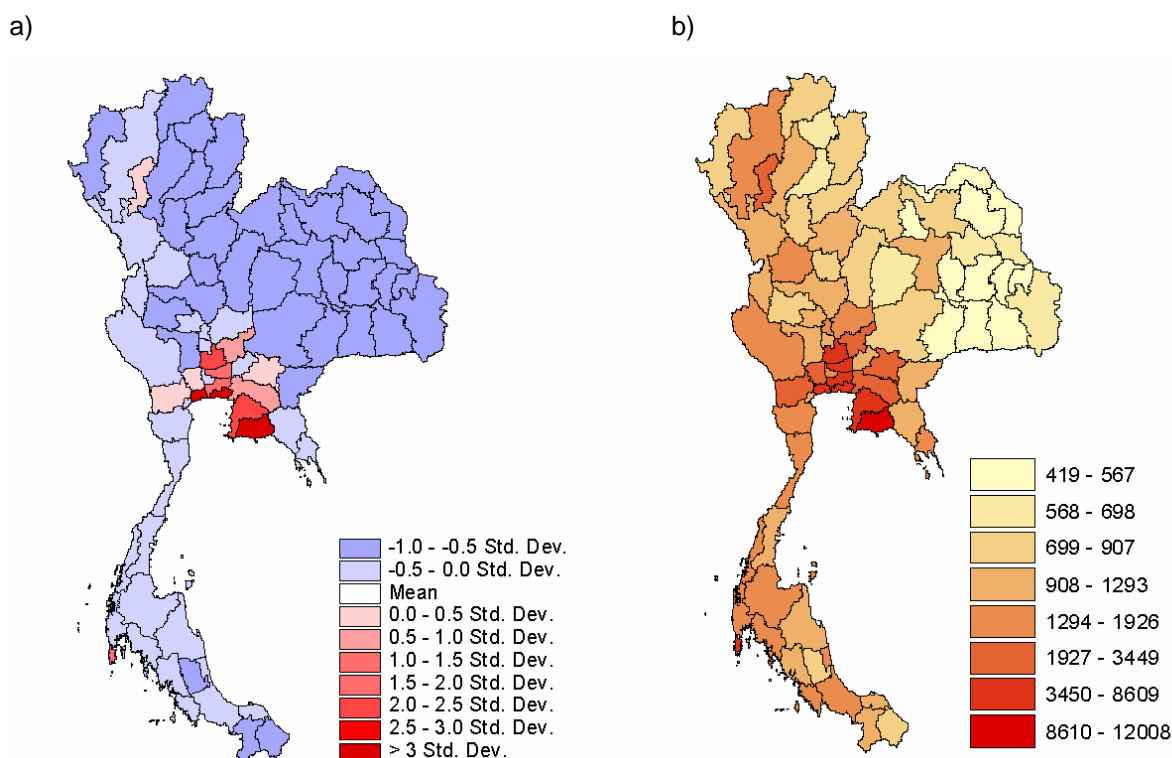
(44%) use a visibly higher share of local content. As can be seen, these indicators cast some early doubts regarding the performance of the Thai NSI. Further evidence is presented in chapter 4.2.

4.1.3 Spatial distribution of economic activities

Industrialisation in Thailand has always been heavily concentrated in the Bangkok region, with approximately 70% to 75% of total production stemming from the Bangkok metropolitan region (Kraas, 1996: 247, Poapongsakorn et al., 2000: 116). Despite agglomeration diseconomies such as massive traffic congestion, inadequate public infrastructure (e.g. sewers), air and water pollution as well as labour shortages (ibid.), Bangkok and its vicinity (provinces of Nakhon Pathom, Nonthaburi, Pathum Thani, Samut Prakan and Samut Sakhon) is still the ‘economic powerhouse’ of Thailand. According to the 2001 Manufacturing Industry Survey, Bangkok and its vicinity host 62% of all manufacturing establishments with more than 10 employees, employs 58% of the manufacturing workforce and accounts for 46.9% of gross output and 52.5% of value added (National Statistical Office & Office of the Prime Minister, 2001: table 7).

This economic structure also becomes visible when scrutinising gross provincial product (GPP) per capita in 2002 in US\$. Figure 4.4 shows the disparities in Thailand, clearly displaying the dominance of the Eastern Seaboard and the Bangkok metropolitan region. Maximum GPP per capita is US\$ 12,008 in Rayong (Eastern Seaboard Region); minimum is US\$ 419 in Nong Bua Lamphu in Northeast Thailand. The classes are built according to the method of standard deviation around the mean of US\$ 1,990.

Figure 4.4: Gross provincial product per capita (2002) a) standard deviation classes; b) in US\$a)



NB Figures have been calculated in US\$ according to average exchange rate in 2002 of 1 Bhat = 0.02329 US\$. Data in b) is classified according to natural breaks, in order to present a very differentiated pattern.

Source: National Economic and Social Development Board, 2004, own graphic

4.1.4 FDI inflow, structure, effects, and policies

Since the focus of this thesis is on TNC-affiliates, the following chapter will scrutinise data about inflows and stocks of FDI in Thailand, its sectoral distribution, destinations for FDI, policies towards FDI, and the impact in terms of the real economy.

4.1.4.1 Inflow and stock of FDI

The previous section provides sufficient evidence to suggest that Thailand's industrial development was closely connected to export and the impact of FDI. The main reasons for which TNCs invested in Thailand were cheap labour costs, political stability and favourable exchange rates. Still, a sufficient domestic market with high growth potential in the 1980s and 1990s and the perspective of the ASEAN free trade area also played an important role. Additionally, the privileges offered by the BOI did attract FDI (see Siamwalla et al., 1999, Poapongsakorn & Tangkitvanich, 2001: pp. 110, Dixon, 1999: pp. 124). As was shown, the existing infrastructure and supplier base also became relevant factors (Brimble, 2005). Consequently, most of the foreign investment in Thailand has been of a resource- and market-seeking nature (see 2.3.2).

Dixon (1999: 2) asserts that economic development in Thailand "has been associated with a much greater involvement of foreign investors and transnational corporations than was the case in Taiwan and South Korea". However, in comparison to neighbouring countries such as Malaysia and Singapore, Thailand's share of worldwide FDI is not exceptional. Contrarily, it has received considerably fewer investments than the other two countries, even though it has caught up with Malaysia since 1996 (Tab 4.5).

Tab. 4.5: Amount and distribution of global inward FDI flows (annual average)

Year	Worldwide (US\$m)	Developing countries (%)	South, East, and South East Asia (%)	Singapore (%)	Malaysia (%)	Thailand (%)
1980-1985	49,831	25.4	9.3	2.67	2.12	0.53
1986-1990	149,702	17.4	9.1	2.30	0.83	0.78
1991-1995	226,123	33.8	20.4	2.84	2.01	0.79
1996-2000	788,358	24.3	12.6	1.47	0.55	0.57
2001-2003	685,300	26.7	13.9	1.57	0.30	0.33

Source: UNCTAD, 1992, 1995, 1999, 2004; own calculation

This pattern also holds true for data on FDI inward stock: in 2003 Singapore held about 10.9% of South, East and South-East Asia's FDI stocks, whereas Malaysia hosted 4.4% and Thailand 2.7% (UNCTAD, 2004).

In order to assess the inflow and inward stock in relation to the local economy, Tab. 4.6 shows the figures for FDI flows as a % of fixed capital formation and of FDI stocks as a % of GDP. Clearly, FDI in Thailand has been increasing since 1995, but the total inflow and stock is far less important than in Singapore and Malaysia or in South, East and South East Asia generally. Furthermore, the figures for Thailand are either no different or slightly higher than for worldwide FDI.

Tab. 4.6: Inward FDI flows and stock in relation to gross fixed capital formation and GDP

	World	South, East and South East Asia	Singapore	Malaysia	Thailand
Inward FDI flows as % of gross fixed capital formation (annual average)					
1981-1985	NA		17.4	10.8	3.1
1986-1989	NA		35.2	9.6	4.9
1990-1995	4.1	6.7	30.5	19.4	4.4
1996-2000	11.9	11.7	39.9	16.9	15.2
2000-2003	10.0	9.8	43.8	9.3	7.8
Inward FDI stocks as % of GDP					
1980	6.6	27.4	52.9	20.7	3.0
1985	8.3	24.6	73.6	23.3	5.1
1990	9.3	20.8	93.1	23.4	9.7
1995	10.2	20.8	78.2	32.3	10.5
2000	19.3	36.6	121.5	58.5	24.5
2003	22.9	34.6	161.3	57.2	25.8

Source: UNCTAD, 1992, 2002, 2004

On the other hand, “FDI flows skyrocketed during and after the crisis” (Ramstetter, 2003:86; see also Figure 4.3), resulting in a FDI stock that more than doubled from 1996 to 2001. Due to the slow growth of GDP, the ratio of FDI stock to GDP increased from 10.5% in 1995 to 27.7% in 2002. This suggests that TNCs have become much more important in the Thai economy. Nevertheless, as Ramstetter (2003) argues, this has not been the case. Rather, the differences are caused by the nature of FDI as a measure of “one source of corporate finance, equity and loans remitted from the parent group abroad, not a measure of real economic activity such as production and employment” (ibid.: 84). For example many Japanese TNCs seized the opportunity to increase their share through Thai joint ventures (Brimble, 2004: 8).

4.1.4.2 Sectoral and regional distribution of FDI

In terms of **sectoral patterns**, the involvement of foreign capital from 1970 to 2003 has not been equally distributed, but strongly focused on manufacturing (42%), trade (21%) and real estate (11%) (Tab. 4.7). Within manufacturing, the textile industry did not attract a large absolute amount of FDI, despite its importance in the early export phase of manufactured goods. Most investment has been assigned to the electrical machinery and appliances sector, including the hard disk drives industry, and the machinery and transport equipment sectors, including the automotive industry. Rather than sector specific pull factors, it can be assumed that the above named (generally favourable) conditions in Thailand have attracted FDI in these sectors, which were ‘pushed’ out of the high cost countries. For example, electronics and machinery were among the major outward flows of Japanese FDI to Asia (Ministry of Finance Japan, 2005).

Considering the **origins of FDI**, Figure 4.5 clearly displays several waves of FDI inflows from different geographical locations. In the aftermath of the first yen revaluation most funds originated in Japan. The next waves, from Japan, the US and the EU, followed from 1995 onwards, accelerating with the crises year 1997, as foreign firms took over Thai companies facing debt and liquidity problems. This is reflected in the massive increase of mergers and acquisitions in Thailand (Brimble, 2004: 7). Japanese investors, especially, used the opportunity to increase their shares in

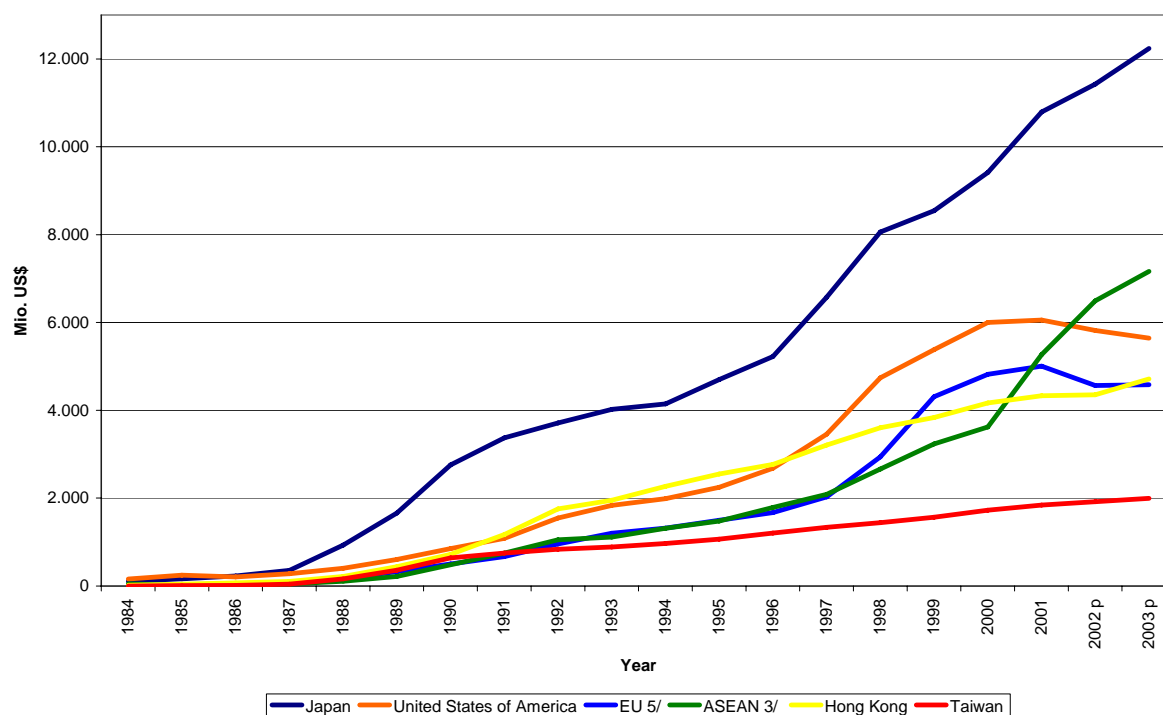
local affiliates, made possible by a relaxation of ownership regulations. This also explains the sudden drop in FDI in 1999 (ibid.). In recent years ASEAN countries, led by Singapore, increased their activities. To a certain extent, TNCs use their regional Singaporean headquarters to invest in Thailand (ibid.).

Tab. 4.7: Accumulated net inflows of FDI according to sector (US\$m) from 1970 to 2003

Sector	FDI net inflow	% of total
Industry	17.664	42
<i>Food & sugar</i>	1.167	3
<i>Textiles</i>	872	2
<i>Metal & non-metallic</i>	2.282	5
<i>Electrical machinery & appliances</i>	4.624	11
<i>Machinery & transport equipment</i>	3.595	9
<i>Chemicals</i>	2.174	5
<i>Petroleum products</i>	416	1
<i>Construction materials</i>	153	0
<i>Others</i>	2.377	6
Financial institutions	1.872	4
Trade	8.703	21
Construction	2.078	5
Mining & quarrying	1.135	3
Agriculture	164	0
Services	3.141	7
Investment & holding company	710	2
Real estate	4.695	11
Others	1.730	4
Total	41.892	100

Source: Bank of Thailand, 2004a; own calculation

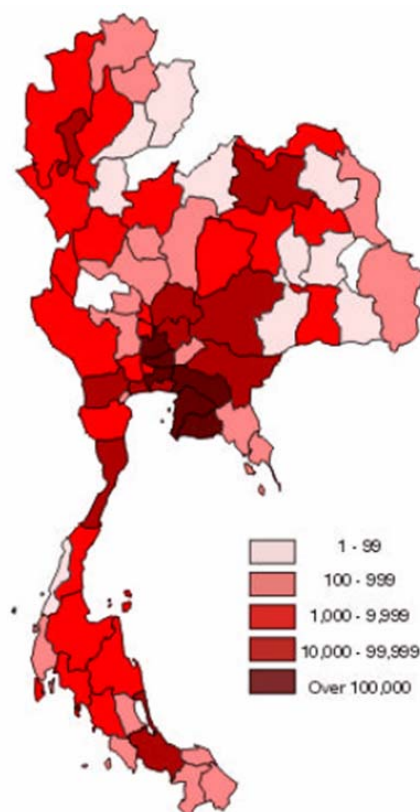
Figure 4.5: Accumulated net flows of foreign direct investment 1984 – 2003 – origin of investment



N.B. 3/ Prior to 1999, ASEAN does not include Cambodia, Laos, Myanmar and Vietnam. 5/ Since May 2004, EU comprises 25 countries, including Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, the Slovak Republic, and Slovenia. Source: Bank of Thailand, 2004a, own calculation

In terms of **destinations for FDI**, the spatial pattern of economic activity (see 4.1.3) is replicated: Most investments went to the extended Bangkok Metropolitan region¹⁹, with the eastern seaboard province of Rayong alone accounting for 31% of total approved FDI from 1987 to 2000. Bangkok itself ranks second with 12%, followed by Chonburi (ESR) with 11% (UNCTAD, 2001: 63). Based on BOI data from 1960 to 1991, Dixon (1999: 232) shows that 50-80% of the projects in this period were located in the extended BMR (Figure 4.6).

Figure 4.6: Distribution of FDI stock in Thailand, by province (BOI approved investment for the years 1987 – 2000 in Mio. of Bhat)



Source: UNCTAD, 2001: 90, based Board of Investment unpublished data

However, due to zoning policies implemented by the BOI (see 4.1.4.4), there has been a redirection of flows away from Bangkok and into the hinterland. This is mirrored by the employment pattern as well. Brimble (2004: 18) detects a steady shift over time from Bangkok to the surrounding provinces, and afterwards to the rest of the country. While in 1970 97% of the FDI induced employment was in Bangkok, its share was reduced to 27% from 1991 to 1998. Consequently, the share of employment in the rest of the country increased from 3% to 37% (ibid.). However, that the figure only includes BOI approved investments must also be taken into account. Hence, it only displays a portion of total investment, since “many foreign MNCs invest without getting BOI approval” (Ramstetter, 2003: 90).

Nevertheless, it can be stated that, initially, the favourable agglomeration conditions in Bangkok (e.g. infrastructure, public administration, labour market etc.) drew most investment into the BMR.

¹⁹ There is no single definition of the extended Bangkok region. This work considers the following provinces as part of the EBR: Bangkok, Samut Prakan, Samut Sakhon, Nakhon Phathom, Nonthaburi, Phatum Thani, Ayutthaya, Chachoengsao, Chon Buri, Rayong.

Subsequently, the government improved the infrastructure of some hinterland areas (e.g. outer Bangkok, ESR) and provided incentives for investing outside of the core region (see 4.1.4.4), which – together with agglomeration costs in Bangkok, such as traffic congestion and factor prices – led to a certain diversion of FDI.

4.1.4.3 Effects of FDI on the Thai economy

Since there are no official, published statistics of sales and employment for foreign TNCs, Ramstetter (2003: 89) estimates the contribution of TNC-affiliates to the Thai economy based on six different official as well as unofficial Thai and foreign sources. He reckons that TNC-affiliates account for about 32% of **value added** in manufacturing and about 16% of total **employment** in manufacturing (Ramstetter, 2003, 2004). This large gap between output and employment is partly due to the dichotomous nature of the Thai economy, which results in a large amount of small local enterprises with little value added (Ramstetter, 2004: 868). According to Brimble (2004: 18), direct employment from foreign investors accounts for up to 800,000, with an additional 1.6 million jobs created through indirect employment effects (figures for 1997). This results in a share of 7.4% of total employment and about 17% of employment in manufacturing (ibid.).

In regard to **exports**, Brimble (2004: 16) estimates (based on the data by Ramstetter, 2003) that TNCs contribute about 60% of total manufacturing exports before, and roughly 70%, after the crisis.

Considering **wages**, Matsuoka (2001, cited in Velde & Morrissey, 2002) and Ramstetter (2004) find evidence that salaries in TNC-affiliates are higher than in local firms. Foreign firms paid about 28% more for white collar, and 12% for blue collar workers in 1998 (Matsuoka, 2001).

Because **labour productivity** was not found to vary significantly with ownership (controlling for other factors), Matsuoka argues that wage differentials between foreign and local firms “should be explained by labour market imperfections, with foreign multinationals dominating segmented labour markets for particular skills” (Velde & Morrissey, 2002: 6). Similarly, Ramstetter (2004) could not find evidence for higher labour productivity in TNC-affiliates generally, after controlling for the large number of very small local enterprises in his dataset. However, European, Japanese and US as well as wholly-owned TNC-affiliates tend to have a higher level of productivity. Clearer evidence is provided by Dollar et al. (1998). They find that foreign firms “generate about 50% more value added from given amounts of capital and labor than domestic firms do” (ibid.: 68). Furthermore, foreign firms were more homogeneous in terms of productivity than domestic companies, of which a substantial group is as productive as TNC-affiliates, while roughly a third displays far lower productivity levels (ibid.: pp. 69). Again, this reflects the typical dichotomy in late-industrialising and developing countries (see Ernst, 2002). In comparison, Yeung et al. (2001: 163) report that “some 80 per cent of Singapore’s exports, 40 per cent of employment and 26 per cent of gross domestic capital formation are directly or indirectly accounted for by foreign TNCs”. These figures, therefore, underscore the greater importance of TNC-affiliates in the city-state.

In respect to **knowledge-spillovers** from TNC-affiliates in Thailand, no systematic study exists, but there is some ‘anecdotal evidence’: Arnold et al. (2000: 66) report of a high turnover of trained technicians and engineers in TNC-affiliates, which could lead to knowledge diffusion. However, it is unclear if the mobility of highly-skilled workers is mainly an intra-TNC phenomenon or if it reaches local firms (ibid.). Generally, they argue that it might be too early to find significant spillovers, since most TNC-affiliates just recently began to deepen their design and engineering activities (ibid.:67, also Brimble, 2003a: 354; see chapter 4.2.2.1, 5.2, 5.3, 6.1.2 and 6.2.2 for more evidence).

Consequently, the examples mainly refer to training of personnel. Brimble (2003a: pp. 354; 2004: pp. 18) mentions the following training activities, which were initiated by TNC-affiliates and which benefit local firms (for more jointly researched evidence see chapter 6):

- The International Disk Drive Equipment and Material Association (IDEMA), Thailand, a lobby group of the HDD-industry that is assembled of mainly TNC-affiliates, created, together with the Asian Institute of Technology, a ‘Certificate of Competence in Storage Technology’ and trained about 500 industry professionals in 2000.
- The Ayutthaya Technical Training Center, a joint venture between the High-Tech Industrial Estate and the King Mongkut Institute of Technology North Bangkok, were given training equipment and new technology from a group of Japanese TNC-affiliates associated with Canon Ltd. Moreover, Mitutoyo Corporation contributed precision instruments and measuring equipment. The centre focuses mainly on vocational training for companies located in the estate, but also fosters mutual knowledge flows about industry needs and university services beyond training. It is seen as a very successful example of university-industry linkages in Thailand.
- Within the BOI’s innovation programme, TNC-affiliates participate in curriculum development for electronics and automotive training courses at the Department of Vocational Education.
- At the Thai-German Institute, a technical training institute jointly funded by the Thai and German government, professionals from German companies train the lecturers and provide most of the state-of-the-art equipment.

Regarding technology transfer and technical assistance to local suppliers as conscious spillovers created by TNC-affiliates, Dahlman and Brimble (1990) could not find any such activity back in 1990. In contrast, there is now some evidence for these types of activity. For example, TNC-affiliates take part in vendor-meet-suppliers activities organized by the BOI Unit for Industrial Linkages Development (BUILD; see 4.1.4.4), where local suppliers visit plants of TNC-affiliates in order to learn about the production process and its requirements for suppliers. Other major TNCs have extensive ‘vendor development programs’ or ‘vendor clubs’ (e.g. Toyota Motors Thailand, see chapter 6) (UNCTD, 2001: pp.146).

4.1.4.4 Policies towards FDI

The Board of Investment (BOI) founded in 1959 is the chief organisation responsible for FDI promotion in Thailand (Wanapha, 2002, Jomo, 1997: pp. 61). During the import substitution phase BOI's primary means were tariffs, tax incentives and guarantees not to nationalise or set up competing state enterprises (Dixon, 1999: 87). In the 1960s its strategy was to develop Thai manufacturing capabilities by providing infant industry protection and access to foreign technology (Jomo, 1997: 61). With the shift towards export-oriented industrialisation, the BOI has also transformed some of its instruments. Nowadays, it generally offers privileged firms exemptions or reductions on import duties, exemption on corporate income taxes for up to eight years, allowance to deduce infrastructure investments and cost for transportation, electricity and water supply from the taxable corporate income and exemption of export duties for export enterprises (Poapongsakorn et al., 2000: 47). However, certain requirements must be met in order to receive this BOI privilege, such as minimum value-added, minimum registered capital, age of machinery used, and restrictions on foreign ownership (*ibid.*).

In order to decentralise economic development (see e.g. Schlörke et al., 1992, Kraas, 1996, Dixon, 1999 pp. 190), the BOI established a zoning policy in the mid-1980s to re-direct FDI away from Bangkok (Dixon, 1999: 226). Three zones have been assigned, offering different levels of exemption/ reduction on import duties and corporate tax.

- Zone 1, with the lowest benefits, encompasses the core Bangkok metropolitan region: the provinces of Bangkok, Samut Prakan, Samut Sakhon, Nakhon Pathom, Nonhtaburi and Pathum Thani,
- Zone 2 includes provinces surrounding this core region: Ang Thong, Ayutthaya, Chachoengsao, Chon Buri, Kanchanaburi, Nakhon Nayok, Phuket, Ratchaburi, Rayong, Samut Songkhram, Saraburi, and Suphanburi,
- Zone 3 consists of the remaining 58 provinces (BOI, 2004).

Since 1992 the BOI has operated the Unit for Industrial Linkages Development (BUILD). Its mission is to act as an intermediary between large (foreign) assemblers and (mainly local) small and medium sized manufacturers of parts, in order to foster linkages and technology transfer. Key aspects of this program are the vendors-meet-customers programme, offering TNC-factory tours for suppliers, the BUILD market place, where customers present opportunities and requirements for local sourcing, and the ASEAN supporting industry database (ASID), which tries to simplify and encourage local sourcing (BUILD, n.d., Brimble, 2003a: 342).

In the aftermath of the Asian crisis the BOI relaxed many requirements and introduced new incentives such as the retraction of zoning requirements for export industries and capacity caps, as well as exemptions on import duties for export industry and exemptions on import tax for non BOI-promoted firms as well (Wanapha, 2002: 3). Furthermore, in August 2000 restrictions on foreign ownership were abolished and local content and export regulations were lifted as they were not compatible with WTO-rules. Besides this regulatory loosening, the BOI tightened some regulations and reduced some incentives: BOI-approved projects are now required to get ISO 9000 certification

within two years after the start of operations, and the maximum tax exemption is varies with the total amount of investment by the TNC (Brimble, 2004: 12).

Generally, the BOI is currently seeking to position itself away from “tax subsidies for Greenfield investment by export-oriented manufactures” (Amin et al., 2002), and towards more comprehensive objectives such as human resource development, entrepreneurship as well as the creation of networks and linkages in order to facilitate R&D and skills development and technological development and transfer (Amin et al., 2002, Wanapha, 2002). Hence, the BOI claims to have changed from a “tax privileges provider” to a “facilitation and investment service provider” (ibid.). The ‘buzzwords’ for this new strategy are: trouble shooting and the creation of an enabling environment, proactive marketing, investment networking, SME development, community enterprises development, gaining expertise on the international investment regime, and excellence in investment promotion administration (Kanasawat, 2002).

Already, consequences of this new approach are being felt (Brimble, 2004: pp. 12). In 2003-2004 the BOI:

- abolished location requirements,
- targeted five industries with customised incentive packages: agro-industry, automotive, fashion, ICT including electronics and high value-added services (including regional operating headquarters),
- recognising the importance of skill development, technology transfer and innovation by implementing a “series of carrot rather than stick measures to promote investment” (Brimble, 2004: 14), such as:
 - additional tax incentives for firms with R&D- or design-expenditure of 1-2% of annual total sales, with S&T personnel share of 1-5% of total workforce, training expenditure of more than 1% of total payroll and expenditure for the development of vendors or educational institutions of at least 1% of annual total sales within the first three years,
 - treatment of projects in eight key fields (such as scientific laboratories, electronic design etc.) as priority activities that can receive maximum benefits regardless of location. These are allowed duty free importation of machinery and are not subject to caps on incentives,
 - treatment of science park projects as priority activities with maximum incentives.
 - realising the importance of strengthening existing and supporting the establishment of new Thai-owned SMEs, in order to provide a better supporting supplier structure.

In summary, Thailand’s economic industrialisation process is closely connected to TNC activities. Shortly after the initial economic take-off large amounts of FDI, mainly from Japan and first tier NICs, sought new production opportunities in Thailand. Later investments from the USA, Europe and other ASEAN countries followed. However, compared to the benchmarking countries of Malaysia and Singapore, Thailand did not receive an exceptionally high share. To the contrary, FDI is distinctively less important in Thailand.

In manufacturing most FDI went into electrical machinery/ appliances and the machinery and transport equipment sector. The major destinations for FDI were the Bangkok Metropolitan and Eastern Seaboard Region. TNCs in Thailand account for about 17% of employment, 30% of value-

added and 70% of exports in manufacturing. There is evidence of higher labour productivity in TNC-affiliates, but taking into account the very heterogeneous structure of local firms this becomes less distinctive. Nevertheless, TNCs pay higher wages than local firms. Moreover, there is some ‘anecdotal evidence’ supporting minor knowledge spillovers.

In respect to FDI-related policy, the Board of Investment is the central organisation in terms of fostering foreign investment. In the beginning, the primary objective of the BOI was simply to bring in FDI in order to create a domestic industry and provide jobs. In the view of Chantramonklasri et al. (1998) the practices of import substitution and infant-industry protection have actually hindered the creation of technological capabilities, encouraging firms “to acquire only the ‘ready-made’ technology embodied in capital goods without utilizing the process of international technology transfer to augment their [the firms’] existing capabilities” (ibid.: 16) instead. Recently, the focus has shifted towards technical change, technological capabilities and hence the BOI starts to provide financial incentives to firms conducting R&D and skills development, especially in some target industries (BOI, 2004, Wanapha, 2002).

4.2 State of the Thai system of innovation – a systematic view

This section appraises the NSI in Thailand by summarising studies on the Thai NSI as such, studies on single actors and secondary data. So far, there have been no attempts to systematically analyse regional systems of innovation in Thailand. It is also questionable, if Thai regions possess the necessary autonomy and governance power to qualify as a RSI in the strict sense (see 2.2.2). Consequently, in the following the general performance of the NSI is evaluated by contemplating secondary data. Subsequently, a brief evaluation of the three main actors in the Thai-SI: private firms, knowledge-related institutes, the government, and their linkages, are presented.

4.2.1 Current performance in a comparative perspective

Benchmarking key indicators of the SI in Thailand with other South-East and East Asian economies in 1996 and 2002 shows that Thailand clearly lags behind first tier NICs like Korea, Taiwan and Singapore, and also behind fellow second tier NIC Malaysia. There is less resource commitment to R&D as % of GDP (GERD). Moreover, most of these funds come from the public sector, whereas in most other countries the majority of money is spent by private businesses (measured in business expenditures as % of GDP (BERD) in % of GERD). Additionally, the human resource commitment in terms of R&D-personnel per capita is lower. These deficits in the input indicators consequently relate to weaker output (or throughput) figures, such as patents granted to residents per million inhabitants or the technology content of exports (see 4.1.2).

In particular, the comparison with other 2nd tier NICs such as Malaysia casts doubt on the performance of Thailand. Even though the number of patents is similar according to the IMD, the US Patent Office registered 320 patents from Thai and 454 from Malaysian residents from 1977 to 2003 (US Patent Office, 2003). Since Malaysia has less than half of the population of Thailand, this suggests a much lower output from the Thai-SI in a both competitive and important US-system.

Having said this, the development from 1996 to 2002 has been positive with a doubling in both GERD and the participation of private funds in R&D (Tab. 4.8, 4.9).

Tab. 4.8: Key S&T indicators (2002)

Country	GERD	BERD in % of GERD [§]	R&D- personnel per capita*	% of R&D- personnel in business enterprises [§]	Patents granted to residents (1999-2001) per Mio. inhabitants [§]
Thailand	0.26	42.1	0.5 ¹	22.5	1.6
Malaysia	0.71	65.6	0.5	51.6	1.1
Singapore	2.15	61.4	5.2	52.4	26.2
Korea	2.53	73.3	4.0	62.2	616.9
Taiwan	2.30	61.1	5.1	65.4	1,097.8
Philippines	0.08 ²	41.2 ²	0.2 ²	10.8 ²	0.1 ³

* full-timework equivalent per 1,000 people; ; [§]based on own calculations

¹ 2001; ²latest figures for 1998; ³for 1998-2000; Source: IMD, 2004, Asian Development Bank, 2003, 2004

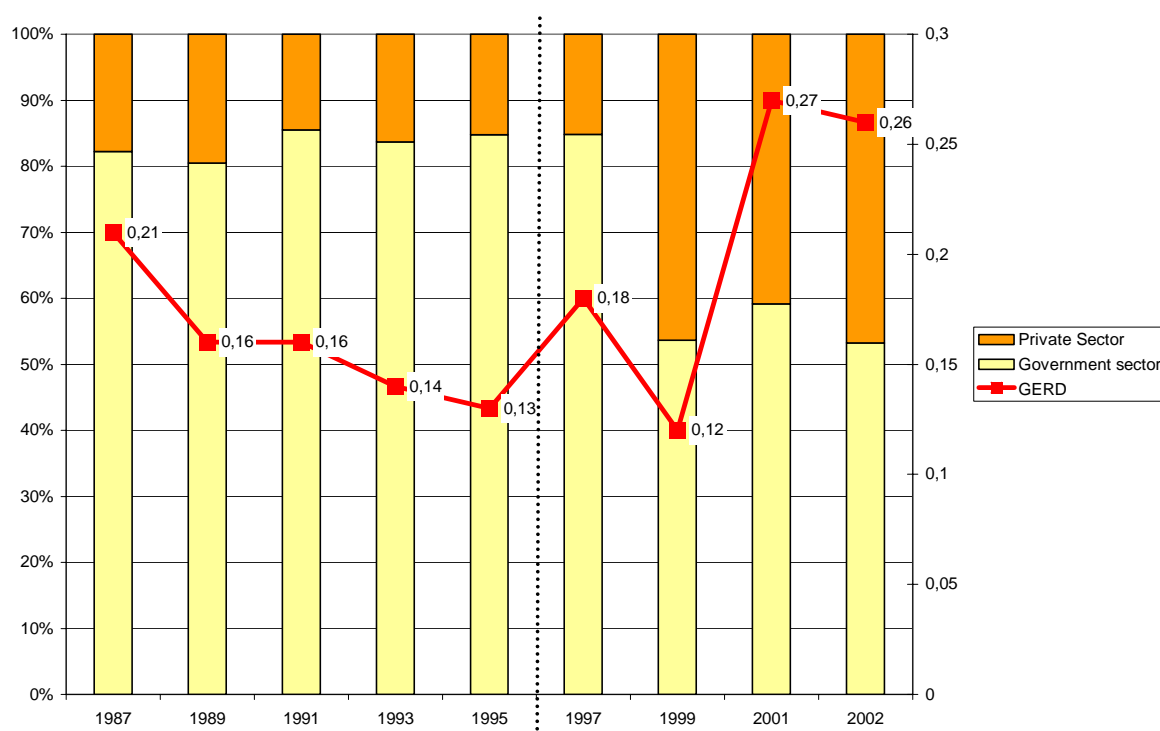
Tab. 4.9: Key S&T indicators (1996)

Country	GERD	BERD in % of GERD [§]	R&D- personnel per capita*	% of R&D- personnel in business enterprises [§] (1995)	Patents granted to residents (1994-1995) per Mio. inhabitants [§]
Thailand	0.13	20.1	0.2	6.3	1.3
Malaysia	0.32 ¹	47.8 ¹	0.3 ¹	37.3 ¹	1.2
Singapore	1.37	63.3	3.1	66.7	4.2
Korea	2.79	64.0	3.0	65.6	135.6
Taiwan	1.86	58.0	3.7	52.9	778.0
Philippines	0.22 ²	2.6 ²	0.2 ²	10.9 ²	0.2

* full-timework equivalent per 1,000 people; [§]based on own calculations, ¹ 1994; ²1992;

Source: Asian Development Bank, 1999, 2001, IMD, 1998, 1999

Figure 4.7: R&D expenditure as share of GDP and according to source (1987-2002)



Source: 1987-1995 NSTDA, 1999:14; 1997 – 2002: IMD, 1999, 2001, 2002, 2004

However, according to NSTDA data, the current level of GERD is only slightly higher than in the period shortly after the take-off phases in 1987. NSTDA (1999: pp. 11) points out that absolute R&D-expenditure more than doubled from 1987 to 1996 but did not keep up with the steep GDP-growth (see Figure 4.7). This also explains the brief increase in the crisis year of 1997, when GDP decreased sharply. The increase of 2001 is presumably due to a new data basis, because the results from the first R&D/ Innovation survey became the basis for new estimates on R&D-expenditure. Still, in international comparisons, GERD ranks very low.

4.2.2 Main actors and linkages in the Thai system of innovation

According to Altenburg et al. (2003: pp. 41), the Thai NSI is seen to consist of three main components: local Thai-owned firms (mainly SME); large, mostly transnational corporations (dealt with together in the subsequent section), and knowledge-related institutions, such as schools, universities, government research institutes etc. Each of these levels is in turn influenced by government policies, which is why government is seen as an actor in its own right (Intarakumnerd et al., 2002). Private bridging organisations and financial intermediaries are not taken into account, so please refer to Intarakumnerd (2004) for an initial assessment. Each of the following sections briefly reflects the quality of the main actors and their linkages.

4.2.2.1 Firms: technological capabilities and linkages

The single most important actor group within a given NSI are private business firms, since these are the units where innovation activity, on a large scale, is or should take place. In order to evaluate firms' skills and capabilities, the framework of technological capabilities, which has been introduced in chapter 2.1.2, is used as a convenient yardstick. The remainder of the chapter provides an overview of studies that have attempted to evaluate the TC-level of companies in Thailand.

The Thailand Development Research Institute (TDRI) conducted one of the first major evaluations of technological capabilities in Thai firms in 1989. Teams of engineers and economists surveyed 119 firms in the biotechnology, materials and electronics industries. These teams rated four distinctive technological capabilities based on 20 different indicators. The study differentiates between a) **acquisition capability**, i.e. the ability to search, assess, negotiate and procure technologies, set it up and start production; b) **operative capability**, which includes the operation, control and maintenance of production facilities, skill development, production planning and quality control; c) **adaptive capabilities** encompassing technology digestion, minor product and process modifications and finally d) **innovative capability**, describing the ability to create major changes in existing products and processes or the invention of new ones as well as in-house R&D and engineering.

The primary findings suggest that operative capabilities are most common, followed by acquisition and adaptive capabilities. Innovative capabilities are scarce. In addition, large firms possess higher TCs, mostly in operative and adaptive, less in acquisitive and innovative capabilities. Foreign ownership (either JV or totally owned) influences operative capabilities quite positively, but has a negative impact on innovative and acquisitive capabilities. Firms with domestic market orientation

in materials and electronics possess more innovative TCs, while the opposite is observed for biotechnology (Vongpanitlerd, 1992).

Making use of the TDRI survey and additional secondary data, Dahlman and Brimble (1990) enquire into the status of technological capabilities, the acquisition of foreign technology, the use, diffusion and development of technology as well as technical human capital in the early 1990s. They assess that,

“while most firms in the modern sector have reasonable adequate capability to operate their existing technology, they are weak in searching for, acquiring and adapting foreign technology. They were even weaker in developing their own technology. Local R&D efforts were minimal in the private sector” (Dahlman & Brimble, 1990: 41).

A subsequent survey done by the TDRI in 1991 establishes the TC-level of firms in machinery and information equipment industries. Generally it finds strong operative capabilities in TNC-affiliates but weak acquisitive, adaptive and innovative capabilities. Thai firms possess especially low capabilities in the machine tool, mould and die industry. In contrast, some capable Thai firms are detected in the telecommunications equipment and computer industries, which exhibit good operative and acquisitive, sometimes even adaptive (reverse engineering), capabilities. However, almost no innovative capabilities are found. Moreover, foreign firms possess state-of-the-art machinery more often as well as better product and process technology than Thai firms. They also invest more in human resources and its development (cited in Brimble & Sripaipan, 1994: pp.22).

In a survey of 20 firms in electronics, steel and petrochemicals, Mukdapitak (1994: pp. 212) asks firms to estimate which of their capabilities are most significant to their competitive advantage. She finds that most firms indicate ‘basic technological capabilities’ in product technology and even only ‘production capabilities’ and ‘basic TCs’ in process technology (terminology refers to the framework by Bell and Pavitt (1995), cf. chapter 2.1.2). Moreover, most firms obviously do not see the need to improve, but report rather on passive or less intense efforts to develop TCs.

Based on the technological capability framework proposed by Ernst et al. (1998a), Poapongsakorn and Tonnguthai (1998) analyse technological capability formation in Thailand’s textile and electronics industries by conducting interviews with 21 companies.

They find that textile firms are able to strengthen their production and management capabilities step-by-step. Initially, the industry benefited from a know-how inflow of Chinese immigrants setting up the textile business. The second generation of entrepreneurs was trained abroad, bringing back knowledge about textile engineering, business management, clothing production and fashion design. Further progress was made by close contacts with clients and suppliers, especially Japanese trading companies, as well as joint ventures with foreign firms, bringing in capital and knowledge.

Moreover, firms benefited from working as subcontractors for firms in East Asian NICs, who provided them with fabrics, patterns, designs and markets. After having established production and investment capabilities in the 1980s, the learning experiences with foreign partners resulted in the development of firms’ own marketing capabilities. A significant share of firms possesses its competitive advantage through its technical and production skills, delivery on time and product

quality rather than its low wages. However, linkages to the science and technology infrastructure are still relatively weak and while firms possess some minor change capabilities, they lack the design skills to cater to leading markets in Europe, Japan and North America.

Foreign firms established the electronics industry in 1960, but it developed only minor technological capabilities before the 1980s, due to a lack of incentives in a highly protected domestic market under an import substitution regime. Poapongsakorn and Tonnguthai (1998: 187) find that the development of TCs has been “extremely slow” and that foreign-owned firms built few linkages with the host economy. However, export oriented firms have, in particular, developed (pre) investment capabilities, such as procurement, installation and execution of test-runs, as well as production capabilities like process operation and quality control, which have formerly been carried out by the parent firm or foreign partners.

Particularly TNC-affiliates, joint ventures and Thai-owned OEM producers display adaptive capabilities for process technology. Product design and R&D-activities are far less common, but these firms also conduct them more often. These activities relate primarily to the modifications of existing processes and machinery in order to overcome weaknesses and meet new industrial standards. Generally, R&D-activity and linkages to the S&T-infrastructure are weak, but there are signs of some Thai-owned SMEs setting up R&D-units and beginning to cooperate with universities and public R&D institutes (Poapongsakorn & Tonguthai, 1998).

An in-depth interview survey of 25 firms organized by the TDRI in 1998 (Chantramonklasri et al., 1998: pp. 38-45) focuses on R&D-activities. Based on the sample, they detect a recent increase in R&D-activity and differentiated firms into five groups. Some conglomerates have initiated R&D programs with competitive pressures requiring them to reduce production costs. Primarily in the agro-industry, the study finds firms contracting R&D-activities out to universities and public R&D-institutes, reflecting the well-developed knowledge base in the S&T-infrastructure in this field. Predominantly, these activities relate to necessary modifications of imported products and are caused by increased competition. The third, and largest, R&D-performing group is subcontractors (OEM), who are forced to implement R&D-activities by increasing demands in terms of product quality and costs from their customers. Therefore, this survey focused on (small) product modifications and process improvements. A fourth group is entrepreneurs, who acquire R&D-knowledge while studying and/or working abroad. Back in Thailand, they start their own businesses concentrating mostly on design and product development, without operating production facilities. The final group of ‘laggards’ consists of the bulk of Thai firms in labour intensive sectors, which lack the financial resources, basic technological capabilities and human resources necessary to carry out R&D. Despite eroding competitiveness these companies do not see the need for R&D.

In a study for the Department of Industrial Promotion, Ministry of Industry, a research consortium from the faculty of Economics, Chulalongkorn University and the Brooker Group plc. surveyed 1,000 firms and established their capabilities in respect to technology, product development, information technology and marketing (MOI, 2001: chapter 5).

Their findings indicate that the majority of firms have moderate **technology capabilities**, yet lack the ability to source computer technology and automatic systems for manufacturing. Hence, most

firms still use manual or mechanical material handling systems (ibid.: 5-69). However, most firms individually select raw material and machinery/ equipment. The firms are well aware of modern technology, only larger ones use medium- to high-technology, though. Most firms are reluctant to invest in these expensive machines. Half of them reported on product or process innovations, which are most often hindered by high costs and a lack of qualified personnel (ibid.: pp. 5-22). About 19% of all firms claim to have established an R&D-unit. The most frequent sources of technology include information from customers and in-house design (ibid.: pp. 5-28). However, modern process logistics such as just-in-time management were only implemented in about 15% of the surveyed firms (ibid.: 5-36).

Tab. 4.10: Share of firms with the following capabilities (2000):

Capability	Share of firms	Capability	Share of firms
Technological Capabilities		IT-Capabilities	
Routine maintenance check	89	Use computers	77.5
Planning for improving production	81	Use internet	45.7
Tooling development	75	Use e-commerce	0.1
Plant layout improvement	75	Use electronic data exchange	0.1
Documentation of products/processes	57		
Product/ Process innovation	53		
CAD – Computer-aided Design	18		
CAM – Computer- aided Manufacturing	13		
CAE – Computer-aided Engineering	7		
Product Development Capabilities		Marketing Capabilities	
Improving quality control methods	81	Own marketing	88
Improving existing products and materials	79	Repay loan within the due date	83
Product design	60	Adequate cash for operation	75
Localization of products developed abroad	37	Define important marketing goals in written form	11
R&D Department established	19	Participate in trade fairs and missions (National Trade Fairs)	11
Accredited with ISO	10	Written plan for individual products/ product groups	9
Accredited with QS	1	Participate in trade fairs and missions (International Trade Fairs)	4
Accredited with other standard (e.g. GMP, HACCP, etc.)	16	Participate in trade fairs and missions (International trade Missions)	3

Source: MOI, 2001, own compilation

For **product development capabilities** the study asserts that a significant share of Thai firms perform product and process innovations, yet do not have formal R&D-units or personnel exclusively assigned to this task (ibid.: 5-73). Firms with technological products (chemicals, transportation equipment and electrical machinery) are among those most likely to realise R&D-units. While about 40% of all surveyed firms claim to be able to implement parts production on the basis of customer drawings and to produce models, only 22% see themselves capable of creating prototypes (ibid.: 5-47). The low rate of firms with international standards certifications casts doubt on their product quality (ibid.: 5-42). In respect to **Information Technology (IT) capabilities**, the study detects that Thai firms use computers, but not for advanced functions such as e-commerce or

data exchange. Looking at **marketing capabilities** the authors conclude that the capabilities are average. Companies pursue marketing strategies; the personnel, however, lack “the ability to analyze the demands and trends of the market” (ibid.: 5-73). Overall the survey concludes that medium and large firms have distinctively higher capabilities than small firms. Moreover, export oriented firms possess higher capabilities. For detailed frequencies of the examined capabilities please refer to Tab. 4.10.

In a study sponsored by the World Bank and commissioned by NSTDA on the policy framework and institutional structure supporting industrial technology development in Thailand, Arnold et al. (2000) analyse the accumulation of technological capabilities in Thailand. They assert that TCs in most firms in Thailand are rather weak. Moreover, they emphasise

“that the shallow technological development of Thai industry is deeply embedded in long-standing patterns of behaviour in firms. Market conditions and other factors may be shifting in ways that call for new capabilities and new kinds of technology development activities, but for the majority of firms this is a ‘new world’ in which they have little or no experience” (Arnold et al., 2000: 56).

The authors introduce a simplified classification of firms in terms of demand for technological change and based on the awareness of the need for technical change, the understanding of what to change and the knowledge on how to change.

- Type 1 firms have low or zero demand, since they ‘don’t know that they don’t know’ – they do not realise or recognise the necessity for technical change and thus have difficulty in comprehending and responding to changing market demands.
- Type 2 firms ‘know that they don’t know, but don’t know what’ – they have latent but ineffective demand. Realising the need for change, they do not know how to improve. They lack the necessary skills and expertise to manage technological change, have weak external networks and rely on technical change provided by their suppliers or by observing other firms’ behaviour.
- Type 3 firms ‘know what, but not always where and how’ – they recognise the importance of change, know what to change and have certain skills to do so. However, they do not always know where and how to acquire relevant new technology.
- Type 4 firms are aware of the relevance of technical change. They possess the absorptive capacity and skills for implementing change and acquiring external knowledge and technology. They can utilise well developed networks and seize technological opportunities (ibid.: 24).

For Arnold et al. (2000) the majority of Thai based companies belong to type 1, with a significant share developing towards type 2. Only a few firms can be considered type 3 (ibid.: 57). Consequently, the authors ascertain the following key thresholds for Thai based firms (see Figure 4.8): Most large TNC subsidiaries, many large domestic firms and some high-tech SMEs possess basic operation and technician capabilities, sufficient to acquire, assimilate and operate technology. Currently, they are struggling to develop design and engineering capabilities for technological upgrading and a degree of reverse engineering. The implementation of formal R&D and further

upgrading is considered irrelevant for most firms at this point in time. A large number of SMEs, especially in labour- and resource-based industries, are improving their basic operational capabilities and trying to develop some capabilities for the “efficient acquisition, assimilation and incremental upgrading of fairly standard technology” (ibid.: 57).

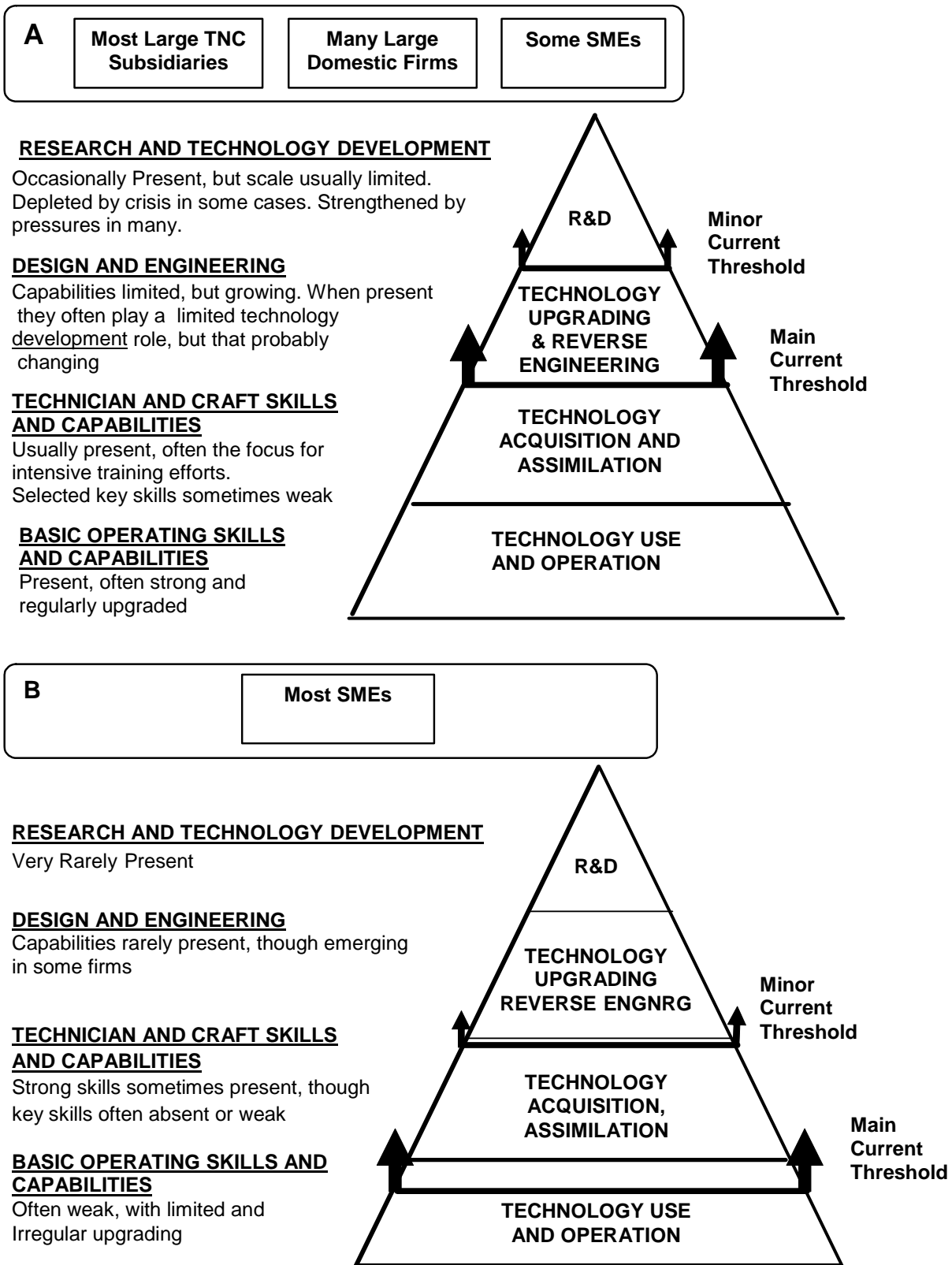
Considering the role of TNC-affiliates, Arnold et al. (2000: pp.62) conclude that the long-standing view of foreign firms undertaking little technology, capability and skill development in Thailand has been changing in recent years. Based on a number of interviews they see a profound change in the works –driven by decentralisation tendencies and a need for on-site engineering and development. Hence, TNC-affiliates are on the verge of increasing local capability development, yet are restricted by a lack of suitable personnel and external training opportunities within Thailand. There is little evidence concerning linkages among these actors in the literature. Intarakumnerd et al. assess that “linkages among the [...] actors of the Thai NIS are generally weak and fragmented” (2002: 1451, see also Kwanjai, 1999: pp.55, Altenburg et al., 2003) and the industrial sector is understood rather as “an agglomeration of largely independent ‘islands’ of manufacturing companies with no strong linkages between them or to other sectors of production” (Chantramonklasri, 1994: 24). In order to gain more insight into these important aspects of a functioning SI, chapter 5 will examine linkages.

In summary, not all studies reviewed share the same evaluation of TCs in Thailand, e.g. MOI (2001) seems to have a more optimistic view than most of the other (sometimes older) studies. However, common ground seems to suggest that most firms in Thailand have not yet developed advanced and innovation related technological capabilities. Innovation activities do take place, but are rarely performed in formal R&D-units and pertain most often to incremental modifications of products and/or processes. On the other hand, many firms still struggle to acquire design and engineering capabilities and lack the ability to introduce computer-aided design and engineering. Moreover, production technology in most companies falls short of state-of-the-art, while advanced acquisition and adaptation capabilities as well as automated production are scarce. Generally, a dichotomy can be observed between more sophisticated large and foreign-owned firms and less capable domestic – and especially small and medium sized – companies.

Having said this, the general perception of most scholars is that “the most striking feature of Thai firms is their weak technological and innovative capability” (Altenburg et al., 2003: 41; see also Intarakumnerd et al., 2002, Intarakumnerd, 2004, Arnold et al., 2000). Intarakumnerd et al. (2002: 1448) point out that Thai firms rely very much on off-the-shelf imported technology in the shape of either machinery or turn-key technology instead of fostering indigenous technological development. The authors argue that this is in part a product of the trading background shared by many Thai firms, which has led to a short-term, very commercially oriented perspective (ibid.).

Nevertheless, there is clear evidence that Thai based firms have gradually developed TCs in due course of industrialisation and are currently in the stage of overcoming intermediate to advanced thresholds (Figure 4.8). While sector affiliation and historic developments have strongly influenced these developments, the core driving force seems to be the competitive pressures associated with a liberalised world economy.

Figure 4.8: Current stages of technological capabilities of firms located in Thailand



Source: Arnold et al., 2000: 58

Moreover, the objectives and capabilities of TNC-affiliates seem to have undergone fundamental change, amidst decentralisation strategies for the headquarters and the need to have development and engineering capabilities on production location. The empirical part of this thesis (chapter 5 and 6) investigates further into this latter aspect. It examines whether or not TNC-affiliates are by now more sophisticated actors and can consequently foster the development of technological capabilities within the Thai system of innovation.

4.2.2.2 Knowledge-related organisations and human capital

This section reflects on the performance of knowledge-related organisations. Firstly, it considers the essential aspect of human capital development in the education system. Secondly, it takes a brief look at the capabilities of universities and public research institutes to shed some light on their suitability for industry collaboration.

Education and Human Capital

The evaluation of the educational standard in Thailand by external observers is not very positive: Even though the official gross enrolment ratio²⁰, at least for primary and secondary education, is favourable (Tab. 4.11) (the ratio in tertiary schooling is also similar to the benchmarking countries). Nevertheless, most students attain vocational colleges rather than universities. Moreover, only a few university faculties provide graduate degrees and curriculum standards are considered poor and outdated. Practical training is insufficient and not reflecting the needs of industry (EIU, 2004, Lall, 2001: pp. 349).

Tab. 4.11: Gross school enrolment ratio* (%) in 2001

Country	Primary School		Secondary School		Tertiary School	
	Female	Male	Female	Male	Female	Male
Thailand	96	100	81 ¹	85 ¹	38	35
Malaysia	95	95	73	66	28 ¹	26 ¹
Singapore	95	96	73 ²	75 ²	40 ³	47 ³
Korea	102	102	91	91	61	102

¹2000, ²1996; ³1997

Source: Asian Development Bank, 2004

Tab. 4.12: Highest level of education attained (most recent years)

Country	No schooling	Primary - incomplete	Primary - completed	Secondary - lower	Secondary - Upper	Post - Secondary
Thailand ¹	8,5	39,3	19,6	12,5	11,2	7,9
Malaysia ²	16,7	13,0	20,7	19,4	23,6	6,9
Singapore ³	14,3	11,2	16,5	36,9	13,7	7,6
Korea ³	8,7	0,9	17,3	15,7	36,2	21,1

¹ Year 2000, age group 6+, ² Year: 1996 age group 25+; ³ Year: 1995 age group 25+

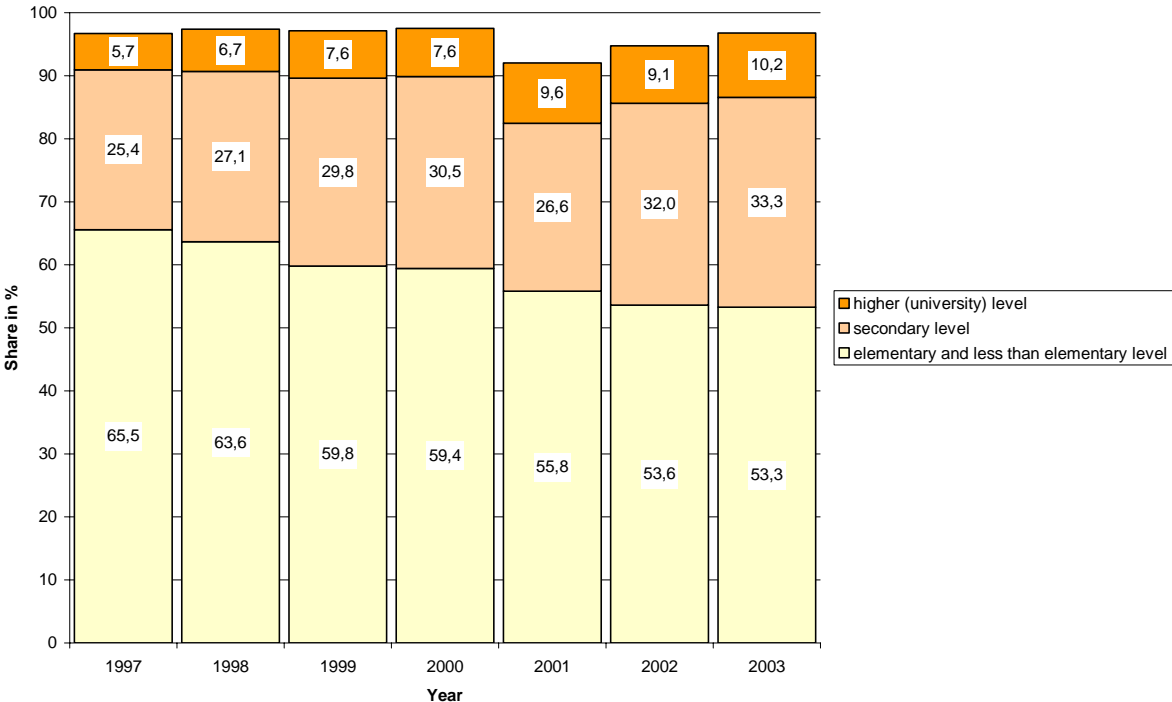
Source: UNESCO Institute for Statistics, 2002

In respect to the highest education level, only 3% of the group aged 25-64 (1996) had completed secondary education versus 42% in Korea, 26% in Malaysia and even 15% in Indonesia. A

²⁰ Gross Enrolment Ratio (%) is the number of pupils enrolled in the given level of education, regardless of age, expressed as a % of the population which, according to national regulations, should be enrolled at this level. For countries with universal primary (secondary) education, the gross enrolment ratio may exceed 100 percent because some enrolled pupils are below or above the official school age (Asian Development Bank, 2004: 383)

remarkable low level caused by low enrolment rates in the 1960s and 70s, when the Thai government was focusing on primary education goals (Worldbank, 2000: 8). This evaluation is backed by UNESCO (2002) data (Tab. 4.12), although the figures are difficult to compare, since reference group and year vary considerably. Further support is provided by the Thai Labour Force Survey (Figure 4.9), which shows that more than 50% of the workforce has elementary or lower than elementary education level. Due to an increase of enrolment in secondary and tertiary education in recent years, the share of higher educated personnel in manufacturing has, however, increased from 1997 to 2003.

Figure 4.9: Qualification Structure of employees in manufacturing 1997 – 2003



NB Figures are based on the 1st quarter report of each year. The figures do not add up to 100%, because following categories were excluded: ‘teacher training’, ‘short course vocational’, ‘others’ and ‘unknown’.

Source: National Statistical Office, 1997, 1998, 1999, 2000, 2001, 2002, 2003, own calculations

In addition to these statistics, evaluations show that graduates of secondary schools have low reading and writing skills, are much too focused on memorising and too little on problem solving. Although students score well in science and mathematics in comparison with pupils in advanced economies, they lag behind their fellow students in neighbouring countries (Middleton & Tzannatos, 1998). Moreover, most engineers and technicians have limited foreign language skills (English as well as Japanese), posing a problem for efficient work and technology transfer in TNC-affiliates (Tambunlertchai, 2002: 42). As a consequence, roughly 40% of companies are concerned about the education level of job applicants, particularly in respect to communication skills (Worldbank, 2001: pp. 12).

The low skill standard is also reflected in low labour productivity (ibid.). Consequently, the “skills required to shift to higher value-added and high-technology industries are still in short supply” (EIU, 2004: 20). Consequently, the shortage of skilled labour is seen as a key obstacle to economic growth and technological development (Middleton & Tzannatos, 1998, Tambunlertchai, 2002: 41).

This is especially true for S&T-manpower, which is regarded as essential for economic development and upgrading. Only 19% of university graduates in Thailand choose S&T degrees (Alpha Research, 2003: 109; see Tab. 4.13), versus 52% in Malaysia (EIU, 2004) and 49% in Korea in 2001/2002 (UNESCO Institute for Statistics, 2004).

Tab. 4.13: Graduates in higher education from public institutions, academic years 1996 - 1999

	1996	1997	1998	1999
Total number of graduates	73,525	82,716	88,154	93,809
Field of study (%)				
Education	12.1	12.9	12.0	12.4
Humanities	4.0	3.4	3.3	3.4
Fine arts	0.9	0.9	1.0	0.9
Law	7.0	7.8	5.8	5.7
Social science	40.9	39.8	41.2	40.9
Natural science	6.4	7.4	7.5	8.2
Engineering	10.2	10.1	10.3	10.5
Medical and health science	12.3	12.2	13.7	12.6
Agriculture	5.6	5.4	5.0	5.2
Others	0.5	0.2	0.1	0.2
Level of education				
Certificate	1.4	1.8	1.9	0.6
Bachelor's	83.0	79.7	78.9	78.5
Post graduate	1.3	1.4	1.6	1.4
Master's	14.0	16.9	17.4	19.3
Doctorate	0.3	0.2	0.2	0.2

Source: Alpha Research, 2003: 113

The mis-match between supply and demand of S&T-manpower in quantitative and qualitative terms has frequently been pointed out by several studies (e.g. Dahlman & Brimble, 1990: chapter 6, Sripaipan & Brimble, 1991, Rangel, 2001, Ritchie, 2000). Even without growing demand for high-skilled employees the Brooker Group predicted in 1997 a manpower gap for 2001 of about 10,000 persons in engineering and 7,000 in science (both at bachelor degree).

However, taken the enrolment rates of the last years, a steep increase in qualified graduates entering the labour market will have been expected in recent years (Worldbank, 2000: 8).

Based on predictions for supply and demand of S&T-labour, Mephokee (2003: pp. 13) concludes that there will be an excess in S&T-labour by 2005, despite shortages at certain levels such as bachelor of science. Nevertheless, based on international comparisons he states that the quantity of human resources in S&T in Thailand is somewhat small and must be improved further (ibid.: 19).

Tab. 4.14: Education expenditure as % of GDP (2001)

Country	Total	Pre- Primary	Primary	Secondary	Tertiary
Thailand	4.7	0.5	1.6	1.0	0.9
Malaysia	7.2	0.1	2.2	2.7	2.1
Singapore	NA				
Korea	6.0	0.1	1.5	2.0	2.1

Source: UNESCO Institute for Statistics, 2004

This goal is, however, hampered by low resource commitment to education (Tab. 4.14). Funding of secondary and tertiary education in particular (approximately 20% of total) is remarkably low when compared to Malaysia and Korea (around 30 – 35 %).

Tab. 4.15: Gap of knowledge and skills of human resources between industry’s demand and education institutes’ supply

Industries	Gap	Education Institutes
Using specific and sophisticated technology and more interdisciplinary knowledge needed	Lacking knowledge and technology information with real-life practical lessons	Using obsolete technology. Too departmentalized knowledge
Little participation in curriculum development	Lacking mechanism in integrating academic curriculum with demands from industries	Developing curriculum based on what instructors believe appropriate
Emphasis on analytical skills in problem solving	Lacking methodology in cultivating students to be self-learners	Emphasis on theoretical lessons and examinations more than self-learning
Need knowledge and working skills such as basic statistics and quality management	Those essential knowledge are not addressed as prerequisite or required courses	Statistics and quality management are selective courses; few students choose to study
Need literacy skills, such as English communication , computer programming skills for managing work processes	Lacking important skills especially for today’s globalization economy, such as skills in international-language communication and computer management	Some courses like English are compulsory courses but not considered by students as important courses. Some courses (e.g. computer) are not available

Source: College of Management, Mahidol University (2003); cited in Intarakumnerd et al., 2003: 25

A recent study by the College of Management at Mahidol University in 2003 (published in Thai; cited in Intarakumnerd et al., 2003: pp.23) shows that the overall knowledge flow between education institutes and industry is exclusively one-way. Curricula are developed by education institutes based on what they believe appropriate, and without consultations with business firms. Moreover, education institutes emphasize “know what” rather than “know how” and “know why”. This conflicts with a need for creativity and continuous self-learning ability, which are important employee characteristics demanded by employers. Consequently, there are several gaps depicted in Tab. 4.15. These gaps have been further illustrated through surveys conducted by TDRI (2002) and the College of Management at Mahidol University (2003) (original in Thai, hence cited according to Intarakumnerd et al., 2003), showing that the education organizations can not meet the demands of industry. Tab. 4.16 presents the results for the case study sectors of automobile and electronics industry (see chapter 6).

Tab. 4.16: Gap between industry’s demand and education institutes’ supply: Examples from the electronics and automobile industry

Industrial Sector’s Demands	Education Institutes’ Realities
Electronic Industry	
<ul style="list-style-type: none"> - Due to rapid changes in this industry’s technology, personnel’s continuous learning ability through internet and information technology play a vital role - Workers lack initiative and eagerness to study/manage new technology, which impedes long-term competitiveness - Due to short product life cycle and faster time to market requirement, effective workers with good operating quality (such as computer controller in production line) to reduce production time are needed. - Insufficient engineering managers, electronics engineers, electrical engineers, mechanical engineers and industrial engineers with industrial experience 	<ul style="list-style-type: none"> - Education institutes fail to catch up with technological changes in industry and very limited in advanced IT study to major universities - Current educational environment do not promote students’ creativity and continuous self learning; institutes emphasize on academic knowledge and examination - In some education institutes, some necessary computer courses have not been introduced into curriculum - Most engineering students do not have practical experience in the industry; only career advising services provided by universities and companies. A better cooperative project with industry is needed to enhance students’ experience
Automobile Industry	
<ul style="list-style-type: none"> - Insufficient engineers with strong technical/engineering skills necessary for fewer-defect production demanded by customers - Since most technologies are imported, lacking English and basic technical skills are serious problems impeding transferring and continuous development of technologies - Due to more complex technologies, specialized-area workers are needed such as those who can handle automation processes 	<ul style="list-style-type: none"> - Education institutes fail to catch up with rapid technological changes in the industry; more emphasis on traditional academic curriculum sometimes using obsolete technologies. - Some universities’ courses are required courses, such as English, but are not stressed as major/important courses.

Source: TDRI, 2002, Mahidol University, 2003, cited in Intarakumnerd et al., 2003: 25

Scientific and applied research in universities and research institutes

Currently, there are about 24 public and 50 private universities (Intarakumnerd et al., 2002: 1451) as well as four major national research institutes under the roof of the National Science and Technology Development Agency (NSTDA): The National Center for Genetic Engineering and Biotechnology (BIOTEC) established in 1983; the National Metal and Materials Technology Center (MTEC) and the National Electronics and Computer Technology Center (NECTEC), both founded in 1986. The latest national center, the National Nanotechnology Center (NANOTEC) was established in 2003 (NSTDA, 2004). Since the opening of the Thailand Science Park in 2002 in Klong Luang, Phatumthani province, these national research centres have concentrated at this site, which is located adjacent to the Asian Institute of Technology and the Rangsit Campus of Thammasat University.

In order to estimate the scientific output of both research institutes and universities in Thailand and the benchmarking countries an online literature review of ISI’s Web of Science (Thomson, 2004), a major scientific publication and citation database, has been conducted. Tab. 4.17 displays the number of journal articles published by authors located in each country from 2000-2004.

Furthermore, it sets the figures in relation to the number of inhabitants in 2003 (Asian Development Bank, 2003) and the number of teaching staff in tertiary education 2001/2002 (UNESCO Institute for Statistics, 2004), which serves as an approximation for the number of researchers at universities.

Tab. 4.17: Publications included in the ISI Web of science (2000-2004)

Country	SCI ²¹	SSCI ²²	SCI per 1,000 residents	SSCI per 1,000 residents	SCI per teacher	SSCI per teacher
Thailand	9,291	473	0.15	0.01	0.15	0.01
Korea	97,161	2,409	2.03	0.05	0.64	0.02
Taiwan	61,567	2,870	2.72	0.13	NA	
Singapore	23,752	1,901	5.66	0.45		
Malaysia	5,559	293	0.22	0.01	0.18	0.01
Indonesia	2,493	299	0.01	0.00	0.01	0.00

Source: Thomson, 2004, UNESCO Institute for Statistics, 2004, Asian Development Bank, 2004

The analysis reveals that the scientific output in terms of science and social science publications in Thailand is weak compared to Korea, Singapore, Taiwan, and Malaysia as well. Of the considered countries, only researchers in Indonesia publish less. This supports Intarakumnerd et al. finding that universities' "research capabilities are generally unsatisfactory" (2002: 1451). Arnold et al state that there is hardly any "international excellence in industry-relevant R&D in the universities" in Thailand (2000: 119).

Additionally, research in public research and technology organisations (RTOs) is considered irrelevant to the industry. To the contrary, RTOs tend to focus on R&D and the provision of technical services, such as testing and calibrating, rather than helping local firms overcome the current thresholds of technology assimilation and adaptation, designing and engineering (Intarakumnerd & Virasa, 2002: pp.1450, Intarakumnerd, 2004). For this reason, RTOs have been criticised for being too supply- and 'linear-model-of-innovation'-oriented, performing basic research for companies instead of collaborating with them (e.g. Lauridsen, 2000: 24, Schiller, 2003: 76, Chantramonklasri, 1994). In industrialised countries it is quite common for firms to pick up results of basic research done by R&D-institutes and universities as an input into their own R&D activities. This, however, is clearly more complicated in late-industrialising countries, where firms lack R&D-capabilities (Arnold et al., 2000: 107). Consequently, at least some of the universities and research institutes should move towards more applied research and should give more attention to people centred technology transfer (Arnold et al., 2000: pp. 121).

²¹ Science Citation Index Expanded is a multidisciplinary index to the journal literature of the sciences. It fully indexes 5,900 major journals across 150 scientific disciplines, including among others: agriculture, neuroscience, astronomy, oncology, biochemistry, biology, pharmacology, biotechnology, physics, chemistry, computer science, materials science, mathematics, surgery and medicine (Thomson, 2004).

²² The Social Sciences Citation Index is also a multidisciplinary index to the journal literature of the social sciences. It fully indexes more than 1,725 journals across 50 social sciences disciplines, and it indexes individually selected, relevant items from over 3,300 of the world's leading scientific and technical journals. Among others it includes the following disciplines: anthropology, political science, history, public health, industrial relations, social issues, law, sociology, linguistics, philosophy, urban studies, psychology (Thomson, 2004).

Linkages between private firms, universities and research institutes are weak. This has partly to do with the fact that business firms doubt the capacity and effectiveness of universities and public research institutes to solve practical problems (Vongpanitlerd, 1992: 85). Existing university-industry linkages are based primarily on personal connections between researchers and firms (Intarakumnerd et al., 2002: 1451). A survey by the Brooker Group (1995: iii) finds that links are “not very substantial and represent short term training or ad-hoc use of consulting or research services rather than long term, more extensive relationships”. According to Arnold et al. (2000: 117), this situation has not changed extensively since the mid-1990s.

A recent study by the College of Management at Mahidol University (2003) identifies the following gaps, which hinder industry-academia collaboration (cited in Intarakumnerd, 2004: 28): first, a lack of continuous cooperative projects or activities and motivation for collaboration; second, missing goals and objectives of the collaboration; third, a lack of intermediates who can understand both sides, coach, and foster the relationship; and finally, a lack of mutual understanding of the partner’s perspective. Currently, a research project organized by economic geographers at the University of Kiel and Hannover investigates the changing role of public research institutions for the national and regional innovation potential in Thailand. Within this project the science and industry side are surveyed, in order to assess the magnitude and type of industry-university linkages as well as structural obstacles for further cooperation (Schiller, 2005, Mildahn, in preparation).

In summary, the output of the knowledge-related public sector is insufficient in terms of quality and quantity. Graduates lack essential skills, there are too few S&T-graduates, the education system is underfunded, and curricula are outdated and not oriented towards the needs of industry. Additionally, scientific research is not relevant to industrial needs and is of an internationally low level of quality. Consequently, there are large gaps between the education/ research sector and the business sector resulting in very limited linkages and interactions, which are instead predominantly of a personal, ad-hoc nature.

4.2.2.3 Government policies and organisations

This section briefly addresses the chief organisations responsible for science and technology policies in Thailand. Even though human skills development and broader industrial development are of major importance for late-industrialising countries, an analysis of all organisations responsible and their policies is beyond the scope of this thesis.

The central planning agency in Thailand is the National Economic and Social Development Board (NESDB), which was established in 1959 (Kwanjai, 1999: 56). The NESDB is responsible for the formulation of strategic ‘National Economic and Social Development Plans’, each covering a period of five years. The first four plans (from 1961 to 1981) did not treat science and technology policies separately and hence gave little prominence to these issues (Lauridsen, 2000: 21). However, in the 1950s the National Research Council of Thailand (NRCT) had already been introduced under the Office of the Prime Minister as a cross cutting policy institution responsible for the development of a national science policy (Arnold et al., 2000: 112, Bell, 2003: 21). In 1979 the Ministry of Science, Technology and Energy (later Environment) (MOSTE) was set up,

effectively succeeding the now incorporated NRCT, as an oversight body for all government policies in S&T. Since many S&T responsibilities were still with the line ministries, MOSTE's role was fairly general (Arnold et al., 2000: 114).

Finally, S&T topics were explicitly addressed in the 5th (1982-1986) and 6th (1987-1991) plans. The latter described the key problems concerning S&T in a specific chapter: a low level of R&D-expenditure, insufficient technological and economic benefits from technology transfer and the insufficient quantity and quality of S&T-manpower. Furthermore, it proposed measures, e.g. institutional strengthening of S&T-policy formulation, planning and implementation, an increase in S&T-manpower as well as in R&D-spending (aim of 0.5% of GNP), and the enhancement of foreign technology transfer (Lauridsen, 2000: pp. 21). Nonetheless, these objectives were rarely formulated into concrete policies

In the 1980s three important organisations were established: first, three national research centres (BIOTEC, MTEC and NECTEC, see 4.2.2.2), secondly, the Scientific and Technology Development Board (STDB), an R&D-funding organisation with a focus on the private sector, and third, the Thailand Development Research Institute (TDRI), a think-tank (Arnold et al., 2000: 114). The 1990s saw the foundation of the National Science and Technology Development Agency (NSTDA) and the Thailand Research Fund (TRF). NSTDA came into being in 1991 under the roof of MOSTE as a 'specialised agency' outside of the standard government bureaucracy. NSTDA was assigned to run the three national research centres and, hence, to both conduct research and fund research in universities and private industry. Consequently, the private sector operations of STDB were incorporated into NSTDA. Moreover, NSTDA became responsible for human resource development programmes, the management of the Science Park (see 4.2.2.2) and the Software Park, an incubator for IT start-ups. Furthermore, NSTDA includes a policy department, assigned to conduct S&T-policy-analysis and generate policy recommendations (Arnold et al., 2000: 115). The TRF, founded in 1993, is an R&D-funding organisation focusing on universities and public institutes (*ibid.*).

In 1997, a specific National Science and Technology Development Plan (1997-2006) was introduced (MOSTE, 1996), which explicitly set targets for manpower development, technology transfer, infrastructure and R&D-expenditure. Furthermore, a Science and Technology Development Action Plan specifying the general targets, was developed. The current 'S&T Action Plan 2003-2013' highlights the strengthening of both the national innovation system and industrial clusters (Intarakumnerd, 2004).

In 2001, the NRCT was removed from MOSTE and again located as an independent agency reporting directly to the Prime Minister. Its task is to review ministries' R&D-budgets at the project level and to manage research projects. Moreover, the government created the interim National Science and Technology Policy Committee (NSTC), which is supposed to advise the cabinet on the development of scientific and technological activities and capabilities (Bell, 2003: 22). In October 2003, the MOST (since 2002 the ministry is solely responsible for S&T) established the National Innovation Agency (NIA), which strives to enhance the national innovation system by inducing innovation in firms largely by providing funds for R&D (NIA, 2005).

This brief overview of some of the main organisations already indicates that there are a large number of administrative bodies responsible for S&T-related policies. On the one hand, this wide array of organisations leads to an overlap of responsibilities and functions, hindering efficient policies and implementation. On the other hand, these cross-cutting policy organisations are not well endowed, since line ministries account for around 90% of total government R&D-spending. These ministries generally assign funds to their core mission and to ministry-related bodies, which leads to parallel and uncoordinated work (Bell, 2003: pp. 22). Hence, a single, influential cross-cutting and coordinating actor such as the NRCT or NSTC would be advantageous (see also Altenburg et al., 2003: 50). However, it is still too early to judge these coordination efforts.

The wide array of organisations responsible for S&T and policy formulation is also reflective of a complex and fragmented set of incentive programmes supporting innovation, skills and capabilities development in private firms (Turpin, 1999: pp. 20). Measures include, for example, tax incentives, grants, consultancy, and training programmes (Bell, 2003: pp. 25). However, rather than aiding the firm, this fragmentation hinders efficient support of firm's upgrading (Turpin, 1999: 24). Moreover, Turpin et al. (2002: 38) state that the major problems with current incentive schemes are the elevated emphasis on R&D, which does not align with the needs of most firms (see 4.2.2.1), the supply- rather than demand-driven nature of the incentives, as well as an overlapping and general lack of coordination of incentives.

In respect to S&T-policies, Bell et al. (2003: pp. 27) criticise the Thai policy system for being much too centrally organised. At the same time, ministries do not efficiently implement the 'top-down' policies (ibid.). Most often, policy formulation is seen as an intra-ministry, ad-hoc affair instead of being the result of a clearly articulated strategy. The involvement of the private sector is of a rather 'representative' nature. Moreover, there is too little monitoring and evaluation of projects, while existing evaluations do not influence new policy formulations and implementations. Several ministries lack specialised knowledge about S&T and innovation, although they have these particular responsibilities. Furthermore, the distinction between policy formulation and implementation is often unclear and there is too little horizontal integration and collaboration, leading to redundant projects (see also Altenburg et al., 2003: pp. 38). Finally, Bell et al. (2003: 31) claim that government R&D-funding is too low and that most of the R&D funded by the government is also performed by government organisations instead of stimulating industry R&D.

This assessment of the policy environment is shared by Intarakumnerd et al. (2002: 1450), who additionally state that neither industrial nor investment or trade policy have attempted to foster indigenous technology capability development or technological learning.

With respect to strengthening the NSI, Altenburg et al. (2003: pp. 46) have identified four core dimensions of innovation policy that should be addressed: assigning responsibility within the Thai government for creating a coherent policy strategy and ensuring coordination, fostering inter-firm linkages and industry-science relations as well as the promotion of innovative entrepreneurs.

Already, there are signs of change: foreign investment policies are more selective and support for supplier-customer linkages has been enhanced (see 4.1.3.4); a strong focus has been laid on the competitiveness issue in selected industries; public RTOs are required to increase revenues and to

orientate towards industrial needs; universities enjoy increased autonomy; the public is increasingly participating in policy planning; and a 'private sector's management style' has been attempted to be introduced in the bureaucratic system (see Intarakumnerd, 2004, Intarakumnerd et al., 2002, Altenburg et al., 2003).

In summary, the reviewed secondary data and literature leads to the conclusion that the state of the Thai NSI is fairly poor. Financial and human resources committed to innovation are low, as is the output in terms of patents. Furthermore, there are major deficits in all three actor-groups. The **firm-sector** is characterised by a dichotomy of fairly capable TNC-affiliates, some larger Thai-owned firms and some high-tech SMEs on the one hand. On the other hand, the bulk of SMEs are struggling to achieve even basic operation skills. Moreover, both groups lack innovative capabilities, especially R&D, have limited product development and engineering capabilities as well as difficulty in implementing advanced processes such as automation or modern organisation modes like JIT. Inter-firm links seem to be limited, especially between TNC-affiliates and local SMEs.

The assessment of the **knowledge-related public sector** reveals that the output of the education and research sector is insufficient in terms of quality and quantity. Graduates lack essential skills, there are too few S&T-graduates, the education system is underfunded, and curricula are outdated and not oriented towards the needs of industry. The same is true for scientific research, which is at a fairly low level internationally as indicated by the number of journal articles. Hence, this sector is neither sophisticated enough to cater to the needs of the more capable firms, nor sufficiently oriented towards the more basic needs of the larger group of less capable firms. Consequently, there are large gaps between the education/research- and the business-sector leading to marginal linkages and interactions between these groups.

Finally, **government policies** and processes are highly centralised and, at the same time, characterised by a redundancy of organisations and programmes with similar objectives. This leads to a fragmented and inefficient support system. Having said this, evidence has been presented which indicates changes in this respect.

5 TNC-affiliates and local firms compared: technological capabilities, absorptive capacity, embeddedness and obstacles to innovation

The first chapters have underlined the theoretical and potentially positive impacts of TNC-affiliates on the system of innovation in late-industrialising countries. Subsequently, the present state of the Thai-SI has been evaluated, based on secondary data and literature. This analysis has indicated fairly high capabilities within TNC-affiliates in Thailand. If this were true, TNC-affiliates could also have a marked positive impact on the modernisation and upgrading of local firms in Thailand through technology and knowledge transfer. Therefore, TNC-affiliates would be attractive partners for collaboration and knowledge exchange, which could foster technological learning by local firms either via teacher-student learning or joint research and work.

Consequently, this chapter tries to establish the capabilities of TNCs and their collaboration behaviour. It is organised as follows: first, section 5.1 provides some general information on the analysed datasets. Second, the hypotheses deduced in chapter 2.4 will be tested, hereby in section 5.2 all firms are analysed, while in section 5.3 the analysis concentrates on advanced firms. The intention is to discover whether advanced local firms can find suitable collaboration partners among foreign firms or not, which is of course strongly sector-dependent, as collaboration requires a common basis and mutual understanding. Finally, some explorative statistics are applied in order to pinpoint key characteristics of advanced and embedded TNC-affiliates and to determine essential weaknesses of the Thai-SI according to the perception of the surveyed firms. Additionally, the embeddedness of TNC-affiliates in knowledge networks is considered and the key characteristics of advanced and embedded firms are examined.

In order to evaluate these findings, most of the results are benchmarked with firms in Singapore and Penang.

5.1 General information

It is stated in chapter 2.3.1 that TNC-affiliates (subsidiaries and branches) are commonly defined by an ownership of 10% or more (UNCTAD 2001). However, it has also been mentioned that other definitions consider a 25%-limit as necessary for foreign control. This thesis defines TNC-affiliates as firms with a foreign ownership of 30% or more. The reason for this is that the questionnaires in all four surveys do not take account of the 10% limit. The surveys in Penang and Thailand distinguish between '100% locally owned' and 'more than 70% locally owned' firms. Because a significant capital stake is necessary to control operations, the 30%-limit is the best available and also considered an appropriate level.

However, in Singapore and Europe the definition of TNC-affiliates has had to be changed, due to differences in the questionnaire. Here, all firms that are not 100% locally owned are considered

foreign²³. Hence, for direct comparison these differences in the definitions need to be kept in mind in order to avoid misinterpretations.

For Thailand the dataset includes 593 local and 401 foreign firms in 2000 and 866 local and 498 foreign firms in 2002. For Singapore it contains information on 190 local and 183 foreign, for Penang on 116 local and 76 foreign and for Europe on 809 local and 233 foreign firms. The analysis in part 5.2 includes additional information on four focus industries in Thailand. These sectors are: food, beverage and tobacco (TSIC code 31), textiles, wearing apparels, leather and leather products (32), chemicals and chemical, petroleum, coal, rubber and plastic products (35) and fabricated metal products, machinery and equipment (38). The choice of sectors is based on the size of the sub-samples and the fact that these are the top four industries in terms of GDP-contribution within manufacturing (see. 4.1.2).

In what follows, some basic indicators are presented, describing the composition of the sample and depicting key differences between TNC-affiliates and local firms.

Age

In Thailand, TNC-affiliates are significantly younger than local firms (Tab. 5.1). The average age for foreign firms is 14.2 (2000) and 13.6 years (2002), while for local firms it is 18.3 years (2000 and 2002). The difference in the means of both years is significant at the 1% level (Mann-Whitney-U-Test²⁴). In Singapore, TNCs are on average older (16.7 years) than local firms (14 years)²⁵, which is significant at the 1% level. In Penang, both local and foreign firms are of a similar average age (13.1 for local and 12.7 for foreign firms).

Tab. 5.1: Distribution of surveyed firms according to age-class

Age / n	Thailand				Singapore 1999**		Penang 2000	
	2000***		2002***		Local	Foreign	Local	Foreign
	Local	Foreign	Local	Foreign				
	540	373	851	485	188	182	119	76
<5	3.1	12.1	3.6	6.4	4.3	5.5	12.7	11.8
5-9	22.6	20.6	19.5	30.3	34.0	23.1	29.1	35.5
10-19	35.7	45.8	39.7	45.6	37.2	32.4	33.6	34.2
20-29	23.9	9.9	22.2	9.9	18.6	29.1	20.9	17.1
>=30	14.6	11.5	14.9	7.8	5.9	9.9	3.6	1.3

*** significant at the 1% level, ** significant at the 5% level (Pearson's Chi-Square)

Number of employees

In Thailand, the mean number of employees in TNC-affiliates is significantly (1% level) higher (1999: 772; 2001: 621) than in local firms (1999: 453; 2001: 384) (Tab. 5.2). In Singapore, firms are generally smaller, but the pattern is the same: 133 employees on average in local and 394 in

²³ In Singapore ownership classes were differentiated into a) wholly foreign owned, b) 30% or less locally owned, c) more than 30% locally owned and d) wholly locally owned. By grouping classes a to c into foreign the resulting mismatch is supposed to be smaller than by grouping classes a and b into foreign and c and d into local. The total number of firms in the disputable group c is 46 (12% of all firms). Assuming equal distribution a total of 30% of firms in this group might be mis-categorized. i.e. 14 companies.

In Europe, the questionnaire only included a dichotomic question concerning the involvement of foreign capital.

²⁴ Since for most scrutinised variables a normal distribution can not necessarily be assumed in the population, the default test for the comparison of means is the Mann-Whitney-U-Test, which does not require normal distributed data. The test sorts values of both distributions and assigns ranks. Subsequently it tests if the ranks are distributed equally (Bortz, 1999: pp. 146).

²⁵ This is also true, when category c) and d) are grouped as local firms (see footnote 23).

foreign companies (1% level). The same is true for Penang, with a mean of 168 employees in local and 524 employees in foreign firms (1% level).

Tab. 5.2: Distribution of surveyed firms according to number of employees

No. of employees / n	Thailand				Singapore 1999***		Penang 1999***	
	1999***		2001***		Local	Foreign	Local	Foreign
	Local	Foreign	Local	Foreign				
	575	391	862	497	160	173	105	69
<20	2.4	0.8	2.5	1.6	37.5	12.1	16.2	4.3
20-49	12.3	5.6	10.2	7.4	19.4	14.5	14.3	11.6
50-99	14.1	11.5	13.3	12.3	19.4	21.4	24.8	13.0
100-299	28.2	31.2	37.7	33.6	11.9	24.9	33.3	33.3
300-499	14.8	16.9	14.6	15.9	5.0	8.1	3.8	8.7
500-999	16.2	15.6	12.1	13.9	1.3	8.7	3.8	14.5
>=1000	12.0	18.4	9.5	15.3	5.6	10.4	3.8	14.5

*** significant at the 1% level (Pearson's Chi-Square); Restriction: TIS1 2 cells, TIS2 one cell and PIS three cells with expected count <5

Fixed Assets

In Thailand, TNC-affiliates have significantly more fixed assets²⁶ than local companies (Tab. 5.3). The median for TNC-affiliates is approximately US\$ 9.0m in 1999 and US\$ 4.2m in 2001, for local firms US\$ 3.1m in 1999 and US\$ 1.8m in 2001 (1% level)²⁷. The same holds true for companies in Singapore and Penang.

In Singapore, the median for local firms is in the class of 'below S\$5m' (approximately US\$ 2.9m), whereas for foreign firms it is in the class of 'S\$10-49.9m' (US\$ 5.8- 28.9m). In Penang, local firms have their median in the 'below RM 10m' (US\$ 2.6m) class, foreign firms in the 'RM 10-25m' (US\$2.6- 6.6m) category.

Tab. 5.3: Distribution of surveyed firms in Thailand according to fixed assets

Fixed assets in Mio. Bhat / n	2000***		2002***	
	Local 255	Foreign 173	Local 257	Foreign 159
1-9	6.3	0.6	9.7	3.1
10-49	24.3	9.2	27.2	16.4
50-99	13.3	15.6	15.2	15.1
100-199	16.9	12.7	18.7	15.1
200-499	15.7	21.4	8.2	16.4
500-999	7.8	13.3	9.3	11.3
>1000	15.7	27.2	11.7	22.6

*** significant at the 1% level (Pearson's Chi-Square); classes according to National Statistical Office & Office of the Prime Minister, 2001

Sales

In Thailand, TNC-affiliates have significantly higher sales (Tab. 5.4): The median for TNC-affiliates is US\$ 14.6m (1999)/ 10.6m (2001), for local firms US\$ 6.5m (1999)/ 3.3m (2001) (1% level). Again, the same pattern can be observed in Singapore and Penang. In Singapore, the median for local firms is in the class of 'below S\$ 5m' (US\$ 2.9m), whereas for foreign firms it is in the class of 'S\$ 10-49.9m' (US\$ 5.8-28.9m). In Penang, the median for local firms is US\$ 2.4m and 9.0m for foreign firms (1% level).

²⁶ Companies' assets that are not processed or bought and sold, such as buildings and machinery.

²⁷ These and the following are based on the exchange rate for June of the respective year.

Tab. 5.4: Distribution of surveyed firms in Thailand according to sales

Sales in Mio. Bhat /n	1999***		2001***	
	Local 593	Foreign 401	Local 318	Foreign 177
<64	31.2	12.0	31.1	15.3
64-<250	20.9	13.7	26.1	23.2
250-<900	31.2	39.4	23.6	27.1
>= 900	16.7	34.9	19.2	34.5

*** significant at the 1% level (Pearson's Chi-Square); classes according to quartiles 2001

Sales per employee

In Thailand, TNC-affiliates have higher sales per employee (Tab. 5.5), i.e. they are more productive than local companies. The median for local firms is US\$ 25,100 (1999)/ 17,600 (2001) and for foreign firms US\$ 54,400 (1999)/ 39,700 (2001) per employee (1% level)²⁸. The companies in Singapore and Penang again replicate this pattern. In Singapore, local firms display a median of US\$ 103,500 per employee whereas foreign companies have a median of US\$ 209,500 (1% level). In Penang, foreign firms have higher sales per employee, with a median of US\$ 50,200, than local firms with US\$ 34,500 (5% level).

Tab. 5.5: Distribution of surveyed firms in Thailand according to sales per employee

Sales in Bhat per employee / n	1999***		2001***	
	Local 555	Foreign 375	Local 317	Foreign 177
<=552.150	29.0	12.5	31.9	13.0
552.151 – 1.071.750	29.0	16.3	30.0	16.9
1.071.751 – 2.442.350	24.1	30.4	22.4	29.4
> 2.442.350	17.8	40.8	15.8	40.7

*** significant at the 1% level (Pearson's Chi-Square); classes according to (rounded) quartiles 2001

Sector

In Thailand, there are significant differences in the sectoral distribution of TNC-affiliates and local firms (Tab. 5.6). TNC-affiliates are more likely to operate in the manufacturing of fabricated metal products, machinery and equipment sector (ISIC 38) whereas local firms are distinctively more often active in the food/ beverage and textile/wearing apparel industry.

Tab. 5.6: Sectoral distribution of surveyed firms in Thailand

Sector / n	2000***			2002***		
	Local 593	Foreign 401	Total 994	Local 866	Foreign 498	Total 1364
Food, beverages, tobacco	17.7	9.5	14.4	15.8	7.6	12.8
Textiles, wearing apparel	16.9	9.5	13.9	19.2	10.2	15.9
Wood, wood products	5.6	1.0	3.7	6.2	1.0	4.3
Paper, paper products, printing	6.9	3.0	5.3	7.2	3.0	5.6
Chemicals & chemical	21.2	25.9	23.1	21.2	22.9	21.8
Non-metallic mineral products	4.9	1.2	3.4	4.0	1.8	3.2
Basic metal industry	1.2	3.0	1.9	3.8	5.8	4.5
Machinery and equipment	23.3	44.4	31.8	20.3	45.4	29.5
Other	2.4	2.5	2.4	2.2	2.2	2.2

*** significant at the 1% level (Pearson's Chi-Square)

²⁸ The median is given, because it is less distorted than the mean by extreme, sometimes unreliable information.

In Singapore, firms surveyed were limited to five sectors (see chapter 3.2.1 on sampling strategy). Local firms often do more business in the machinery and equipment sector (ISIC 38), while TNC-affiliates focus more on chemicals (35). In Penang, foreign firms are more often involved in the fabricated metals, machinery and equipment sector (38), while local firms dominate both the food (31) and paper (34) industries (Tab. 5.7).

Tab. 5.7: Sectoral distribution of surveyed firms in Singapore and Penang

Sector / n	Singapore			Penang		
	Local 188	Foreign 181	Total 369	Local 116	Foreign 76	Total 192
Food, beverages, tobacco	-	-	-	14.7	2.6	9.9
Textiles, wearing apparel	-	-	-	0.9	2.6	1.6
Wood, wood products	-	-	-	2.6	-	1.6
Paper, paper products, printing	-	-	-	9.5	1.3	6.3
Chemicals & chemical	16.0	25.4	20.6	23.3	23.7	23.4
Non-metallic mineral products	7.4	4.4	6.0	0.9	-	0.5
Basic metal industry	2.1	1.6	1.9	6.0	5.3	5.7
Machinery and equipment	75.0	69.1	72.1	38.8	60.5	47.4
Other	-	-	-	3.4	3.9	3.6

NB In Singapore and Penang national classification is based on ISIC Rev. 3, which had to be matched with the TSIC-classes that are based on ISIC, Rev. 2.

Market orientation

In Thailand, TNC-affiliates are more oriented towards export markets than local firms (Tab. 5.8). Exports account for 53% (mean) of sales for TNC-affiliates (median 50%) and only 38% for local firms (median 20%) in 2001 (significant at 1% level). In 1999, the average was 61% for TNC-affiliates (median: 70%) and 55% for local firms (median: 57%) (5% level). Hence, the export share of the firms surveyed in 2002 is markedly lower than in the 1999 dataset. This is evidently caused by the sample size and its composition in 2002, as the share of manufactured exports as a percentage of GDP in manufacturing decreased only gently from 10.9% in 1999 to 10.2 percent in 2002 (Bank of Thailand 2004a, b). As a result, the extension of the sample size resulted in the inclusion of more domestic oriented firms, which had formerly been less willing to participate in the survey.

In Singapore, for TNC-affiliates exports accounted for 60% (mean)/ 70% (median) of sales, while local firms had an export share of only 23% (mean)/ 10% (median) (1% level).

In Penang, TNC-affiliates' exports represent 55% (mean)/ 65% (median) of sales, whereas local firms display an export share of only 24% (mean)/ 8% (median) (1% level).

Tab. 5.8: Distribution of surveyed firms according to export share

Export share / n	Thailand				Singapore		Penang	
	2000***		2002***		1999***		2000***	
	Local 593	Foreign 401	Local 863	Foreign 492	Local 190	Foreign 182	Local 114	Foreign 76
<20	53.0	34.1	44.0	25.2	54.7	22.0	63.2	34.2
20 - <40	10.0	10.9	14.9	16.3	11.6	11.5	14.0	9.2
40 - <60	5.9	9.9	7.0	11.2	4.2	10.4	5.3	9.2
60 - <80	5.4	7.7	8.5	9.6	8.4	12.1	4.4	5.2
80 - 100	25.8	37.1	25.5	37.7	11.0	43.9	13.1	42.0

*** significant at the 1% level (Pearson's Chi-Square); Restriction: PIS: one cell with expected count <5

Summary

TNC-affiliates in Thailand, Singapore and Malaysia are typified by the following characteristics:

- they are **larger** in terms of the number of employees, fixed assets and sales,
- they are **more competitive**, displayed by a higher productivity (sales per employees) and a higher export share (assuming that global markets are more competitive than domestic markets)
- they concentrate mostly in **medium to high tech sectors**, such as chemicals (35) and machinery and equipment (38) (exception Singapore), whereas local firms dominate in more basic industries such as food (31) and – at least in Thailand – textiles (32).

Concerning the age, there is no straightforward evidence: foreign firms are younger in Thailand, older in Singapore and of similar age as local firms in Penang.

These characteristics have an impact on the innovation potential of the firms. As, for example, the European Union's Community Innovation Surveys has shown, larger firms have a higher propensity to innovate than medium-sized firms (Eurostat, 2004: pp. 36), since they typically have more resources that can be devoted to R&D and innovation. Moreover, the sectors in which TNCs are active in the case study regions, such as chemicals; machinery and equipment, are those which account generally for the majority of R&D and innovation activities (e.g. Dosi et al., 1990: pp. 90, Pavitt, 1984). Consequently, it can be generally assumed that TNCs are more innovative, something that is also reflected in their higher productivity levels (partly caused by process innovations) and their export successes. However, this does not necessarily mean that TNCs carry out these activities within host countries such as Thailand. Chapter 2.3.2 states that TNCs tend to conduct R&D at their headquarters and transfer the knowledge and technology to their production sites worldwide.

Concerning age, in general younger firms can be assumed to be at an earlier stage of the product life cycle and hence in a phase where either product- or process- innovation are essential (see 2.1.4). However, the age of TNC-subsidiaries must be appraised differently, because they do not begin with a new product. Here, a higher age may sooner allow for more innovation activities, owing to better embeddedness in the host SI, learning curve effects, and the development of more autonomy vis-à-vis or the assignment of innovation responsibilities by the parent company (see 2.3.4).

In order to avoid misinterpretations, these basic characteristics and their influence on innovation must be kept in mind while analysing the dataset according to the stated hypotheses.

5.2 Technological capabilities and absorptive capacity of TNC-affiliates vis-à-vis local firms

The first hypothesis: “TNC-affiliates are actors with higher capabilities than local firms, and consequently, they are suitable contributors to the upgrading of the host countries' SI”, covers all surveyed firms. Most parts of the questionnaire are only applicable to companies that carry out either innovation or R&D, because they relate to these activities and to external collaboration in R&D and innovation. Hence, the data on the bulk of non-innovating firms, which make up about 75-80% of the surveyed companies, is limited to some general information. Nevertheless, these

questions allow one to evaluate the technological capabilities and absorptive capacity of the respective firms. Consequently, in the following two sections two sub-hypotheses will be tested:

- H1a: TNC-affiliates possess higher TCs than local firms (see 5.2.1)
- H1b: TNC-affiliates have better absorptive capacity than local firms (see 5.2.2)

5.2.1 Technological capabilities

Chapter 1.1.4 introduced Hobday's technological trajectory framework, in which firms follow the learning route from **OEM to OBM**. This learning route can also be seen as a fairly broad **TC-typology**. One can expect TNC-affiliates with access to the knowledge of their parent companies to be more advanced than local firms in regard to this typology. Tab. 5.9 depicts the average percentage of sales according to these TC-groups of foreign and local companies.

Tab. 5.9: Average (mean) % of firms' sales in each TC-group: Thailand

	2000			2002		
All						
/ n	Local 593	Foreign 401	Total 994	Local 864	Foreign 496	Total 1360
MA	7.9***	38.8***	20.4	9.9***	24.2***	15.1
OEM	30.8	26.8	29.2	38.5	36.6	37.8
ODM	16.9***	12.3***	15.0	16.2**	13.4**	15.2
OBM	31.2***	13.5***	24.0	34.0***	25.4***	30.9
Food/ Beverage/ Tobacco						
/ n	Local 105	Foreign 38	Total 143	Local 137	Foreign 38	Total 175
MA	7.1***	36.2***	14.9	10.7***	27.6***	14.4
OEM	15.1	9.5	13.6	27.5	22.4	26.4
ODM	11.0	11.9	11.3	10.7	11.2	10.8
OBM	48.6*	34.3*	44.8	50.3	38.2	47.7
Textiles/ Wearing apparel/ Leather						
/ n	Local 100	Foreign 38	Total 138	Local 166	Foreign 51	Total 217
MA	3.9***	26.2***	10.0	5.0***	15.9***	7.6
OEM	46.6	44.2	45.9	54.1	62.9	56.2
ODM	21.3	17.2	20.2	23.4**	9.0**	20.1
OBM	17.6*	4.5*	14.0	17.5	13.7	16.6
Chemicals						
/ n	Local 126	Foreign 104	Total 230	Local 184	Foreign 114	Total 298
MA	9.3***	37.5***	22.1	12.1*	19.2*	14.8
OEM	30.9**	20.8**	26.4	35.4	33.5	34.7
ODM	14.9	12.3	13.7	14.8	14.3	14.6
OBM	33.7**	18.5**	26.8	34.3	33.1	33.8
Machinery/ Equipment						
/ n	Local 138	Foreign 178	Total 316	Local 176	Foreign 224	Total 400
MA	11.0***	48.1***	31.9	14.5***	31.1***	23.8
OEM	31.1	26.7	28.6	35.3	33.7	34.4
ODM	16.3***	10.0***	12.8	12.7	12.7	12.7
OBM	31.1***	7.2***	17.6	36.7***	21.3***	28.1

*** significant at 1% level, ** significant at 5% level, * significant at 10% level (Mann-Whitney-U-Test)

NB the figures do not always add up to 100%, because the questionnaire included a further category called "others", which was filled in by some companies, but has not been considered for this analysis.

Deviating from Hobday’s original classification, the surveys in Thailand, Penang and Singapore included ‘manufacturing arm’ (MA) as an additional group. MAs are companies that manufacture products according to design specifications provided by the parent company or an associate company within the corporate group. MAs are therefore similar to OEMs, with the distinction of not selling to an external buyer.

Obviously, the data does not support the above stated assumption (Tab. 5.9). Not surprisingly, TNC-affiliates are embedded into the corporate production network and therefore sell a certain share to parent or associate companies, i.e. MA. However, it strikes one that fewer TNC-affiliates in Thailand have competences and objectives (assigned by their headquarters) to participate in design or branding activities. On the other hand, a higher share of local firms performs these functions. Not only does this display to some extent their TCs, but also the need to perform these functions, since there is simply ‘nobody else’ (i.e. no other firm within the corporate network) that can fulfil these objectives. Because, for example, the task of creating a brand in the food industry is very different from creating a brand in the automotive industry, the following tables show the sector-specific distribution of sales in each TC-group.

Tab. 5.10: Average (mean) % of firms’ sales in each TC-group: Singapore and Penang

/ n	Singapore			Penang		
	Local 184	Foreign 178	Total 362	Local 113	Foreign 76	Total 189
MA	8.8***	38.0***	23.2	8.6***	31.1***	17.6
OEM	35.7***	25.5***	30.7	37.4	31.6	35.1
ODM	17.9*	11.3*	14.6	24.1*	18.2*	21.8
OBM	15.2	12.8	14.0	21.4	11.6	17.5

*** significant at 1% level, ** significant at 5% level (Mann-Whitney-U-Test)

OBM is most common among food and chemicals firms, as well as for local companies in the machinery sector. Textile firms rely primarily on OEM-sales. While MA sales are important for all foreign firms, they are especially high in the machinery sector.

The result of a larger number of local firms selling in more advanced ODM and OBM categories supports the Wong’s (1999a; see chapter 2.1.4) criticism of Hobday’s (1995b) framework. Obviously, advanced technological capabilities do not necessarily result in design or brand activities, but can also lead to an upgrading within other categories e.g. the OEM category. Further support for this criticism can be found in the benchmark regions, Penang and Singapore (Tab. 5.10). Here, the overall number of ODM and OBM-sales is smaller than in Thailand despite a more advanced technological level according to the secondary data (see chapter 4). Of course, there is a bias in the data, because TNC-affiliates will most likely sell to other enterprises in the transnational production network, leaving headquarters to organise marketing and product development. Additionally, local firms have difficulty qualifying for the MA-status; qua definition they are rarely integrated into a corporate network and, therefore, cannot sell to a parent or associate company within the corporate network. However, not only do the presented categories determine the buyer, but they also specify functions such as design and marketing, which headquarters could assign to their affiliates. And indeed, the figures show that about one quarter of TNC-affiliates possess these responsibilities.

Another indicator for technological capabilities is the **ISO-certification** established by the International Organization for Standardization (ISO). All South-East Asian surveys asked firms if they are certified according to the 1994 edition of ISO 9001, 9002 or 14001. ISO 9002 certifies quality management in production and assembly. ISO 9001 additionally verifies design, development and customer service. Consequently, it is a more advanced measure (see DIN, 1994b, a). ISO 14401 certifies an environment management system (ISO, 2004).

According to this indicator, TNC-affiliates are evidently more sophisticated than local firms in all three regions (Tab. 5.11 and 5.12). Generally, the less demanding ISO 9002 is more widespread. In Thailand, the share of ISO 9001 certified firms has increased sharply from 2000 to 2002, with foreign firms leading the way. This indicates that TNC-affiliates increasingly perform design and development activities, which they would like to have certified. Because TNC-affiliates are mainly export-oriented, these figures also hint towards a need to become certified for marketing reasons or customer requirements on the world market. This is especially true for the environment protection related ISO 14001.

Tab. 5.11: Share of ISO-certified firms in Thailand

ISO / n	2000			2002		
	Local 593	Foreign 401	Sig. ⁺	Local 863-864	Foreign 496-498	Sig. ⁺
9001	4.9	5.5	0.676	16.1	27.8	0.000
9002	31.4	55.9	0.000	23.3	35.7	0.000
14001	4.4	15.2	0.000	5.3	18.1	0.000

⁺ Significance according to Pearson's Chi-Square (2-sided) based on 2x2 tables

Tab. 5.12: Share of ISO-certified firm in Singapore and Penang (1999)

ISO / n	Singapore			Penang		
	Local 190	Foreign 183	Sig. ⁺	Local 116	Foreign 76	Sig. ⁺
9001	11.6	23.0	0.004	6.9	11.8	0.238
9002	34.7	58.5	0.000	31.9	61.8	0.000
14001	4.2	15.3	0.000	2.6	11.8	0.010 ^s

⁺ Significance according to Pearson's Chi-Square (2-sided) based on 2x2 tables; ^sone cell expected count <5

A third indicator that is available for all companies in Thailand refers to different **technological activities**. Tab. 5.13 depicts the share of local and foreign firms carrying out the following activities: a) **basic production capabilities** such as quality control, testing and acquisition of external technology; b) **intermediate capabilities** such as the adaptation of external technology and reverse engineering and c) **intermediate to advanced capabilities** like basic and detailed design (cf. chapter 2.1.2).

It should be kept in mind, that the appraisal of the activities is generalised as each activity subsumes a fairly wide array of different activities. For example the acquisition of external technology can include the basic procurement of machinery as well as the advanced acquisition of patents or licenses. Moreover, these activities differ in respect to industry and product, e.g. basic design in the creation of a new read/write head for a hard disk drive is certainly very different from designing a new base plate in the same industry. Moreover, both activities are difficult to compare with firms designing new trunk lining parts for pickup trucks in the automotive industry.

Both the general and sector specific data in Tab. 5.13 lead to the following conclusion: Generally, the most common technological activities are the more basic ones: quality control and testing followed by acquisition and adaptation of external technology. Basic and detailed design are only carried out by one third to half of all companies, while even less perform reverse engineering. Hence, the obvious conclusion: the more advanced an activity the fewer firms perform it. Although reverse engineering is generally seen only as an intermediate capability (chapter 2.1.2), it requires a significant amount of absorptive capacity in order to ‘make sense’ of competitors’ products, which explains the low frequency.

Tab. 5.13: Share of firms that conducted the following technological activities within three years prior to the survey

Technological activity (Sector) / n	2000		2002	
	Local 593	Foreign 401	Local 866	Foreign 498
Quality control	91.4*	94.5*	85.6**	90.2**
Food/ beverage	89.5	97.4	89.1	92.1
Textile/ wearing apparel, leather products	90.0	89.5	80.1	78.4
Chemicals/ chemical and plastic products	92.1	94.2	85.3*	92.1*
Metal products/ machinery/ equipment	95.7	94.9	89.2*	93.8*
Testing	87.7*	91.5*	77.8***	85.1***
Food/ beverage	83.8***	97.4***	82.5	92.1
Textile/ wearing apparel, leather products	87.0	89.5	70.5	64.7
Chemicals/ chemical and plastic products	92.1	92.3	83.2	86.8
Metal products/ machinery/ equipment	92.0	90.4	83.0**	90.7**
Acquisition of external technology	55.0***	66.6***	54.5***	70.1***
Food/ beverage	57.1	63.2	56.9	65.8
Textile/ wearing apparel, leather products	64.0	57.9	57.2	68.6
Chemicals/ chemical and plastic products	54.0	64.4	50.0***	65.8***
Metal products/ machinery/ equipment	54.3***	73.0***	57.4***	74.3***
Adaptation of external technology	67.3	69.1	54.5***	68.2***
Food/ beverage	66.7	76.3	61.3***	86.8***
Textile/ wearing apparel, leather products	70.0	63.2	50.6	60.8
Chemicals/ chemical and plastic products	63.5	68.3	54.3***	70.2***
Metal products/ machinery/ equipment	71.0	71.3	58.5**	69.5**
Reverse engineering	38.3***	29.2***	24.4	22.5
Food/ beverage	30.5	34.2	29.9	21.1
Textile/ wearing apparel, leather products	27.0	18.4	13.3	7.8
Chemicals/ chemical and plastic products	41.3**	28.8**	20.7	25.4
Metal products/ machinery/ equipment	50.7***	30.9***	35.2*	26.5*
Basic design	56.3***	38.2***	39.1	36.7
Food/ beverage	38.1	47.4	32.8***	60.5***
Textile/ wearing apparel, leather products	57.0	44.7	31.9	25.5
Chemicals/ chemical and plastic products	56.3***	36.5***	31.5	40.4
Metal products/ machinery/ equipment	65.2***	32.6***	53.4***	32.7***
Detailed design	49.7***	39.2***	32.6	30.8
Food/ beverage	35.2**	55.3**	29.2***	55.3***
Textile/ wearing apparel, leather products	44.0	44.7	25.5	23.5
Chemicals/ chemical and plastic products	49.2	38.5	27.2	31.0
Metal products/ machinery/ equipment	66.7***	34.3***	44.3***	28.8***

*** significant at 1% level, ** significant at 5% level, * significant at 10% level (Pearson Chi-Square (2-sided)), + one cell expected count < 5

Comparing TNC-affiliates and local firms, foreign companies are significantly more active when it comes to the acquisition (2000/2002) and adaptation (2002) of external technology as well as testing and quality control (2000/2002). Therefore, these fields offer scope for local firms to learn from TNCs. However, generally less TNC-affiliates work in more sophisticated domains such as reverse engineering, basic and detailed design. This supports the theoretical argument that most TNCs still conduct product development related activities at their home base or in preferable foreign locations in the industrialised world, but not in late-industrialising countries like Thailand (see 2.3.2). TNC-affiliates in the food industry may be the exception, as they are very committed to design activities.

More sector and technology specific assertions are:

- **Acquisition of external technology:** more foreign firms acquire external technology than local firms (statistically significant for chemicals (2002) and machinery (2000/2002)). This could be expected because TNC-affiliates have easier access to external technology via their headquarters, better financial resources and higher requirements and turnover of technology due to global competition.
- **Adaptation of external technology:** a significantly similar picture in 2002, with no marked differences in 2000. TNCs frequently have to adapt their processes and technology to local conditions (see chapter 2.3.2). This is true for local firms as well, but since they acquire external technology less often, they adapt these technologies less often, too.
- **Reverse engineering:** more local firms carry out reverse engineering (significant for all firms, for chemicals and machinery in 2000, at the 10% level for machinery in 2002). Since reverse engineering is an important step for R&D, product and process development, most TNCs will perform this activity at their R&D-department abroad. Since local firms must conduct it in Thailand, they should exhibit higher frequencies. The less significant results for 2002 hint towards upgrading amongst TNC-affiliates.
- **Basic and detailed design:** generally, foreign firms perform design functions less often (significant in the machinery sector). Again, these functions are traditionally performed by TNCs at their home base (2.3.2). Contrary evidence is found in the food industry, where significantly more foreign firms have design capabilities.
- **Testing and quality control:** very important for all firms, but significantly more important for foreign firms. This can be explained by their export orientation: global markets tend to be more demanding than local markets.

The final set of indicators analyses **innovation activities**, distinguishing between input indicators (R&D and other innovation activities), throughput indicators (patents) and output indicators (new products, new processes, share of new products/processes at turnover) (for discussion of indicators see chapter 3.1).

Tab. 5.14 Input-, Throughput- and Output indicators for innovation activities in Thailand

Share of companies that conducted/ introduced... n	2000		2002	
	Local 593	Foreign 401	Local 866	Foreign 498
R&D	16.2	14.0	10.6	11.4
Food/ beverage	21.0	31.6	20.4*	34.2*
Textile/ wearing apparel, leather products	7.0	2.6	1.8	2.0
Chemicals/ chemical and plastic products	14.3	20.2	13.0	16.7
Metal products/ machinery/ equipment	20.3**	11.2**	11.9	8.0
Other innovation activity	23.8	20.2	14.3	17.5
Food/ beverage	27.6	36.8	22.6	28.9
Textile/ wearing apparel, leather products	14.0	13.2	10.8	7.8
Chemicals/ chemical and plastic products	22.2	21.2	12.5	17.5
Metal products/ machinery/ equipment	27.5*	19.7*	17.6	21.2
Either R&D or other innovation activity	26.5	24.2	20.8	22.3
Food/ beverage	31.4	44.7	34.3	36.8
Textile/ wearing apparel, leather products	16.0	13.2	12.7	9.8
Chemicals/ chemical and plastic products	24.6	28.8	19.6	27.2
Metal products/ machinery/ equipment	30.4*	21.9*	23.9	23.0
Patents[#]	3.0	3.2	3.6**	1.4**
Food/ beverage	1.0	2.6	3.6	-
Textile/ wearing apparel, leather products	1.0	-	1.8	2.0
Chemicals/ chemical and plastic products	1.6	2.9	4.9	2.6
Metal products/ machinery/ equipment	5.8	4.5	4.5* ^s	1.3* ^s
Product innovation in last 3 yrs.	15.9*	12.0*	6.6	8.0
Food/ beverage	16.2	26.3	10.9	15.8
Textile/ wearing apparel, leather products	10.0	10.5	3.6	2.0
Chemicals/ chemical and plastic products	15.9	14.4	4.9	7.9
Metal products/ machinery/ equipment	18.8**	10.1**	9.1	9.3
Process innovation in last 3 yrs.	13.5	12.5	7.0	7.4
Food/ beverage	9.5	18.4	9.5	13.2
Textile/ wearing apparel, leather products	11.0	13.2	5.4	2.0
Chemicals/ chemical and plastic products	12.7	12.5	7.1	10.5
Metal products/ machinery/ equipment	19.6*	11.8*	7.4	7.1
Either product or process innovation	19.6	16.2	11.0	12.0
Food/ beverage	18.1*	31.6*	16.1	23.7
Textile/ wearing apparel, leather products	12.0	13.2	7.8	3.9
Chemicals/ chemical and plastic products	19.8	17.3	10.3	12.3
Metal products/ machinery/ equipment	25.4**	14.6**	12.5	13.7
Innovative[§]	8.1	7.0	6.2	7.8
Food/ beverage	3.8	7.9	8.8	2.6
Textile/ wearing apparel, leather products	7.0	7.9	4.2	2.0
Chemicals/ chemical and plastic products	6.3	6.7	3.8**	9.6**
Metal products/ machinery/ equipment	10.9	8.4	8.0	9.7

*** significant at 1% level; ** significant at 5% level; * significant at 10% level (all Pearson Chi-Square (2-sided))

[§] Fisher's Exact Test, which has been used where sample size is small and one or two cells have an expected count <5).

[#] A patenting firm is a firm that has applied for at least one patent or has been granted at least one patent during 1997/1999 for the 2000 dataset or 2000/2001 for the 2002 dataset.

[§] i.e. more than 25% of sales with new products or more than 25% of production volume with new processes

The analysis of these indicators (Tab. 5.14) results in the following findings: First of all, most of the differences between local and foreign firms are not statistically significant. The share of firms performing any of the looked-for activities is smaller in 2002 than in 2000 (with the only exception being the share of local patenting firms). However, the two datasets are not panel data; hence, these changes might simply be due to differences in the sample size and composition.

Second, the general pattern observed in **2000** is one of more local firms performing either R&D or other innovation activities. Local firms do not only score well in this input but also in the output figures: the shares of firms bringing about either product or process innovations, as well as the share of innovative firms, are higher than for foreign firms. Only in the throughput indicator (patents), local firms present lower figures. However, the total number of patents and patenting firms is very low, with less than 20 patenting companies with a total of 20 to 60 granted patents. In **2002**, most of these tendencies (all for the total figures) have reversed. This leads to the conclusion that TNC-affiliates have apparently successfully ‘caught up’ with or even overtaken local firms when it comes to innovation. This could be a result of greater learning experiences in TNC-affiliates, but more importantly it signifies changes in TNCs’ strategy: They foster the decentralisation of R&D- and development-activities which can also result in the upgrading of volume production facilities in Thailand.

Third, from a sectoral point of view, the **food industry** is a very innovative sector, with one in three firms performing innovation related functions. TNC-affiliates clearly tend to be engaged more often in innovative activities. This reverberates the requirement that the industry adapt products continuously to the (ever changing) local taste. Moreover, the industry is partially dependent on local resources or climate, making local innovation activities necessary. Companies in the **textile industry** rarely perform R&D, but innovate, for example, by designing new clothes. Nevertheless, it is the least innovating sector among the four focus industries. Differences between local and foreign firms are mixed and mostly miniscule. In the **chemical industry** foreign companies are generally more innovating than local firms, despite mixed results and marginal differences for product and process innovations. However, TNC-affiliates were significantly more often innovative than local companies in 2002. The reverse is true for the **machinery sector**, in which less foreign firms carry out R&D and (for 2000) other innovation activities. This is significant for both product (5% level) and process (10% level) innovation in 2000.

Tab. 5.15 provides figures for the equivalent indicators in the benchmarking regions. While the results for Thailand do not show a clear difference between local and foreign firms, the pattern in Singapore and Penang is strikingly different. In both of these regions, foreign firms are more likely to be innovating or innovative. This is for the most part true for Europe as well, however, less foreign firms conduct R&D in Europe (in relation to local firms; the absolute share is much higher than in South East Asia). While a smaller numbers of local R&D-firms in Singapore and Penang reflect a lack of capabilities, the lower share of foreign firms in Europe displays the fact that they predominantly have major R&D-centres in their home countries. As expected (see chapter 2.3.2), a larger proportion of firms in Europe carry out innovations.

Tab. 5.15: Input-, Throughput- and Output indicators for innovation activities in Singapore, Penang and Europe

Share of all companies that conduct/ introduced/ are... / n	Singapore		Penang		Europe	
	Local	Foreign	Local	Foreign	Local	Foreign
	190	183	116	76	739-809	204-233
R&D	17.9***	37.2***	22.4	32.9	71.9*	65.9*
Patents [#]	2.6***	13.1***	4.3	7.9	21.8***	36.3***
Product innovation	17.9***	43.2***	28.4**	44.0**	63.9***	76.5***
Process innovation.	20.0***	39.3***	31.9**	49.3**	58.8**	66.8**
Prod. or proc. Innovation	27.4***	51.4***	37.1*	50.7*	74.4**	81.1**
Innovative [§]	11.6***	27.3***	16.4*	27.6*	21.1 [†]	21.6 [†]

*** significant at 1% level; ** significant at 5% level; * significant at 10% level (all Pearson Chi-Square (2-sided))

[#] A patenting firm is a firm that has applied for at least one patent or has been granted at least one patent in the three years prior to the survey; in Europe only firms that filed a patent are included.

[§] I.e. more than 25% of sales with new products or more than 25% of production volume with new processes.

[†] NB in Europe no information about the share of new processes were obtained, therefore only firms that retrieve more than 25% of sales with new products are considered innovative.

In summary, based upon the presented indicators, TNC-affiliates in Thailand cannot generally be considered more technological capable than local companies. They are more often certified according to ISO-standards and they are more likely to carry out basic to intermediate technological activities such as testing, quality control, acquisition and adaptation of external technology. However, their sales in the advanced ODM and OBM categories are lower. Furthermore, they are involved in basic and detailed design, as well as in reverse engineering to a lesser degree. Finally, available innovation indicators do not reveal significantly more sophisticated TNC-affiliates (despite slightly higher shares in 2002). This is particularly striking when contrasted with the benchmarking regions of Penang and Singapore, where foreign firms are more likely to engage in innovating activity. Obviously, TNCs use their operations in Thailand for assembly and some home-base exploiting activities (see 2.3.2), whereas firms in Penang and especially Singapore have been assigned at least some higher-order activities. In the case of Singapore, this is due to the fact that many TNCs use Singapore as their regional headquarters, assigning R&D and design functions to these (e.g. Yeung, 2001, Yeung et al., 2001, Giroud, 2003, McKendrick et al., 2000, Kiese, 2004). Likewise, a more conducive environment in terms of S&T-infrastructure and human capital supports this development (see 4.2.1).

Hence, in Thailand there is no evidence of higher performance from TNC-affiliates per se, from which local firms could benefit. However, there are some indications for recent upgrading amongst foreign firms. This trend suggests that TNCs may change their strategy and assign higher order innovation and technological activities to their volume-production sites in Thailand. This implies, then, the development and transfer of capabilities to these affiliates.

The figures for Europe show that local firms should be expected to perform R&D and innovation activities more often than foreign firms, since the latter's headquarters are undertaking R&D activities for them. Thai domestic companies do not enjoy this luxury. If they do not perform these functions in Thailand, they will not perform them at all.

From a sectoral point of view, TNCs in the food and chemicals industries are more likely to assign R&D-functions to their affiliates in Thailand. This is primarily due to the need for adaptation to local/regional tastes, national legislative requirements, and for a desired proximity of R&D to

volume production and/or local conditions. Moreover, innovation – at least in the food industry – is perceived as less sophisticated than in machinery and equipment industries. In contrast, affiliates in the machinery sector rely more on the traditional mechanism of importing new products and processes from their R&D-facilities abroad. Since this industry is exceptionally export-oriented and must appeal to highly competitive global markets, TNCs perform R&D and product innovation close to leading markets and in collaboration with main customers. For these reasons, the opportunity for R&D in Thailand is more restricted.

These data, however, only display frequencies. Information concerning the type of innovation activity performed is not included, i.e. the quantitative pattern does not necessarily also reflect the qualitative pattern. Consequently, section 5.3 will explore the characteristics of advanced foreign and local firms. But firstly, the next section will analyse data pertaining to the absorptive capacity of all companies.

5.2.2 Absorptive capacity

Chapter 2.1.3.2 introduced the notion of absorptive capacity and its significance for the development of technological capabilities, successful technology transfer and collaboration. Additionally, the chapter presented some indicators, which can be used to measure ACAP. Nevertheless, all innovation surveys in South East Asia asked non-innovating companies only a few questions, which can be related to ACAP. Therefore, this section investigates local and foreign firms' ACAP by analysing the qualification level of the workforce and training expenditure. The data on the qualification structure for 2000 and 2002 (Tab. 5.16) show that TNC-affiliates employ more highly educated personnel than local firms. This is principally significant at the 1% level. This pattern can also be observed at a sectoral level, even though the results are only significant for the chemical industry in 2000 and 2002.

Consequently, TNC-affiliates possess more absorptive capacity or at least better resources to develop ACAP. TNC-affiliates may even, through their higher wages, contribute to the lack of suitable professionals at local firms (see 4.1.4.3). The resulting lower level of ACAP in local firms diminishes the opportunity for technology transfer. However, all firms have increased their share of highly-skilled workers from 2000 to 2002. This represents a shift towards a more knowledge-intensive economy in Thailand.

The same pattern of better human capital-endowed TNC-affiliates can be observed in data for Singapore and Penang (Tab. 5.17). The total share of university graduates is higher in Singapore than in Penang, which corresponds to secondary data on the development level of the respective SI in both Singapore and Malaysia (chapter 4.2). However, Thailand's companies present even higher shares of university graduates, which – according to the secondary data – cannot be related to the sophistication of the companies. It must sooner reflect the relatively lower standards of university education in Thailand (see 4.2.2.2).

Tab. 5.16: Employment structure in Thailand (2002 and 2000): Average share of personnel according to highest qualification²⁹

2002	Local	Foreign	Total
/ n	731-733	388-390	1119-1123
University graduates	16.2***	20.6***	17.7
▪ Scientists	0.6*	0.9*	0.7
▪ Engineers	1.7***	3.1***	2.2
▪ Others	13.0***	14.9***	13.7
Vocational school graduates	21.5***	27.6***	23.6
▪ Technical	10.6***	13.5***	11.6
▪ non-technical	9.7*	11.1*	10.2
Secondary school	38.3	37.5	38.0
Primary school	24.1***	14.3***	20.7
2000	Local	Foreign	Total
/ n	409	289	698
University graduates	10.9***	13.9***	12.1
▪ scientists	0.8	0.8	0.8
▪ engineers	1.5**	2.1**	1.7
▪ others	6.8	6.9	6.8
Vocational school graduates	16.8***	21.8***	18.9
▪ technical	6.9	8.4	7.5
▪ non-technical	8.2	7.6	8.0
Secondary school	34.9***	44.5***	38.8
Primary school	37.5***	19.9***	30.2

*** significant at 1% level; ** significant at 5% level; * significant at 10% level (Mann-Whitney-U-Test)

Tab. 5.17: Employment structure in Singapore and Penang (1999): Average share of personnel according to highest qualification

Singapore	Local	Foreign	Total
/ n	184	178	362
University graduates	7.0***	12.0***	9.4
Diploma holders	11.6***	13.6***	12.6
Skilled (NTC-2 & above)	40.6***	31.1***	35.9
Unskilled	40.4	43.3	41.8
Penang	Local	Foreign	Total
/ n	113	71	184
University graduates	4.4**	6.6**	5.2
Diploma holders	4.9***	8.4***	6.3
Certificate holders	8.1	7.8	8.0
Secondary school (incl. A-levels)	55.2	64.2	58.7
Primary school	27.7***	13.7***	22.3

*** significant at 1% level; ** significant at 5% level; * significant at 10% level (Mann-Whitney-U-Test)

Tab. 5.18 displays the training expenditure of local and foreign firms. On average, foreign firms spent more money than local firms on training in 2000 and 2001 (significant at the 10% level), while in 1997 and 1999 local firms report slightly higher figures. The share of firms spending more than 4% of sales is less than one tenth in the 2nd survey. Hence, companies seem reluctant to enhance the intensity of their efforts to build ACAP.

²⁹ The dataset was subject to extensive plausibility checks and cases which were implausible or did not add up to 100 in the main categories were excluded. The checks on the subcategories (e.g. technical, non-technical) were less stringent and cases were kept in the dataset even if the figures did not add up to the superior level, because otherwise too many cases would have been excluded. Hence, the reliability of the subcategories is not as good as for the main categories.

Tab. 5.18: Training expenditure as % of sales in Thailand

	1997		1999		2000		2001	
	Local	Foreign	Local	Foreign	Local	Foreign	Local	Foreign
/ n	186	119	216	152	271	174	277	183
> 2% [#]	32.3	24.4	32.9	25.0	20.7	29.9	21.3	30.1
> 4% [#]	22.1	18.5	23.6	19.1	5.9	9.8	7.6	11.5
mean [§]	0.9	0.7	1.1	0.9	0.8***	1.2***	0.9***	1.3***

*** significant at 1% level; ** significant at 5% level; * significant at 10% level (Mann-Whitney-U-Test)

[#] the figures are distorted, because missing values and no expenditure were both coded as nil were in the first survey. Consequently they are excluded, resulting into an overestimation of the share.

[§] in order to correct for this ([#]) bias the calculation of the mean includes all nils. Moreover, firms with training expenditure of more than 50% of sales are excluded due to lack of plausibility. The median is nil.

Tab. 5.19 presents the figures for the benchmarking regions. However, the data are not directly comparable, as training expenditure in Singapore and Penang was related to payroll rather than sales. In both Penang and Singapore (at least according to the median), foreign firms invest more in human capital development than local firms.

Tab. 5.19: Training expenditure as % of payroll in Singapore and Penang

	Singapore		Penang	
	Local	Foreign	Local	Foreign
/ n	126	156	87	61
> 2%	57.1	61.0	49.3	62.2
> 4%	32.5	20.6	33.2	37.6
median	1.0***	2.0***	1.0*	2.0*
mean	3.1***	2.3***	3.8*	5.0*

NB For comparison with the Thailand data, companies with no training expenditures or missing values have been neglected

*** significant at 1% level; ** significant at 5% level; * significant at 10% level (Mann-Whitney-U-Test)

In comparison, a study by Eurostat establishes that firms spend between 0.5 to 3.0% of total labour costs for additional training (Nestler & Kalilis, 2002). Relating total training expenditure to annual sales, a “skills study” by Forrester Research reports that the 255 surveyed European companies spend on average 0.05% of sales for training (Meyer, 2004). As a special case, start-ups in Canada were surveyed, reporting an average of 2.7% of sales for employee training (Kang, 2000). A survey of 100 affiliates of TNCs in South Africa did, however, record a share of 5% of firms with training expenditure exceeding 15% of sales (Gelb & Black, 2004: 209). Hence, the figures for Thailand (0.9-1.3% of sales) are clearly higher than for the average European firm, while the figures for foreign firms in Thailand lag behind those of TNC-affiliates in South Africa (ibid.). In general, training expenditure can have two objectives: first, to compensate for the weaknesses of graduates of the education system, and secondly, to train specific skills required for the high-skill production process. Compared to other late-industrialising countries, such as Malaysia, Singapore and South Africa, Thai firms either do not have the resources to foster human capital sufficiently or do not see the need for doing so.

In summary, TNC-affiliates are clearly better endowed with human capital than local firms. This is probably the result of highly-skilled workers seeking positions with TNC-affiliates, where working conditions and wages are frequently more favourable (e.g. Ramstetter, 2004). On the other hand,

TNC-affiliates require higher levels of skill for more complex, state-of-the-art production technology (4.2.2.1) and the required ability to communicate in English (or Japanese). Many firms in Thailand consider “a college degree [...] as a proxy for English skills” (Worldbank, 2001: 17). Reflecting upon the intensity with which ACAP is consciously developed, considering training expenditure as a valid representation of this, the findings are mixed. In Thailand (2002), Penang and to a certain degree in Singapore, foreign firms spend more money on training than local firms and hence contribute more resources to the improvement of the ACAP. Similar to indicators of technological and innovation activities, this pattern changed from the first to the second survey in Thailand. Whereas local firms exhibit higher expenditure on training in 1997/99 they lack behind TNC-affiliates in 2000/01. Presumably, this is caused by a recent upsurge in the collective efforts of foreign firms in a drive to upgrade their operations in Thailand.

However, approximately half of all foreign and local firms in Thailand still spent less than 0.5% of sales on training. Despite the acknowledged need for human capital for the creation of technological capabilities and competitiveness, local firms seem to disregard this path of advancement. Nevertheless, the share of highly qualified employees increased between surveys in 2000 and 2002. Consequently, firms in Thailand ‘learn by hiring’ sooner than ‘by (further) training’. One reason why firms are reluctant to spend more money on training may actually be the lack of qualified human capital and subsequent personnel mobility. Firms might be reluctant to invest in human capital, a scarce commodity on the market and easily poached by a competitor.

5.3 Technological capabilities and absorptive capacity of advanced TNC-affiliates vis-à-vis advanced local firms

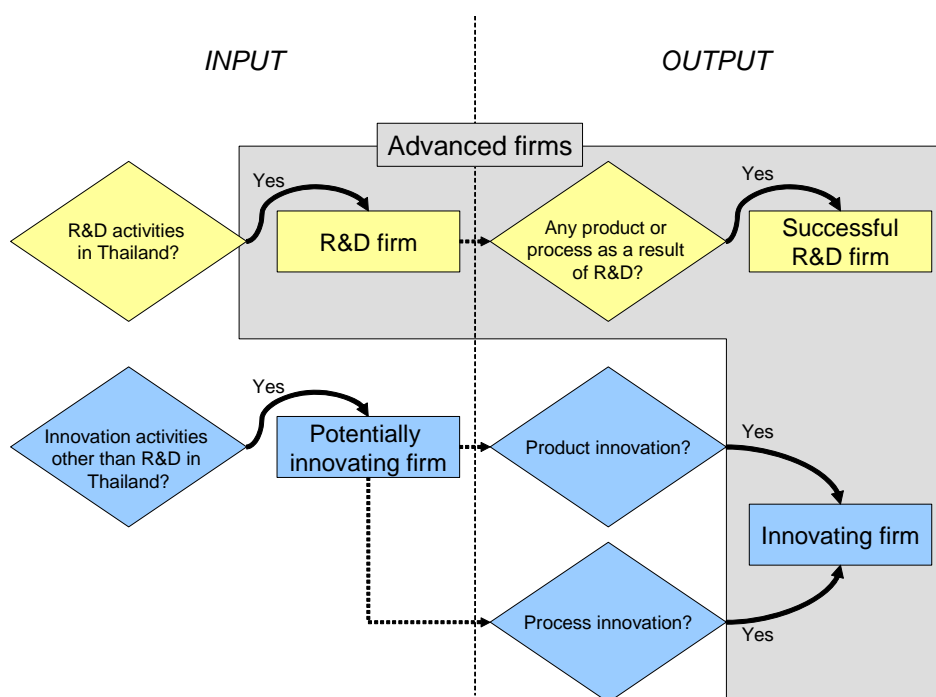
The previous section shows – based on data for the entire sample – that foreign firms are generally not superior in terms of technological capabilities, but that they possess different capabilities than local firms and have a significantly higher absorptive capacity in respect to human capital.

This chapter focuses exclusively on advanced firms, in order to establish the kinds of differences that can be observed within this group. Furthermore, it examines whether or not advanced local firms can find suitable collaboration and technology transfer partners for sophisticated technological capability building and innovation among foreign firms. Thereby, the term **advanced firm** needs clarification. Chapter 4.2.2.1 shows that even large local firms, TNC-affiliates and high-tech SMEs in Thailand, struggle to overcome the design and engineering stage (main current threshold) and that only a minority have achieved research and technology-development skills (minor current threshold) (see also own data analysis in 5.2).

In order to identify a group of exceptionally capable firms, the following filters have been applied: First, firms that have either introduced a new product onto the market or have adopted a new process into production in the three years prior to the survey (in accordance with the Oslo-manual (OECD, 1997a: 42) henceforth called **innovating**) are considered advanced. Second, firms that conduct R&D are included. Even though this definition mixes input- and output indicators (see 3.1), it is an appropriate indicator for identifying technologically more capable and, hence, advanced firms in the Thai context.

However, this definition can lead to two problems: First, it hinders a straightforward comparison with the benchmarking regions. In Singapore and Penang innovating firms were exclusively asked to answer the question regarding R&D. Hence, when considering concerns for perfect matching among the regions alongside those for taking the particularities of Thailand into account as the focus country, this study gravitates towards the latter argument. Secondly, the application of this definition is occasionally impossible. The R&D/Innovation surveys treat R&D and ‘innovation activities other than R&D’ separately. Some questions refer only to firms reporting R&D, while others refer to firms claiming to conduct innovation activities without necessarily being innovating firms, i.e. having achieved an output (inspired by Ellis & Polcuch, 2005 henceforth called **potentially innovating** companies). Thus, not all analysis applies specifically to ‘advanced’ firms, but must be limited at times to the sub-groups of R&D-performing, innovating or potentially innovating firms (Figure 5.1 visualises the different groups). Moreover, the size of the advanced firm sample is fairly small (see Tab. 5.20 and 5.21). For this reason a sector specific analysis in Thailand is not pursued.

Figure 5.1: Visualising key terms



own graphic

Tab. 5.20: Sample size of R&D-, innovating, potentially innovating and advanced firms in Thailand

	2000		2002	
	Local	Foreign	Local	Foreign
Total	593	401	866	498
- potentially innovating	141	81	124	87
- R&D-performing	96	56	92	57
- innovating firms	116	65	95	60
- R&D and innovating firms	65	35	34	28
- advanced (either R&D- or innovating firms)	147	86	153	89

Tab. 5.21: Sample size of R&D-, innovating and advanced firms in Singapore and Penang

	Singapore		Penang	
	Local	Foreign	Local	Foreign
Total	190	183	116	76
- R&D performing	34	68	26	25
- advanced (= innovating firms)	52	94	43	38

Consequently, this chapter tests the following hypothesis:

H2: Even within the group of advanced firms, TNC have higher capabilities than local firms

- H2a: Advanced TNC-affiliates possess higher TCs than advanced local firms (see 5.3.1)
- H2b: Advanced TNC-affiliates possess a higher absorptive capacity than advanced local firms (see 5.3.2)

5.3.1 Technological capabilities and innovation activities of advanced firms

As was conducted for all companies in the previous chapter, the TCs of advanced companies will be measured at the outset with the following set of indicators: MA to ODM framework, ISO-certification and technological activities (5.3.1.1). Secondly, additional innovation variables only available for advanced firms will be analysed in order to examine the more sophisticated levels of TCs, namely the R&D and innovation processes (5.3.1.2).

5.3.1.1 Basic technological capabilities of advanced firms

Similar to the pattern established for the **MA to ODM framework** for the entire sample (chapter 5.2.1.1) advanced local firms have higher sales in ODM and OBM categories than advanced foreign firms. In comparison to the total sample, advanced firms have unmistakably higher sales in OBM and fewer sales in OEM (see Tab. 5.9 and 5.22): figures for OBM are between 9 and 11%-points higher (only exception local firms in 2000); OEM figures have decreased by about 7 to 11%-points. This contrast is even stronger if one compares advanced and not-advanced (henceforth called **basic**) companies: Advanced firms have a high sale-share in OBM whereas basic firms have higher shares in OEM and MA. This is true for local and foreign firms alike (the only exceptions include local firms in 2000, where advanced and basic firms have the same amount of shares in OBM).

Tab. 5.22: Average (mean) % of advanced firms' sales in each TC-group: Thailand

/ n	2000			2002		
	Local 147	Foreign 86	Total 233	Local 152	Foreign 87	Total 239
MA	11.2***	32.6***	19.1	6.1***	20.0***	11.2
OEM	20.4	19.7	20.2	27.7	25.5	26.9
ODM	18.2	12.2	16.0	17.9	15.3	17.0
OBM	31.3*	22.5*	28.1	45.8*	36.1*	42.3

*** significant at 1% level, ** significant at 5% level, * significant at 10% level (Mann-Whitney-U-Test)

NB the figures do not always add up to 100%, because the questionnaire included a further category called "others", which was filled in by some companies, but has not been considered for this analysis.

Firms in Singapore and Penang exhibit a trend similar to that in Thailand, although it is less salient (Tab. 5.10 and 5.23). The picture gets clearer when the scope for comparison is limited to advanced and basic firms. However, in this case ODM sales are not distributed equally, as in Thailand, but are higher for basic foreign firms in Penang and basic local firms in Singapore.

Tab. 5.23: Average (mean) % of advanced firms' sales in each TC-group: Singapore and Penang

/ n	Singapore			Penang		
	Local 51	Foreign 92	Total 143	Local 42	Foreign 38	Total 80
MA	9.8***	43.2***	31.3	9.7***	32.9***	20.7
OEM	34.5**	22.8**	27.0	32.5	35.3	33.8
ODM	21.4**	10.3**	14.3	25.2**	10.5**	18.2
OBM	23.2**	14.9**	17.9	26.6	21.3	24.1

*** significant at 1% level, ** significant at 5% level, * significant at 10% level (Mann-Whitney-U-Test)

Advanced firms are more often certified to any **ISO certification** than firms in the total sample (Tab.5.24 and 5.25). Even within the group of advanced firms, TNC-affiliates seek ISO certifications significantly more often, which is again caused by both customer requirements and marketing reasons necessitated by the global market (see 5.2.1). This is evident for all three regions, even though in 1999 firms in Singapore were much more often certified with the more demanding ISO 9001 than firms in Thailand (2000) or Penang (1999). This reflects the higher design responsibilities in Singapore.

Tab. 5.24: Share of ISO-certified advanced firms in Thailand

ISO / n	2000			2002		
	Local 147	Foreign 86	Sig. ⁺	Local 152-153	Foreign 88-89	Sig. ⁺
9001	9.5	14.0	0.300	17.1	42.0	0.000
9002	40.8	55.8	0.027	40.5	43.8	0.616
14001	8.8	26.7	0.000	11.2	29.2	0.000

⁺ Pearson Chi-Square (2-sided) based on 2x2 tables

Tab. 5.25: Share of ISO-certified advanced firms in Singapore and Penang (1999)

ISO / n	Singapore			Penang		
	Local 52	Foreign 94	Sig. ⁺	Local 43	Foreign 38	Sig. ⁺
9001	21.2	40.4	0.018	9.3	15.8	0.376 [§]
9002	44.2	62.8	0.031	41.9	78.9	0.001
14000	13.5	23.4	0.149	7.0	15.8	0.208 [§]

⁺ Pearson Chi-Square (2-sided) based on 2x2 tables; [§]at least one cell expected count <5

In terms of **technological activities**, advanced firms – compared to all firms – are more often technologically active – this is true for all considered activities (cf. Tab. 5.13 and 5.26).

Furthermore, basic and detailed design, which are higher order activities, are as or even slightly more often carried out by advanced TNC-affiliates in comparison with advanced local firms. This is a reversal of the pattern observed for all firms. In acquiring and adapting external technology, foreign firms still prevail. Consequently, in the group of advanced firms there is clear indication of a similar or even higher share of capable foreign firms. Hence, even if these firms cannot be considered 'teachers', because they are not more sophisticated overall, they are at least on par with

the local firms, and, consequently, suitable cooperation partners, even in terms of more advanced technological activities.

Tab. 5.26: Share of advanced firms that conducted the following technological activities within three years prior to the survey

	2000		2002	
	Local 147	Foreign 86	Local 153	Foreign 89
Quality control	88.4*	95.3*	95.4	94.4
Testing	85.0**	94.2**	90.8*	96.6*
Acquisition of external technology	63.9	69.8	69.9**	84.3**
Adaptation of external technology	76.9	83.7	75.8	84.1
Reverse engineering	54.4	52.3	48.4	48.3
Basic design	66.7	60.5	63.4	65.2
Detailed design	59.9	62.8	60.1	64.0

*** significant at 1% level, ** significant at 5% level, * significant at 10% level (Pearson Chi-Square (2-sided))

5.3.1.2 R&D and innovation capabilities of advanced firms

In the following, the **technological activities related to innovation** performed by innovating firms are presented in Tab. 5.27. This question was not addressed to R&D firms and can hence only be analysed from the sub-sample (see Tab. 5.20).

Most of these innovating companies acquire external equipment and carry out training; obviously these are the most important innovation activities. Interestingly, there is a significant difference between local and foreign firms in the acquisition of external technology in the form of patents and licences. Clearly, local firms lack the capital, knowledge or absorptive capacity to utilise this kind of external knowledge. One other reason that may explain why more TNC-affiliates use this kind of activity could be the transfer of patents and licences within the corporate network. This arms length transfer requires less capability on behalf of the receiver, because it is based on strong intra-corporate assistance and trust-based knowledge exchange. This is different from market-moderated exchanges relied upon by local firms, subsequently demanding higher absorptive capacities and capabilities.

Tab. 5.27: Share of innovating firms in Thailand carrying out the following activities linked to product and process innovation

	1999		2000		2001	
	Local 116	Foreign 65	Local 94	Foreign 60	Local 94	Foreign 60
Acquisition of machinery, equipment and software	84.5	83.1	74.5	83.3	77.7	85.0
Acquisition of external technology e.g. patents and licences	25.9***	44.6***	16.0***	36.7***	19.1***	38.3***
Industrial design and engineering, market research, marketing expenses	57.8	58.5	29.8	33.3	38.3	36.7
Training	73.3	80.0	64.9	65.0	74.7	75.0

*** significant at 1% level, ** significant at 5% level, * significant at 10% level (Pearson Chi-Square (2-sided))

Moreover, foreign firms are more often involved in the procurement of external machinery. Since the capital goods industry in late-industrialising countries is typically weak (see chapter 2.1.1), companies must acquire these goods from abroad. Consequently, this provides a very clear

indication that TNC-affiliates in Thailand contribute to the SI by bringing in codified, disembodied as well as embodied technology via international technology transfer (see 2.1.3.3).

Comparing the results with those of innovating firms in Singapore and Penang (Tab. 5.28), it can be seen, that a) the ranking of activities is the same in all three regions, b) the share of firms performing each activity is also roughly at the same level and c) the relation between the share of local and foreign firms performing each activity is also the same (the only exception being industrial design in Thailand (1999) and acquisition of machinery in Penang). Hence, innovating firms in Singapore, Penang and Thailand do not really differ in respect to these – admittedly fairly general – indicators. Moreover, the share of foreign firms in Thailand performing these activities is just as high as in Penang and Singapore. The only exceptions are ‘industrial design and engineering, market research and marketing’, which are more frequently carried out by TNC-affiliates in the latter two regions (according to Thailand 2000/2001 figures). This leads to the conclusion that the depiction of ‘lazy TNC-affiliates’ is inaccurate for advanced firms in Thailand.

Tab. 5.28: Share of innovating firms in Singapore and Penang carrying out the following activities linked to product & process innovation

	Singapore		Penang	
	Local 51	Foreign 94	Local 42-43	Foreign 36-37
Acquisition of machinery, equipment & software	78.4	81.9	81.4*	64.9*
Acquisition of external technology e.g. patents and licences	23.5	31.9	19.0	27.0
Industrial design and engineering, market research, marketing expenses	45.1	41.5	48.8	43.2
Training	62.7	69.1	58.1	63.9

*** significant at 1% level, ** significant at 5% level, * significant at 10% level (Pearson Chi-Square (2-sided))

Input indicator: Innovation and R&D expenditure

Since the previous section only reported the frequencies of companies performing innovation related activities (see Tab. 5.14), it is necessary to explore these activities further. Analyzing the resources allocated to these activities will suffice for this. The three surveys done in South East Asia included questions pertaining to **innovation expenditures** (including the activities named in the previous section, see also chapter 3.1) and **R&D expenditure**. Both are given as intensity values, i.e. in percentage of sales. While in Singapore and Penang this information is classified, in Thailand exact figures are available, offering the opportunity to calculate location parameters. By calculating these parameters, firms claiming to have an R&D- intensity of more than 25% and firms claiming to have an innovation-intensity of more than 60% have been excluded from the calculation due to implausibility. This assertion is based on the fact that, in the 13 largest OECD countries, the industries with the highest R&D-intensity, exhibit an average of 11% (pharmaceuticals) and 10% (aerospace) (Legler, 2003: 48). Still, the standard deviation is very large; hence the median, which can act as a less distorted parameter, has been calculated additionally. Tab. 5.29 displays the parameter for the innovation intensity of all innovating firms. Overall, innovating local firms spend

more money on ‘innovation activities other than R&D’ than innovating foreign firms. This pattern is consistent from 1997 to 2001, but statistically significant only for 1999.

Tab. 5.29: Innovation expenditure in % of sales for innovating firms in Thailand

	1997		1999		2000		2001	
	Local 78	Foreign 51	Local 114	Foreign 59	Local 23	Foreign 22	Local 27	Foreign 22
Mean	1.06	0.49	2.72**	0.75**	1.64	1.42	2.97	2.08
Median	0.03	0.02	0.47	0.09	0.25	0.10	0.26	0.10
s	2.80	1.23	6.85	1.70	3.32	1.42	7.88	6.03

** significant at 5% level; * significant at 10% level (Mann-Whitney-U-Test)

Reliable information on R&D-intensity is only available for about one third of the 149 R&D-firms in Thailand in 2000/2001. The response rate was higher in the first survey, where between 50% (1997) and over 80% (1999) of the 154 R&D-firms reported on their R&D-expenditure. According to this indicator, TNC-affiliates committed slightly more resources in 2000 and 2001, whereas in 1997 and 1999 local firms spent more money on R&D (Tab. 5.30).

Tab. 5.30: Mean and Median of R&D-expenditure in % of sales of R&D-firms in Thailand

	1997		1999		2000		2001	
	Local 50	Foreign 29	Local 83	Foreign 47	Local 28	Foreign 19	Local 34	Foreign 21
Mean	1.20	0.40	1.56**	0.72**	1.46	1.92	1.38	1.88
Median	0.30	0.12	0.44	0.19	0.34	0.35	0.36	0.70
S	2.14	0.53	3.10	1.72	3.92	3.45	3.75	3.53

*** significant at 1% level; ** significant at 5% level; * significant at 10% level (Mann-Whitney-U-Test)

The tendency for foreign firms to spend more money on R&D (at least in the more recent years), and local firms to spend more money on other innovation activities, supports Arcona and Suez’s (1999, 2002) observation that in late-industrialising countries innovation is less often taking place in formal R&D-departments, but within the production process (see chapter 2.2.1.2). This may be more common among local firms than among foreign ones, as the latter presumably transfer their organisational structure to the host country, including a formal R&D-department (if they perform innovation activities). However, this conclusion is not supported by the frequencies found in the share of potentially innovating and R&D-firms (see Tab. 5.20). Nevertheless, resource allocation is a stronger indicator, because it displays what is actually considered important to a firm.

Tab. 5.31: Expenditure for innovation and R&D activities in % of sales by advanced firms in Thailand

	1997		1999		2000		2001	
	Local 126	Foreign 80	Local 100	Foreign 76	Local 146	Foreign 83	Local 144	Foreign 84
< 2%	86.9	94.1	68.5	89.4	95.4	93.3	94.1	94.4
2-4.9%	6.9	4.7	14.4	4.7	2.0	1.1	3.3	0.0
5-9.9%	3.5	1.2	8.9	3.5	0.0	3.4	0.0	2.3
10-19.9%	2.1	0.0	5.5	2.4	2.6	1.1	1.3	2.3
20-39.9%	0.0	0.0	1.4	0.0	0.0	1.1	0.7	1.1
>= 40%	0.7	0.0	1.4	0.0	0.0	0.0	0.7	0.0
>= 5%	6.2	1.2	17.1	5.9	2.6	5.6	2.6	5.6

Comparing **expenditure on innovation related activities of advanced firms** in Thailand with those in Singapore and Penang is difficult, because it is necessary to add up the separately surveyed expenditures on R&D and ‘innovation activities other than R&D’ in Thailand. In order to sum up these values, missing values had to be recoded as 0-values, which may have led to an underestimation of total expenditure. Still, even when taking this underestimation into account, it becomes clear that advanced firms in Singapore and Penang spent more money on innovation (Tab. 5.31 and 5.32). Thereby, local firms spent more in Singapore, Penang and Thailand in both 1997 and 1999, while foreign firms spent more in Thailand in both 2000 and 2001.

Tab. 5.32: Expenditure for innovation and R&D activities in % of sales by advanced firms in Penang and Singapore (1999)

/ n	Singapore		Penang	
	Local 49	Foreign 93	Local 42	Foreign 36
< 2%	24.5	34.4	31.0	27.8
2-4.9%	34.7	30.1	31.0	22.2
5-9.9%	16.3	15.1	23.8	25.0
10-19.9%	10.2	15.1	4.8	11.1
20-39.9%	10.2	3.2	2.4	11.1
>= 40%	4.1	2.2	7.1	2.8
>= 5%	40.8	35.5	38.1	50.0

Tab. 5.33: R&D-expenditure in % of sales classes of R&D-firms in Thailand, Singapore and Penang

/n	TIS 1		TIS 2		SNIS		PIS	
	Local 52	Foreign 29	Local 35	Foreign 21	Local 31	Foreign 66	Local 26	Foreign 28
< 1%	67.3	89.7	77.1	71.4	32.3	30.3	26.9	25.0
1 – 2.9%	19.2	10.3	11.4	9.5	29.0	37.9	15.4	35.7
3 – 4.9%	1.9	0.0	2.9	4.8	19.4	21.2	30.8	17.9
5 – 9.9%	5.8	0.0	0.0	9.5	9.7	7.6	3.8	7.1
10 – 19.9%	1.9	0.0	2.9	4.8	6.5	0.0	15.4	7.1
>= 20%	3.8	0.0	5.7	0.0	3.2	3.0	7.7	7.1
Chi-Sq-Sig	0.301 [§]		0.428 [§]		0.427 [§]		0.522 [§]	
> 3%	13.4	0.0	11.5	19.1	38.8	31.8	57.7	39.2
> 10%	5.7	0.0	8.6	4.8	9.7	3.0	23.1	14.2

[§] one or more cells with expected count <5; class sizes according to Singapore and Penang questionnaire

Limiting focus to **R&D-firms**, Tab. 5.33 displays **R&D-expenditure** in Thailand, Singapore and Penang. Compared to firms in the latter two regions, firms in Thailand spent far less on R&D. This is in line with observations of general innovation expenditure (Tab. 5.31 and 5.32). While in 1997 local firms clearly (but not significantly) committed more resources to R&D than TNC-affiliates, by 2001 TNC-affiliates have clearly increased their efforts. Their share in the medium-technology category (with R&D-expenditure of 3% to 10% of sales³⁰) is higher than for local firms. But this figure of 19% is still relatively low placed beside 30-60% of the firms in Singapore and Penang. In

³⁰ The figures approximately resemble medium technology (höherwertige Technologie) with an R&D intensity of 3.5 to 8.5%, and high technology (Spitzentechnologie) with an R&D intensity of more than 8.5% as categorized by the BMBF (2000).

Europe 47% of foreign and 37% of local firms qualify for medium-technology. There is also an observable increase in high-technology firms. The 2nd Thailand dataset includes as many high-tech firms (> 10%) as Singapore. In both regions, a larger number of local firms are high-tech. In Europe, 9% of foreign and 10% of local firms are high-tech, which casts some doubts about the reliability of the very high figures in Penang.

In conclusion, a small elite group of foreign and local firms exists in Thailand that invests large amounts of money in R&D. However, the majority of firms spend less than 1% of sales on R&D (Tab. 5.33). Though, even in this group, a noticeable shift can be detected, with foreign firms spend slightly more capital on R&D in 2001 than in 1997.

In terms of the **R&D-personnel intensity** (R&D-personnel as percentage of the total workforce) R&D-firms in Thailand show a gentle increase from 4.6% (median: 2.2%) in 1999 to 4.9% (2.7%) in 2001. While in 1999 local firms employed a higher share of R&D-personnel 4.9% (2.3%) than foreign firms: 4.0% (2.1%) the difference in the mean has balanced in 2001. However, the difference in the median is persistent: local firms have an intensity of 4.9% (3.0%) and foreign firms of 4.8% (2.0%).

These average figures are similar to those in Penang (4.6% in 1999), where local firms also possess a higher intensity (5.7%) than foreign firms (3.7%). Considering the median, the difference is only marginal: local firms: 2.5%, foreign firms 2.6%.

In Singapore (1999) the data is consistent and clearly higher than in Penang and Thailand: The average for all firms is 7.3% (median: 5.5%). Local firms have a higher intensity with 10.2% (6.7%) than foreign firms with 5.9% (4.8%). However, even these figures are surpassed by firms in the European regions, which exhibited a mean of 9.5% (median: 5.7%) in 1996 without showing differences between local and foreign.

Considering the **allocation of R&D-expenditure**, it is evident that most Thailand-based firms invest in product-oriented R&D: Persistently, local firms spend about two-thirds of their resources on product-oriented R&D. In contrast, foreign firms have increased their share from 58% to 68% between 1999 and 2001. This shift is quite remarkable, because it indicates that TNC-affiliates have, in the past, focused more on process-oriented R&D, which is implemented for smooth operation and upgrading of volume-production. However, more recently TNC-affiliates have been assigned additional responsibilities for product development that was previously performed at the home base of the firm. These R&D-activities are not focused on research at the technological frontier, but at developing the necessary absorptive capacity to transfer and develop products initially created at the main R&D-facility abroad further (see chapter 6 for complementary evidence). Consequently, this is a first sign of upgrading R&D-facilities (see 2.3.2) and taking a necessary first step towards accumulating more capabilities in the future.

Moreover, local firms and – even more conspicuously – TNC-affiliates have shifted investment in R&D away from experimental development and towards applied and basic research from 1999 to

2001. Having said this, in 2001 half of the remaining resources are dedicated to experimental development, but 31% (locals) to 36% (foreigners) are designated for applied research. This indicator supports the impression that TNC-affiliates are more recently committing to the upgrading of their operations in Thailand by transferring more fundamental and product oriented research (for further evidence see chapter 6).

Throughput indicator: Patents

In Thailand, the overall number of patents applied for and granted either abroad or in Thailand in the three years prior to each survey was very low. Out of a total including more than 1,000 firms, a maximum of 18 local and 13 foreign firms applied for a patent. The total number of patents obtained was 78 in 2000 and 79 in 2002. Nevertheless, there is a striking contrast between TNC-affiliates and local firms. In 2002 TNC-affiliates applied for only 0.02 patents and 0.01 patents were granted per firm. In contrast, local companies applied on average for 0.11 patents and obtained 0.08. Consequently, in 2002 TNC-affiliates hardly sought patent protection, while local firms used this protection mechanism a bit more often (in Thailand as well as abroad). This can have two causes: either foreign firms have nothing to protect, i.e. hardly any patentable inventions are created by TNC-affiliates in Thailand, or TNCs do not see the need or benefits of patent protection in Thailand, either because the market is too small, the protection too weak or the process of gaining the patent takes too long.

Contrarily, in 2000, both TNC-affiliates and local firms applied on average for 0.16 patents per firm. While local firms obtained 0.04, foreign firms were granted 0.13 patents per firm. Hence, the pattern has changed: TNC-affiliates, who sought more patents in 2000 than local firms, applied for and obtained fewer patents in 2002. This is contrary to the above findings that more TNC-affiliates are becoming active in terms of R&D and innovation. Considering the time lag between R&D/innovation activities and the filing of a patent, the data suggests that TNCs in Thailand may increase their patent activity in the near future.

In comparison, TNC-affiliates in Singapore applied for 1.02 patents and were granted 0.44 patents per firm. In contrast, local companies applied for 0.07 patents on average and obtained 0.02. In Penang, foreign firms applied for 0.53 patents and were granted 0.24 patents per firm, while local firms applied for 0.56 patents and obtained 0.34. However, the actual number of patenting firms is pretty low in the benchmarking regions as well. A maximum of 15 firms in Singapore and 5 firms in Penang applied for patents. In both cases single firms account for a large share of the total number of patents.

To set the figures in relation to industrialised regions: The ERIS project established an average of 9.3 patents per foreign firm and 1.4 per local firm. Consequently, firms in South East Asia lagged behind markedly. When comparing these mean figures, it must be kept in mind that they were corrected for neither firm size nor industry, which both have a severe impact on patent propensity (e.g. Brouwer & Kleinknecht, 1999, Arundel & Kabla, 1998). Hence, if TNC-affiliates display higher patent rates this could be due to their larger size.

Output indicator: Innovative firms

Since the purpose of the innovation process is the introduction of new products into the market or new processes into the production process, Tab. 5.14 has already presented some information on the output. Moreover, the definition of the term ‘advanced firm’ already includes firms that are successful, because there are innovating firms.

In order to retain more information from the data, it is useful to compute the share of innovative firms, i.e. firms that earn more than 25% of sales with new products or produce more than 25% of production volume with new processes (Kiese, 2004: 140). While Tab. 5.14 presented the share of innovative firms from all firms, Tab. 5.34 displays the relation to advanced firms only. For this, the definition of innovative firms in Thailand has been extended to include firms that earn more than 25% of annual sales from R&D related products or processes. This is justified by the fact that, otherwise, only the sales from product and process innovations other than R&D would have been counted. Since there is no such distinction in Singapore and Penang the data for Thailand had to be summarised.

Tab. 5.34: Share of innovative companies in % of all advanced companies (n)

Region	Local firm	Foreign Firm
Thailand (2002)	49.7*	60.7*
Thailand (2000)	38.1	37.2
Singapore	42.3	53.2
Penang	44.2	55.3
Europe [§]	37.0 [§]	32.5 [§]

[§] in Europe only the share of product innovations of annual sales was considered

* significant at the 10% level according to Pearson Chi-Sq.

It can be seen from this data (Tab. 5.34) that more foreign than local firms are innovative in Singapore and Penang. Thus, TNC-affiliates rely more on new products and processes. This is explained by their stronger export focus: High demands on the world market in terms of product quality and costs as well as short product-life-cycles, require state-of-the-art production technology and frequently new or markedly improved products. Actually, this reflects one ownership-specific advantage (see chapter 2.3.2), which constitutes the existence of TNCs.

In the data from the first Thai survey of 2000 no such differences between foreign and local owners can be detected. However, in 2002 foreign firms are clearly more often innovative than their local counterparts, leading to the conclusion that TNC-affiliates in Thailand have in recent years followed a path of development similar to that taken earlier on in Penang and Singapore. Referring to the technological trajectories (see 2.1.4), this mirrors a shift from producing ‘mature products’ with ‘established technology’ towards manufacturing ‘new products’ with ‘state-of-the-art-technology’. Of course, this process could not take place over such a short time frame as two years. Yet, despite differences in the data composition, this change could hint towards an upgrading of TNC-operations in Thailand.

Moreover, local firms in Thailand tend to spend more money on innovation (Tab. 5.29) and only slightly less money on R&D (Tab. 5.30) than their foreign counterparts in 2000 and 2001. Hence, their input is approximately as high as that of TNC-affiliates, but their output is significantly weaker (10%-level). This originates partly from less effective organisation of the innovation

process in local firms and from the transfer of new products and processes from TNC-headquarters to their affiliates in Thailand, who subsequently achieve an essential share of their turnover/production with these products/ processes.

Objectives for R&D and innovation

The previous section ascertains that advanced TNC-affiliates in Thailand conduct R&D- and other innovation activities as often as, or even more often than, local firms. Moreover, foreign firms are more innovative (2001). On the other hand, firms in Thailand lag behind their counterparts in Singapore and Penang, because these regions are more favourable locations for development and R&D-activities for TNCs. Consequently, the question arises, why do TNC-affiliates perform R&D- and other innovation activities in Thailand at all?

According to the Oslo Manual (OECD, 1997a), potentially innovating and R&D-firms were asked about the objectives for these activities. Subsequently, firms could indicate their importance on a five-point Likert-scale. The share of firms assessing an objective as either important or very important was calculated and the objectives ranked accordingly.

The motives of TNC-affiliates are similar to those of local firms: the six most important reasons are related to a) **product and market diversification** ('extend product range', 'open new markets') b) **market position** ('increase market share', 'improve product quality'), c) 'production **cost reduction**' and d) **innovation/ upgrading** ('learn about new technology'). Tab. 5.35 shows the ranking of objectives for R&D in 2000 and 2002 in exemplary fashion.

The most remarkable change over time relates to 'learning about new technologies' as an objective for R&D and innovation. Rising from a rank of 6 to 4 (R&D), and 5 to 2 (innovation) for local firms respectively, it has become even more important for foreign firms: jumping from a rank of 13 to 2 (R&D) respectively, and 7 to 2 (innovation). This is a very clear indication that Thai firms in general, and TNC-affiliates in particular, are becoming much more aware in terms of the need for technological upgrading. Moreover, it reflects commitment from foreign firms to conduct technological learning on-site, rather than simply relying on the import of ready-to-use technologies. This corresponds to the recognition that even the acquisition and adaptation of external technology requires local learning and resource commitment. As a consequence, TNC-affiliates should be expected to build up the learning and research capacities necessary for collaboration on technological issues with local partners.

Additionally, minor changes can be detected in the increase of R&D-objectives related to market and product diversification and position, whereas pure cost reduction has become relatively less important. This hints towards a shift away from pure price competition towards other competitive factors, such as quality, product diversification etc. Another interesting minor detail is that foreign firms assess the improvement of production flexibility as an important objective for innovation. This indicates that the shift away from standardised towards more flexible production technology in times of shortened product-life-cycles is taking place in late-industrialising countries like Thailand as well (for further evidence see interview in the HDD-industry, chapter 6.2).

Tab. 5.35: Share of R&D firms that assessed the following as important or very important objectives for R&D in Thailand

/n	2000				2002			
	Local 75-85		Foreign 43-49		Local 79-87		Foreign 51-55	
	%	rank	rank	%	%	rank	rank	%
Improved product quality	91.7**§	1	3	81.6**§	97.7	1	1	92.7
Reduce production cost	79.8	2	1	85.7	81.4	5	6	72.2
Extend product range	79.5	3	2	71.1	84.5	2	3	90.9
Open up new markets	77.7**§	4	5	59.1**§	83.1	3	4	79.6
Increase market share	77.7**§	5	4	71.7**§	77.1	6	5	74.1
Learn about new technology	76.2*	6	13	57.1*	81.6	4	2	92.7
Reduce energy consumption	57.5	7	11	56.5	69.9	7	13	57.4
Reduce environment effects	56.3	8	9	51.1	62.2	8	11	58.8
Replace products being phased out	53.3	9	6	65.1	62.0	9	9	61.5
Improve cycle time	50.0	10	8	50.0	58.3	11	8	62.3
Improve work conditions	50.0*	11	12	41.3*	50.0	13	12	58.8
Improve production flexibility	48.2	12	10	44.7	52.3	12	10	59.3
Fulfill regulations & standards	48.1	13	7	50.0	60.7**§	10	7	62.3**§

*** significant at 1% level ** significant at 5% level; * significant at 10% level (Pearson's Chi-Sq.)

Chi-Square test based on 3x2 crosstab (ownership x importance of objective (not/ not very important, neutral, important/ very important))

§expected count for at least one cell <5

Innovating firms in Singapore and Penang recognize the same objectives as important ones. However, 'opening up new markets' is assessed as important by far more firms in these two regions than in Thailand (in Singapore it ranks first for local and foreign firms, in Penang first for local and third for foreign firms). Unfortunately, 'learning about new technology' was not an answer category in these regions. Furthermore, 'replacing products being phased out' is, at least for local Singaporean and foreign firms in Penang, a vital objective, underlining a stronger product development competency in these regions.

From the perspective of technological and innovative capabilities, the most interesting finding is that 'learning about new technology' has experienced a rapid rise in its importance for R&D and innovation from 2000 to 2002, for local and foreign firms alike.

This reflects the notion that firms become aware of the need for, and commit themselves to, the development of technological capabilities and absorptive capacity. Moreover, this indicates a certain strategic shift away from pure short- to medium-term profit-seeking motives, such as extending the product range, opening up new markets or increasing the market share, and towards a more long-term strategic objective that is related to future capabilities and options concerning technical change.

In summary:

- Advanced firms sell a higher share in the ODM and OBM category and less in OEM, but there is no evidence for a higher frequency of foreign firms in these categories.
- Advanced firms seek ISO-certification more frequently, and it is much more common for foreign than local firms.
- Advanced firms pursue all technological activities to a higher degree. Strikingly, advanced TNC-affiliates perform high-order activities, such as basic and detailed design, more often than local firms. This is the reversal of the trend observed for the whole sample. It indicates a dichotomy within the group of foreign firms: Advanced firms are very sophisticated, performing many high order functions, whereas a large group of basic TNC-affiliates is constricted to basic operation and some intermediate technological capabilities, such as quality control, testing, acquisition and adaptation of external technology.
- A significant higher share of innovating foreign firms transfers new technology to Thailand as part of its innovation activities. This mirrors the significance of innovating TNC-affiliates for the NSI in terms of access to internationally available technology, either embodied in machinery or disembodied as in blueprints and licenses.
- Generally, firms in Thailand commit very limited financial resources to R&D and innovation compared to those in Singapore and Penang. However, the R&D-personnel intensity is comparable to Penang.
- While in recent years foreign firms spend more on R&D, local firms allocate more funds to other innovation activities. Although the data cannot be used as a time series it can be cautiously claimed that there may be an increase in spending from foreign firms on R&D and innovation alike.
- Most firms – either local or foreign – spend the bulk of their money on product development and experimental development. However, comparing the two surveys, there is some indication that there has been a recent shift towards more applied and basic research.
- The extent of patent activities is very limited in all three regions, displaying a fundamental lack of basic research capabilities by both local and foreign firms that could be translated into patentable products or processes.
- While there are only minor differences in 1999, in 2001 TNC-affiliates are clearly more often innovative. This is valid for all R&D- and innovation-related products and processes. Hence, TNC-affiliates in Thailand seem to upgrade in terms of inputs as well as outputs. Since foreign firms are incorporated into international production networks, they receive more assistance and have more resources available to facilitate this process.
- The most important objectives for R&D and innovation are product and market diversification, market position, cost reduction and learning about new technology. Remarkably, the latter one – a relatively long-term strategic aim – has experienced a rise in appraisal, especially from foreign firms.

In conclusion, within the group of advanced firms, TNC-affiliates are seen to dominate over local firms in terms of technological and innovative capabilities more visibly than within the group of all

firms. This makes them, above all, suitable technology transfer and collaboration partners. In particular, they foster the SI by bringing in new technology, either embodied or disembodied.

5.3.2 Absorptive capacity of advanced firms

In chapter 5.2.2, absorptive capacity has been examined by analysing the qualification structure of local and foreign firms. It has been found that foreign firms in all three regions employ staff with higher qualifications. The following section takes this analysis one step further by testing H2a: “Advanced TNC-affiliates possess higher absorptive capacity than advanced local firms”. For this, the employment structure³¹ is compared in respect to three dimensions a) local vs. foreign firms, b) advanced vs. basic firms. Moreover, c) the different surveys are compared in regard to location and time. The subsequent part offers additional scrutiny of the sub-sample of R&D-firms, in order to investigate whether or not firms that have organised innovation activities in a formalised R&D-unit, representing a more strategic approach towards innovation, exhibit enhanced human resources. For the sake of lucidity, the subcategories for the Thailand dataset (scientists, engineers and other university graduates, as well as technical and non-technical vocational school graduates) are excluded from the illustration.

Advanced vs. basic firms

For Thailand, the figures in Tab. 5.36 and 5.37 give evidence that the qualification structure in foreign firms is higher than in local firms. This is not only true for the total sample (see 5.2.2) but also for advanced and basic firms.

The differences between foreign and local firms are most significant at the 1% level in the groups of ‘all firms’ and ‘basic firms’. In the group of advanced firms, no significant difference can be found for 1999. Nonetheless, in 2001 foreign firms employed significantly more vocational and less primary school graduates (5% level).

Still, within the group of ‘advanced firms’ TNC-affiliates tend to have a slightly better educated workforce, especially when looking at the median rather than the mean.

Comparing only advanced and basic **local** firms, the figures show that advanced firms employ more university and vocational school graduates (the latter only in 1999). These differences are partly statistically significant. On the contrary, the differences in the employment structure of basic and advanced **foreign** firms are minor and mostly statistically insignificant. Hence, it can be concluded that foreign firms employ more high-skilled personnel regardless of their own technological and innovative activities.

³¹ Note that the original dataset has been subject to extensive plausibility checks prior to the analysis, which resulted into considerable data reduction, because implausible elements and such whose structure does not add up to 100 were excluded.

Tab. 5.36: Thailand: Qualification structure of local and foreign firms (2001): advanced vs. basic

Local firms	/n	All 733		Advanced 126		Basic 607	
		Mean	Median	Mean	Median	Mean	Median
University graduates		16.2	10.4	19.1	12.5	15.6	10.0
Vocational school graduates		21.5	16.7	20.9	17.1	21.6	16.7
Secondary school		38.3	38.5	35.9	34.9	38.8	40.0
Primary school		24.1	21.3	24.2	20.0	24.0	21.7
Foreign firms	/n	All 390		Advanced 68		Basic 322	
		Mean	Median	Mean	Median	Mean	Median
University graduates		20.6	15.0	20.5	15.1	20.6	14.3
Vocational school graduates		27.6	23.9	26.2	21.0	27.9	24.9
Secondary school		37.5	36.3	37.9	36.4	37.5	36.3
Primary school		14.3	0.0	15.4	0.5	14.1	0.0

Significance- level (Mann-Whitney-U-Test) 2001	Local vs. Foreign firms			Advanced vs. Basic firms	
	All	Advanced	Basic	Local	Foreign
University graduates	.01	-	.01	.10	-
Vocational school graduates	.01	.05	.01	-	-
Secondary school	-	-	-	-	-
Primary school	.01	.05	.01	-	-

Tab. 5.37: Thailand: Qualification structure of local and foreign firms (1999) advanced vs. basic

Local firms	/n	All 409		Advanced 94		Basic 315	
		Mean	Median	Mean	Median	Mean	Median
University graduates		10.9	6.7	11.9	6.7	10.6	6.7
Vocational school graduates		16.8	12.2	20.5	14.7	15.7	11.7
Secondary school		34.9	30.2	35.8	29.0	34.6	30.8
Primary school		37.5	36.8	31.8	24.6	39.1	40.0
Foreign firms	/n	All 289		Advanced 59		Basic 230	
		Mean	Median	Mean	Median	Mean	Median
University graduates		13.9	10.0	14.5	11.5	13.8	10.0
Vocational school graduates		21.8	15.6	18.6	16.1	22.6	15.5
Secondary school		44.5	45.7	41.9	44.8	45.1	46.7
Primary school		19.9	5.1	25.0	15.5	18.5	2.7

Significance- level (Mann-Whitney-U-Test) 1999	Local vs. Foreign firms			Advanced vs. Basic firms	
	All	Advanced	Basic	Local	Foreign
University graduates	.01	.05	.01	-	-
Vocational school graduates	.01	-	.01	.01	-
Secondary school	.01	-	.01	-	-
Primary school	.01	-	.01	.10	.05

The structure observed in Thailand is also visible in Singapore and Penang (see Tab. 5.38 and 5.39): Here, foreign firms also hire staff with higher qualifications. In contrast to Thailand, foreign and local advanced firms alike employ a significantly higher share of university graduates than their basic competitors. In Singapore this is also true for diploma holders. In conclusion, in these better-established systems of innovation, foreign firms are more differentiated in terms of human capital.

On the one hand, this underlines the limited functions that advanced TNC-affiliates in Thailand perform, which do not require ‘extra-capable manpower’. On the other hand, it indicates a lack of capable human capital, which prevents even advanced foreign firms from employing more high-skilled employees (cf. 4.2.2.2).

Tab. 5.38: Singapore: Qualification structure of local and foreign firms (1999): advanced vs. basic

Local firms / n	All 184		Advanced 50		Basic 134	
	Mean	Median	Mean	Median	Mean	Median
University graduates	7.0	3.1	10.4	7.1	5.7	2.0
Diploma holders	11.6	9.5	13.2	11.3	11.0	8.0
Skilled (NTC-2 & above)	40.6	36.5	29.1	20.0	44.8	41.0
Unskilled	40.4	39.5	47.3	50.0	37.8	30.0

Foreign firms / n	All 178		Advanced 92		Basic 86	
	Mean	Median	Mean	Median	Mean	Median
University graduates	12.0	9.3	15.3	13.0	8.4	6.0
Diploma holders	13.6	12.0	14.8	13.3	12.3	10.0
Skilled (NTC-2 & above)	31.1	22.7	27.6	20.4	34.9	25.0
Unskilled	43.3	41.7	42.3	40.5	44.4	50.0

Significance- level (Mann-Whitney-U-Test) Singapore	Local vs. Foreign firms			Advanced vs. Basic firms	
	All	Advanced	Basic	Local	Foreign
University graduates	.01	.01	.01	.01	.01
Diploma holders	.01	.10	.05	.10	.05
Skilled (NTC-2 & above)	.01	-	.05	.01	-
Unskilled	-	-	.10	.10	-

Tab. 5.39: Penang: Qualification structure of local and foreign firms (1999) advanced vs. basic firms

Local firms /n	All firms 113		Advanced 41		Basic 72	
	Mean	Median	Mean	Median	Mean	Median
University graduates	4.4	3.0	6.1	5.0	3.4	1.0
Diploma holders	4.9	3.0	5.1	3.9	4.9	2.7
Certificate holders	8.1	5.0	8.6	6.0	7.8	4.5
Secondary school (incl. A-levels)	55.2	60.0	54.9	60.0	55.4	57.5
Primary school	27.7	20.0	25.6	15.0	29.0	20.0

Foreign firms /n	All firms 71		Advanced 35		Basic 36	
	Mean	Median	Mean	Median	Mean	Median
University graduates	6.6	5.0	7.9	7.0	5.2	3.0
Diploma holders	8.4	6.0	8.2	7.0	8.7	5.0
Certificate holders	7.8	5.0	8.9	7.0	6.8	4.5
Secondary school (incl. A-levels)	64.2	70.0	68.5	70.0	60.0	69.0
Primary school	13.7	5.0	8.2	4.0	19.1	10.0

Significance- level (Mann-Whitney-U-Test) Penang	Local vs. Foreign firms			Advanced vs. Basic firms	
	All	Advanced	Basic	Local	Foreign
University graduates	.01	-	-	.01	.01
Diploma holders	.01	.01	.10	-	-
Certificate holders	-	-	-	.10	-
Secondary school (incl. A-levels)	.05	.05	-	-	-
Primary school	.01	.05	.05	-	-

In total, the share of university graduates in Thailand is as high as or even higher than in Singapore and Penang. At first sight this might suggest higher ACAP in Thailand. However, taking into account the weak qualification of human capital and the deficiencies of the education system in Thailand (see 4.2.2.2), it sooner indicates the necessity to recruit university graduates for even more common, standardised tasks.

R&D- vs. non-R&D-firms

When comparing only R&D- and non-R&D-performing firms, the findings for advanced and basic firms can be transferred (Tab. 5.40 and 5.41). Still, the conclusion drawn is both clearer and stronger: In the sample of all and of non-R&D-firms, there is a significant difference in the qualification level of employees between local and foreign firms. TNC-affiliates possess better-educated human capital. At the same time, R&D-firms present a similar employment structure, regardless of their ownership. Consequently, while foreign firms always employ better-qualified staff, the group consisting of local firms is sharply divided: R&D-firms with highly educated human capital and non-R&D-firms with less qualified employees.

Tab. 5.40: Thailand: Qualification structure of local and foreign firms (2001) R&D vs. non-R&D

Local firms /n	All 733		R&D 75		Non-R&D 658	
	Mean	Median	Mean	Median	Mean	Median
University graduates	16.2	10.4	23.2	16.5	15.4	10.0
Vocational school graduates	21.5	16.7	23.5	20.0	21.2	16.5
Secondary school	38.3	38.5	34.1	30.0	38.7	40.0
Primary school	24.1	21.3	19.2	5.0	24.6	22.3
Foreign firms /n	All 390		R&D 41		Non-R&D 349	
	Mean	Median	Mean	Median	Mean	Median
University graduates	20.6	15.0	21.1	17.3	20.5	14.3
Vocational school graduates	27.6	23.9	26.1	21.4	27.8	24.0
Secondary school	37.5	36.3	35.6	33.7	37.8	36.7
Primary school	14.3	0.0	17.2	8.8	14.0	0.0

Significance- level (Mann-Whitney-U-Test) 2001	Local vs. Foreign firms			R&D vs. Non-R&D firms	
	All	R&D	Non-R&D	Local	Foreign
University graduates	.01	-	.01	.01	-
Vocational school graduates	.01	-	.01	.10	-
Secondary school	-	-	-	.10	-
Primary school	.01	-	.01	.05	-

Despite a similar pattern in Singapore and Penang (Tab. 5.42 and 5.43), there is a noteworthy dissimilarity in the structure of university graduates: While foreign firms again exhibit a higher general qualification level, it is, more or less, an inhomogeneous group. Rather, differences in the share of university graduates are so large, that they are significant at the 1% (Singapore) or 5%-level (Penang). Consequently, foreign firms employ more qualified personnel than local companies, but R&D-firms require even more of them. This indicates a higher specialisation, commitment and capability – summarised: a higher ACAP – of R&D-conducting TNC-affiliates in Singapore and Penang in comparison to Thailand.

This is a manifestation of the superior quality of the systems of innovation in Singapore and (partly) in Penang, which supply a higher quality and quantity of human resources (see 4.2). Moreover, the figures display a higher demand for skilled labour from R&D-performing TNC-affiliates in these regions, suggesting that they carry out more sophisticated functions in terms of R&D, design and engineering. Again, this might be related to the existence of regional headquarters of TNCs in Singapore.

Tab. 5.41: Thailand: Qualification structure of local and foreign firms (1999) R&D vs. non-R&D

Local firms /n	All 409		R&D 60		Non-R&D 349	
	Mean	Median	Mean	Median	Mean	Median
University graduates	10.9	6.7	14.3	8.5	10.3	6.5
Vocational school graduates	16.8	12.2	21.8	16.2	16.0	11.7
Secondary school	34.9	30.2	35.5	32.3	34.7	30.0
Primary school	37.5	36.8	28.4	21.4	39.0	40.0

Foreign firms /n	All 289		R&D 38		Non-R&D 285	
	Mean	Median	Mean	Median	Mean	Median
University graduates	13.9	10.0	16.5	14.3	13.5	10.0
Vocational school graduates	21.8	15.6	20.1	18.7	22.0	15.2
Secondary school	44.5	45.7	42.1	45.3	44.8	46.2
Primary school	19.9	5.1	21.3	11.6	19.7	4.6

Significance- level (Mann-Whitney-U-Test) 1999	Local vs. Foreign firms			R&D vs. non-R&D firms	
	All	R&D	Non-R&D	Local	Foreign
University graduates	.01	-	.01	.05	-
Vocational school graduates	.01	-	.01	.01	-
Secondary school	.01	-	.01	-	-
Primary school	.01	-	.01	.05	-

Tab. 5.42: Singapore: Qualification structure of local and foreign firms (1999): R&D vs. non-R&D

Local firms /n	All 184		R&D 33		Non-R&D 151	
	Mean	Median	Mean	Median	Mean	Median
University graduates	7.0	3.1	12.2	10.0	5.8	2.0
Diploma holders	11.6	9.5	13.7	12.0	11.1	9.0
Skilled (NTC-2 & above)	40.6	36.5	24.7	20.0	44.0	40.0
Unskilled	40.4	39.5	49.3	50.0	38.4	33.0

Foreign firms /n	All 178		R&D 66		Non-R&D 112	
	Mean	Median	Mean	Median	Mean	Median
University graduates	12.0	9.3	16.0	14.0	9.5	6.3
Diploma holders	13.6	12.0	14.3	13.0	13.2	11.0
Skilled (NTC-2 & above)	31.1	22.7	25.2	17.5	34.6	25.0
Unskilled	43.3	41.7	44.5	41.2	42.6	45.1

Significance- level (Mann-Whitney-U-Test) 2001	Local vs. Foreign firms			R&D vs. Non-R&D firms	
	All	R&D	Non-R&D	Local	Foreign
University graduates	.01	.10	.01	.01	.01
Diploma holders	.01	-	.01	-	-
Skilled (NTC-2 & above)	.01	-	.05	.01	.05
Unskilled	-	-	-	.10	-

Tab. 5.43: Penang: Qualification structure of local and foreign firms (1999) R&D vs. non-R&D

Local firms	/n	All 113		R&D 26		Non-R&D 87	
		Mean	Median	Mean	Median	Mean	Median
University graduates		4.4	3.0	6.7	5.1	3.7	2.0
Diploma holders		4.9	3.0	4.5	3.2	5.1	3.0
Certificate holders		8.1	5.0	9.0	6.3	7.8	5.0
Secondary school (incl. A-levels)		55.2	60.0	57.9	60.0	54.4	58.0
Primary school		27.7	20.0	21.8	7.3	29.5	20.0
Foreign firms	/n	All 71		R&D 23		Non-R&D 48	
		Mean	Median	Mean	Median	Mean	Median
University graduates		6.6	5.0	8.3	6.3	5.7	4.2
Diploma holders		8.4	6.0	7.2	6.4	9.0	5.0
Certificate holders		7.8	5.0	9.8	7.7	6.9	4.8
Secondary school (incl. A-levels)		64.2	70.0	68.3	70.0	62.2	70.0
Primary school		13.7	5.0	9.0	6.0	16.0	5.0

Significance- level (Mann-Whitney-U-Test) 1999	Local vs. Foreign Firms			R&D vs. Non-R&D firms	
	All	R&D	Non-R&D	Local	Foreign
University graduates	.01	-	.05	.01	.05
Diploma holders	.01	.05	.05	-	-
Certificate holders	-	-	-	-	.10
Secondary school (incl. A-levels)	.05	-	.10	-	-
Primary school	.01	-	.01	.10	-

Training expenditure

In terms of intensity of effort put into the development of enhanced ACAP, training, R&D and innovation expenditure in % of sales are the only available indicators (for the latter two see 5.3.2.1). Advanced firms clearly spend more money than all other firms for further training, with foreign firms investing more money in their employees than local firms in recent years: about 2.1% in contrast to about 1.1% (in 2000 and 2001; both significant at the 5% level). Contrary to those in Thailand, foreign firms in Singapore (2.6%) and Penang (4.8) spend less than their local counterparts (3.0% and 5.1%).

In summary, TNC-affiliates display higher absorptive capacity in terms of skilled labour and commitment of resources on training, and – in recent years – on R&D (for the latter see 5.3.1.2). However, spending on other innovation activities and R&D-personnel intensity (see 5.3.1.2) is lower. Based on the results of statistical significant tests, it can be concluded that foreign firms in Thailand have a similar qualification structure, regardless of their R&D-activity. Furthermore, local R&D-firms are remarkably similar to foreign firms. On the other hand, local non-R&D-firms are very different. The results for advanced vis-à-vis basic firms are similar but less distinctive. Despite a higher qualification structure, TNC-affiliates display a predominantly lower R&D-personnel intensity.

In contrast, local and foreign firms in Singapore and Penang exhibit stronger differences between and among each other depending on their R&D or innovation activity.

R&D-firms in Thailand have a similar R&D-personnel intensity to firms in Penang, thus not lagging behind in this respect. Meanwhile, the R&D-personnel intensity in Singapore (in 1999) is clearly higher. This reflects the quality of its respective system of innovation, which is capable of supplying a sufficient amount of high-skilled labour. Moreover, the figures for TNC-affiliates in Singapore support the assumption that they have been assigned more demanding functions, which are connected to the regional headquarters function and the regional division of labour (e.g. Yeung et al., 2001, Giroud, 2003).

5.4 Embeddedness of TNC-affiliates in innovation and knowledge networks

The previous sections state that, in terms of recent years, advanced foreign firms are even more technologically capable than advanced local firm. Furthermore, both groups have a similar absorptive capacity. In conclusion, the pre-conditions for collaboration, collective learning and joint capability building in this group are favourable. In what follows, the embeddedness of TNC-affiliates in the host economy as well as in external networks and the access to external technology sources are considered vis-à-vis local firms. The purpose of this investigation is to test H3: “R&D performing and potentially innovating TNC-affiliates are suitable technology transfer partners for local firms, since they are strongly embedded in the host economy and have access to foreign/ external technology”. The latter aspect has already gathered support, because it has been proven that advanced TNC-affiliates acquire external technology, either embodied or disembodied, significantly more often (see Tab. 5.26 and 5.27). This section seeks further evidence for TNCs’ embeddedness in international knowledge networks. Moreover, TNCs must be embedded in domestic networks, in order to diffuse technology and knowledge within the Thai NSI. Accordingly, this section examines domestic networks as well. Since there is no single appropriate indicator available, the analysis is based on the following variables: intense collaborations on R&D, product and process innovation, external procurement of R&D-services, own R&D abroad, and external sources of information.

Collaboration

Discussions about the theoretical notion of innovation as a chain linked process (2.1.3.1), the importance of cooperation networks within the concept of systems of innovation (2.2.1.1), and the argument of embeddedness of TNC-affiliates in the host economy (2.3.3), all point towards the need to explore collaboration patterns for collective learning.

The R&D/Innovation surveys in Thailand asked R&D- and potentially innovating firms about the intensity of their collaborations with external partners in terms of R&D, product and process innovation. Tab. 5.44 displays the share of **advanced** firms that claimed to have had intense or very intense cooperation in either of these activities within the three years prior to the survey³² (For the

³² NB In Thailand, missing values and the answer ‘cooperation is not relevant’ were coded as nil. For the presented analysis all nils were recoded as ‘no/ not intense cooperation’, since it can be assumed that collaborating firms would have indicated the intensity of its collaboration effects. Nevertheless, this procedure may result into an underestimation of collaboration frequencies. However, the alternative of leaving all nils as missing values would have resulted into an overestimation of the share of intensely cooperating firms. In order to minimise the distortion

disaggregated figures please see Appendix A9). Clearly, customers are the most important cooperation partners, followed by other partners along the value-chain, including suppliers and parent/ associate companies.

Horizontal partners such as R&D-institutes/ universities, technical and business service providers as well as government agencies are only of medium importance, whereas other firms and competitors (at least in 2001) are sought by only a small minority of firms as partners. The data show distinctive preferences by local and foreign firms: A higher share of TNC-affiliates is collaborating intensely with customers (2001), parents/associates, foreign owned suppliers and competitors. In contrast, more advanced local firms cooperate with R&D institutes and universities.

Tab. 5.44: Share of advanced firms that collaborate intensely with the following partners on R&D, product or process innovation (Thailand)

	1999			2001		
	Local 147	Foreign 86	Total 233	Local 153	Foreign 89	Total 242
Customers, buyers	52.4	54.7	53.2	62.7	69.7	65.3
Locally-owned suppliers	38.1	27.9	34.3	44.4	48.3	45.9
Foreign-owned suppliers	32.0	41.9	35.6	36.6	44.9	39.7
Parent/ associate companies	15.6***	60.5***	32.2	30.1***	64.0***	42.6
R&D-institutes/ universities	20.4**	9.3**	16.3	22.9	14.6	19.8
Business Services Providers	10.9	7.0	9.4	13.7	13.5	13.6
Technical services providers	15.6	15.1	15.5	17.0	18.0	17.4
Other government agencies	NA			11.8	15.7	13.2
Competitors	10.2	17.4	12.9	8.5	12.4	9.9
Other firms	10.2	4.7	8.2	7.8	6.7	7.4

*** significant at 1% level ** significant at 5% level; * significant at 10% level (Pearson's Chi-Sq, based on 2x2 crosstabs (ownership x intensity (very/ no))).

The ranking of the most important cooperation partners is similar in Penang and Singapore (Tab. 5.45): customers, parents and suppliers. Additionally, technical service providers are more important than in Thailand, as are local research institutes and universities in Singapore. As for most partners in Thailand, a higher share of TNC-affiliates tends to report intense cooperation with external partners. In both regions TNC-affiliates use (local) R&D-institutes and universities more often than local firms. This is the reversal of the figures for Thailand. It indicates the higher quality of these institutes in Singapore and Penang. Moreover it shows that TNC-affiliates perform different functions that make it useful to collaborate with basic and applied research organisations.

Comparing the figures for South East Asia with Europe, it can be seen that the general ranking of important cooperation partners is similar: customers (partners with 30.6% of the local and for 37.6% of the foreign firms), suppliers (17.8%/ 23.1%), services (17.3%/ 21.5%), R&D institutes/ universities (8.3%/ 14.9%) and finally other firms (6.5%/ 8.7%). Consequently, service providers are more important for European firms. Similar to South-East Asia, TNC-affiliates display a higher propensity for intense cooperation with any external partner.

in comparison to the benchmarking regions, missing values in Penang and Singapore have also been coded as 'no/ not intense cooperation'.

Tab. 5.45: Share of advanced firms that collaborate intensely with the following partners on product or process innovation (Singapore and Penang)

	Singapore			Penang		
	Local 52	Foreign 94	Total 146	Local 43	Foreign 38	Total 81
Customers, buyers	69.2	64.9	66.4	62.8**	86.8**	74.1
Suppliers	44.2	46.8	45.9	NA		
- Foreign-owned	NA			37.2	50.0	43.2
- Locally owned	NA			32.6	36.8	34.6
Parent/ associate companies	28.8***	73.4***	57.5	23.3***	65.8***	43.2
R&D-institutes/ universities	NA			4.7**§	18.4**§	11.1
- in Singapore	21.2	27.7	25.3	NA		
- overseas	7.7	8.5	8.2	NA		
Business Services Providers	15.4	11.7	13.0	16.3	26.3	21.0
Technical services providers	26.9	27.7	27.4	34.9	39.5	37.0
Competitors	7.7	6.4	6.8	11.6	15.8	13.6
Other firms	17.3	9.6	12.3	4.7	7.9	6.2

*** significant at 1% level ** significant at 5% level; * significant at 10% level (Pearson's Chi-Sq, based on 2x2 crosstabs (ownership x intensity (very/ no)). § expected frequency in more than one cell <5

Even though the questionnaire in Thailand did not explicitly request the location of the cooperation partner, the following assumptions can be made: partners that are supposed to be located outside the Thai system of innovation include a) customers, at least for TNC-affiliates (see chapter 5.1 for export orientation of foreign firms); b) parent and associate companies overseas (by definition), and c) foreign-owned suppliers –although there is a certain amount of/ rise in follow-source suppliers (cf. e.g. Ivarsson & Alvstam, 2004), it can be assumed that a significant share of foreign-owned suppliers is still located outside of Thailand³³.

The Partners most likely to be located within the Thai-SI are locally owned suppliers and government agencies. Additionally, service firms and research institutions/ universities are presumably for the most part Thailand based. The rationale behind this assertion for services is that globalisation in this industry is a rising but still new phenomenon, and despite modern ICT-technology services frequently require spatial proximity, “since many services are [...] deeply embedded in the social, cultural and political fabric of host societies” (UNCTAD, 2004: 96). At the same time local universities are the ‘natural first choice’ for firms, which seek collaboration with universities, unless there are scientific reasons not to do so. The assumption that such cooperation is likely regionally and/ or nationally oriented is supported by empirical data for Singapore and Europe (Kiese, 2004: 159, Revilla Diez, 2002a: pp. 241).

For competitors, the assumption would also tend towards the regional scale, since trust, which is easier established between firms working in the same environment and in spatial proximity to each other, is an important facilitator for this sensitive type of collaboration.

Based on these assumptions, advanced TNC-affiliates can be considered as important interfaces between the international and national system of innovation. Many foreign firms (and more than local firms) are embedded into international knowledge networks through intense collaboration with partners abroad, such as customers, parents/ associates and foreign-owned suppliers. At the same

³³ This assumption is supported by the data for Penang, where the majority of collaboration with foreign-owned suppliers takes place outside of Malaysia, in either Asia or the rest of the world.

time, a reasonable share is embedded in domestic knowledge networks, especially with locally owned suppliers and government agencies. Actually, the share of TNC-affiliates that collaborates intensely with locally owned suppliers has increased remarkably from 1999 to 2001 (see Tab. 5.44). Moreover, there are as many foreign as local firms reporting intense collaborations with service providers. Research institutes and universities alone are significantly less often sought as cooperation partners by foreign firms.

Consequently, it seems logical to suggest that as many TNC-affiliates as local firms are embedded in domestic networks. This gives domestic actors reasonable opportunities to benefit from the knowledge acquired from TNC-affiliates.

Enquiring into the main reasons for participating in these collaborations, the firms' answers reveal that diffusion and acquisition of new knowledge are the driving forces. In all three regions local and foreign firms listed 'know how transfer', 'entering new technology fields' and 'establishing long term strategic partnerships' as well as 'faster time to market' as important reasons. Thus, local and foreign firms alike collaborate in order to be part of information and knowledge networks. It can be concluded that both R&D and potentially innovating foreign firms are active technology transfer partners. However, there is no information regarding their role within the technology transfer process, i.e. if they act mutually as recipients and senders.

Acquisition of R&D-services

Another form of acquiring knowledge involves the outsourcing and acquisition of R&D-services. This variable entails information about both knowledge networks and the location of the R&D-services provider (Tab. 5.46).

Tab. 5.46: Thailand: Share of R&D-performing firms that acquired R&D services

	1999		2001	
	Local 96	Foreign 56	Local 91	Foreign 57
Acquisition of R&D-services	30.2	35.7	22.0	15.8
• Other firms in Thailand	12.5	12.5	14.0	5.3
• Public institutes in Thailand	11.5	10.7	17.2*	7.0*
• Universities in Thailand	16.7	12.5	17.2*	7.0*
• Abroad (any provider)	11.5	17.9	8.6	12.3

** significant at 5% level; * significant at 10% level (Fisher's Exact Chi-Square-Test)

In 1999, there were only small differences, with local firms using domestic research facilities slightly more often; whereas foreign firms tend to procure R&D-services from other countries (no information on the type of foreign R&D-service providers is included in the questionnaire). These small differences have grown larger in 2001 and, as a result, some of the differences have become statically significant. Consequently, foreign firms contribute to international technology transfer by acquiring foreign knowledge. This enhances the domestically available knowledge-pool. However, TNC-affiliates rely less on the domestic research infrastructure, presumably because of the aforementioned deficiencies in this infrastructure (4.2.2.3). Additionally, the organisational structure of TNCs includes research departments close to headquarters or in advanced countries, which can moderate R&D-service acquisition. This is a loss for the Thai NSI, because these

domestic R&D-acquisitions have two major benefits. First, they create demand, which would foster advances in output from Thai organisations in terms of quantity and quality. Second, the acquisition of R&D-services is connected to knowledge flows from the customer to the R&D-service provider, which helps the latter to gain knowledge about industry demands and state-of-the art technology.

The data on the benchmarking regions does not include detailed information on outsourcing. In general, 32% of local and 24% of foreign firms in Singapore and 42% of local and 24% of foreign firms in Penang acquire R&D-services. Hence, local firms generally tend to acquire external R&D-services more often. This is presumably caused by their smaller size (see 5.1), which frequently results in fewer resources committed to permanent in-house R&D.

Considering that the two Thailand survey datasets are not directly comparable, it is nevertheless striking that foreign firms procure R&D-services from external domestic sources less often in 2001 than in 1999. It is unlikely that domestic R&D-service capabilities have decreased. It is more likely that the demands by TNC-affiliates for R&D have increased, and domestic R&D-services are unable to meet these demands. As a consequence, these functions may preferably be performed in-house. This is more or less consistent with the observed increase in R&D-capabilities in foreign firms.

All surveyed firms were asked if they conduct R&D abroad. Naturally many foreign firms have R&D-facilities overseas (29.8% in 2002 and 32.2% in 2000). Only a small minority of local firms (3.6% in 2002 and 2.7% in 2000) operate R&D-units in other countries. Favourite locations for R&D functions are the triad-regions: Japan, the USA and the EU, because they offer access to the lead-markets, strong competitors and world-class universities (Tab. 5.47).

Tab. 5.47: Location of R&D-facilities abroad (1999)

Country / n	Local Firm 15	Foreign Firm 129
Japan	73.3	57.4
USA	33.3	14.0
EU (total)	26.7	22.5
China	20.0	6.2
Taiwan	13.3	4.7
Australia	13.3	3.9
Germany	13.3	3.9
India	6.7	1.6
Singapore	0.0	3.9
Korea	0.0	5.4
Malaysia	0.0	3.9

NB Distribution of international R&D activities is not available for 2001 because of failures in the data labels.

Source of information

Potentially innovating and R&D-firms were asked to estimate the importance of different sources of information for R&D and innovation activities in the three years prior to the surveys. For this analysis, the share of firms assessing a source as either important or very important has been calculated and ranks have been assigned (Tab. 5.48). This variable provides an outlook on a firm’s capability to utilise different sources of knowledge. Additionally it includes – to a certain extent –

information on the location of the source. Consequently, the question indicates local and foreign firms' capability for knowledge acquisition.

Tab. 5.48: Thailand: Important and very important sources of information for R&D and innovation activities in the three years prior to the survey

/ n	Local 69-107 %	2000			Foreign 49-67 %	Local 108-147 %	2002		Foreign 63-88 %
		R	R	R			R		
Clients	74.8	1	2	75.8	71.4	2	3	77.9	
Sources within the enterprise	61.9	2	3	73.1	80.1	1	1	83.0	
Foreign-owned suppliers	59.1	3	5	53.9	47.1	9	8	49.4	
Locally-owned suppliers	54.0*	4	9	40.0*	55.9	5	6	51.8	
Specialist literature	49.0	5	6	40.6	55.2	6	5	59.3	
Fairs and exhibitions	48.5	6	10	33.3	53.2	8	9	39.2	
Internet	47.9	7	6	40.6	69.0*	3	2	81.8*	
Competitors	47.4	8	4	56.3	37.21	10	10	34.6	
Parent/ associate company	46.4***	9	1	83.6***	60.0*	4	4	75.6*	
Professional conferences & meetings	44.9	10	8	40.3	53.9	7	7	50.0	
Technical service providers	33.7	11	11	32.7	32.3	11	13	26.5	
Universities or other higher education inst.	30.4	12	14	21.8	30.0	13	12	28.6	
Govt. or private non-profit research institutes	28.4	13	15	20.4	26.9*	14	15	20.3*	
Business Service Providers	25.9	14	12	26.0	16.8	15	14	23.4	
Patent disclosures	21.1	15	13	24.5	30.7*	12	11	33.3*	

*** significant at the 1% level, ** significant at the 5% level. * significant at the 10% level according to Pearson's Chi-Square Test (based on a 2x3 table with ownership x importance); R= Rank

Generally, the most important sources are those which are either directly linked to the enterprise itself, sources within the firms or parent/ associates, or to the value-chain, such as customers and suppliers. Furthermore, 'soft sources' such as specialist literature, the internet and fairs are central suppliers of new ideas. At the same time 'horizontal partners' like service firms (either technical or business), competitors and public research institutes and universities as well as demanding sources such as patents are rarely perceived as important.

Local firms identify customers and internal sources as by far the most important sources of information, but also consider locally owned suppliers significantly more important than foreign firms (in 2000). Foreign firms consider clients and internal sources as very important as well, but appreciate the knowledge received from their parent and associate firms even more. This is significant at the 1%/10% level for 2000/2002.

In 2002, the internal sources are more important than in 2000. This is also valid for the Internet, which is named especially often by TNC-affiliates. At the same time parent/ associate firms became

less important to foreign firms. While foreign-owned suppliers are less decisive in 2002, foreign firms especially have underlined the usefulness of local suppliers. This is in line with the observed increase in collaboration intensity (see Tab. 5.44).

Moreover, local firms noticeably indicate collaboration with public research institutes more frequently, while foreign firms more often make use of patent disclosures (both are significant at 10% level for 2002). The latter is clearly related to a higher absorptive capacity necessary to utilise this source. The fact that local firms rely more on local research institutes reflects their stronger embeddedness in the local S&T-infrastructure.

These findings have the following implications for the considered hypothesis:

- Foreign firms make better use of information from abroad than local firms. They recognize new ideas from the following sources as important more often: parent/ associate firm within the corporate network, sources within the enterprise (which also might be foreign sources for TNC-affiliates), Internet and patent information. Moreover, their customers are more often globally dispersed, since TNC-affiliates primarily cater to the global market. In conclusion, foreign firms bring in important information from e.g. lead users in the most demanding markets. In conclusion, foreign firms transfer knowledge from abroad to Thailand more often, either through knowledge exchange with the named partners or through via absorptive-capacity intense patent-research.
- Furthermore, foreign-owned suppliers are fairly important sources of information for local firms (esp. in 2000). Since at least some of these suppliers are supposed to be located in Thailand, it can be asserted that TNC-affiliates in Thailand foster the upgrading of local firms quite significantly. However, in 2002 the importance of foreign suppliers has declined markedly. In 2002 local firms also evaluated the Internet, which provides access to global information, as very important. Notwithstanding, they rely more on local institutions such as public research institutes and universities than foreign firms.

The pattern in Thailand is similar to the one in Penang (no information for Singapore is available). Firms in both regions rank the same sources as most important, indicating no differences in information-acquisition capability.

In summary, TNC-affiliates make better use of foreign sources of information for R&D and innovation, and source R&D-services more often from units abroad. Moreover, about 30% of the foreign firms perform R&D elsewhere – hence advanced TNC-affiliates transfer technology and knowledge from abroad to Thailand. Local firms on the other hand rely much more strongly on domestic sources of information. This pattern is also supported by the figures for intense R&D and innovation collaborations: Foreign firms frequently seek cooperation with partners that are (possibly) located outside of the Thai NSI and can consequently facilitate technology transfer. The share of firms that is embedded in the Thai NSI is mostly as high as the share of local firms –the only exception being the cooperation with research institutes and universities. TNC-affiliates hardly collaborate with the domestic S&T infrastructure. Both foreign and local firms state that the diffusion of knowledge is an important reason for collaboration.

5.5 Exploring key characteristics of advanced and embedded TNC-affiliates in Thailand

The previous sections conclude, in short, that advanced TNC-affiliates can be beneficial to the Thai NSI, because they are by definition more capable than basic local and foreign firms, and are equally or even more competent than locally-owned advanced firms. Moreover, they transfer technology from abroad, by acquiring embodied and disembodied technology, by procuring R&D-services from abroad or performing their own R&D in other countries, whose results are then (partly) transferred to Thailand. Additionally, these advanced foreign firms seem to be more embedded within international knowledge networks, and are for the most part as embedded as local firms in domestic networks.

Consequently, this chapter relates to:

Q1: What are key characteristics of advanced TNC-affiliates in Thailand? (see 5.5.2) and

Q2: What are main determinants of embedded TNC-affiliates? (see 5.5.3)

Hence, the research objective for this chapter is to determine independent variables that explain if a given TNC-affiliate is either advanced or embedded. Besides for scientific interest, answers to these questions would be very relevant to the design of custom-tailored policies targeting those TNC-affiliates, which promise positive impacts on the Thai NSI.

In the remainder of this chapter the CHAID analysis, which will be implemented for this investigation, will be introduced. Second, both the 2000 and 2002 datasets are analysed in order to find characteristics of advanced TNC-affiliates (5.5.2), of generally embedded and foreign firms embedded in the Thai NSI (5.5.3).

5.5.1 Excursus: Explorative data analysis using CHAID analysis

For the implementation of the CHAID analysis the software package AnswerTree 3.1 from SPSS is utilised. It offers decision trees algorithm as a tool for explorative statistics. These explorative statistics are part of data mining procedures that try to discover formerly unrecognised patterns within complex datasets. Other methods in the field of data mining are e.g. factor, cluster, discriminant and regression analysis. Since much information in the R&D/ Innovation survey is either nominal or ordinal, methods that require metric variables as either dependent/ group variables or independent/ characteristic variables are not appropriate. Furthermore, the decision tree analysis does not require a large set of dummy variables that can easily result in a high degree of complexity in e.g. regression analysis. Hence, the exhaustive CHAID (Chi-squared Automatic Interaction Detection) algorithm, which creates non-binary decision trees, is implemented.

The original CHAID algorithm developed by Kass (1980), creates segments based on Chi-square tests. Hereby, the dependent variable (group variable or criteria) as well as the independent variables (predictor variable) can be of nominal, ordinal or metric scale. Metric variables, however, are categorised automatically. The procedure basically operates in two steps (cf. Baltes-Götz, 2004: 28; Bühl & Zöfel, 2002: ch. 1.4; SPSS, 2001: pp. 220):

a) **Merging:** For each predictor variable, the categories will be analysed if they display significant differences in respect to the dependent variable. To accomplish this, different statistical procedures (F-Test for metric, either Pearson's Chi-Square Test or Likelihood-quotient- Test for nominal and Likelihood-quotient- Test for ordinal variables) generate the significance probability (p-value) for each category pair of every predictor variable. The category-pair with the highest p-value will be merged. For ordinal and metric predictors only neighbouring categories can be merged. All categories that display significant differences, i.e. whose p-value is smaller than the α_{merge} , generally 5%, will be retained. The result is a new set of categories for each predictor.

b) **Splitting:** For every predictor variable the association with the dependent variable will be tested (for procedures according to scale level see a). If a predictor variable includes categories that have been merged in step a), the resulting p-value will be adjusted based on the Bonferroni method. This is necessary, because the merging of categories results in an artificial reduction of the p-value in step b) (see Baltes-Götz, 2004: pp. 29). If the p-value is smaller than α_{split} , i.e. the difference is statistically significant at e.g. the 5%-level, the predictor variable will cause a node, which creates new branches. The first node will be created by the predictor variable with the lowest p-value. This process continues as long as either no more significant predictor variables can be found or a 'stop-criteria' is reached. Stop-criteria can be a) the specified maximum number of branches/ nodes is reached, b) the size of the node falls short of the minimum size for split-able nodes, or c) further splitting would result into nodes with less than the required minimum specified size of final nodes. If no further splitting is possible, the respective nodes are referred to as final nodes.

Based on this basic CHAID algorithm, Biggs et al. (1991) developed the exhaustive CHAID algorithm. Exhaustive CHAID can be considered superior (Bühl & Zöfel, 2002, ch. 1.8; Baltes-Götz, 2004: pp. 29) for two reasons: first, the algorithm is more thorough and precise, because it merges categories for each predictor variable until only two categories remain (SPSS, 2001: 225) and second, it corrects some of the inconsistencies of the Bonferroni-adjustment in the traditional CHAID (for details see Baltes-Götz, 2004: 33). Hence, despite extended processing time, the exhaustive CHAID is used in this research³⁴.

The user influences the automatic routine of (extensive) CHAID by determining the following parameters: α_{merge} , α_{split} , maximum number of branches/ nodes, minimum size of major nodes (which are split-able) and minimum size of final nodes. Alternatively, the procedure can be run semi-automatically, i.e. the user chooses appropriate predictor variables for each node from a list of significant predictor variables. The second alternative allows for the selection of qualitatively equivalent predictors that might better fit theoretical assumptions/ arguments.

In order to control the quality of the analysis, both a misclassification matrix and an estimation of risk are produced. Furthermore, for large datasets, cross-validation is possible, by using only a small sample (training data) of the database to develop the decision tree and subsequently validating the model with the remaining 'test data'.

³⁴ Alternative algorithms available in AnswerTree 3.1. are C&RT (Classification& Regression Trees, developed by Breiman et al. (1984)) and QUEST (Quick and Unbiased, Efficient Statistical Tree by Loh and Shih (1997)). Both create binary decision trees and were therefore discarded.

Advantages of the method are seen in the transparency of the analysis, the fact that it does not require assumptions concerning the functional relation between independent and dependent variables and its ability to reveal hidden interactions between independent variables. On the other hand, there are some disadvantages, such as the creation of complex and difficult to interpret segments every now and then and the need for rather large samples, because the tree structure results in a steep decrease in the absolute size of elements in the end nodes. Moreover, analysis leads to a loss of information on metric variables, because these must be categorized. Finally, there can be problems with highly correlating variables: occasionally significant split variables might be neglected for the tree building process, because another highly correlating and significant split variable was chosen. Subsequently, this can 'erase' the other variable from the process, even though it would explain the splitting very well (Munzer, 2000: pp. 211).

5.5.2 Key characteristics of advanced TNC-affiliates

In this first step of the analysis, key determinates of advanced foreign firms are to be identified. For this, one dependent variable (called INVATING) has been created, which is coded 1 for all advanced firms and 0 for basic firms. Moreover, a set of 28 independent variables is compiled, which are available for basic and advanced firms alike (Tab. 5.49). Basically, this is the general information gathered in part A of the questionnaire. The parameters for the analysis are determined as follows: α_{merge} and α_{split} is 5%, the maximum number of branches/ nodes is 10, the minimum size of major nodes is 60 and the minimum size of final nodes=30.

Figure 5.2 and Tab. 5.50 display the results of the analysis of the 2002 data. Foreign firms that carry out detailed design, acquire external technology, and have more than 700 employees have the highest hit rate, i.e. the highest share of advanced firms within this final node: About 75% of the firms in this group are advanced. The index in Tab. 5.50 indicates that this group is four times more likely to carry out R&D or achieve product or process innovations than the average foreign firm.

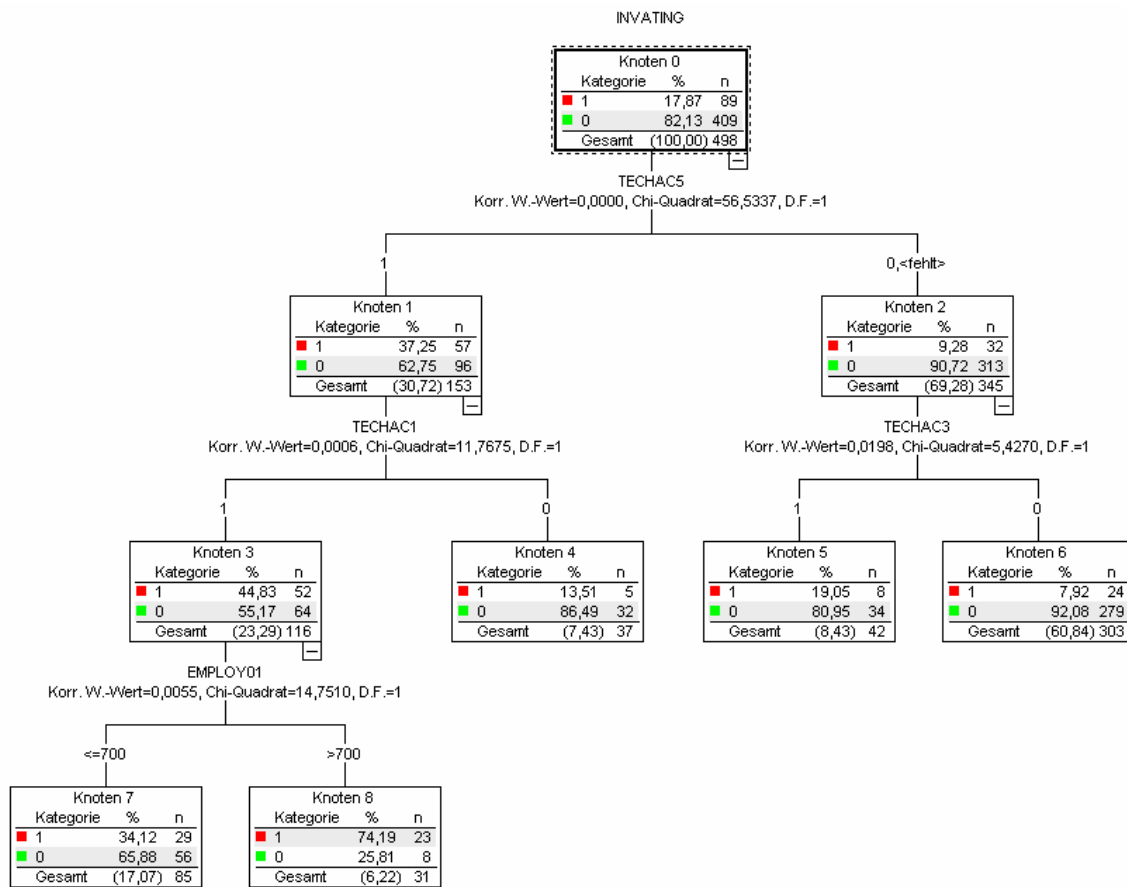
The overall pattern of Tab. 5.50 suggests that the variables 'performing detailed design' and 'acquiring external technology' have the most significant, positive impact on a foreign firm's chance to be advanced. In line with theoretical considerations, firm size (measured in number of employees) also has a positive impact, as larger firms generally commit more resources to innovation activities and are more likely to have a formal R&D-department. According to the misclassification matrix and the risk estimates, the likelihood for a misclassification is 14.9% (with a standard error of 0.016). Hence, the model is – taking into account the limited number of variables used – quite accurate.

Tab. 5.49: Dependent and independent variables included in the exhaustive CHAID analysis

Variable Name		Scale	Description
2000	2002		
Dependent variable			
INVATING	INVATING	Nominal	R&D performing or product innovation introducing or process innovation applying (yes/no)
Independent variables			
BKK	BKK	Nominal	Firm located in the BKK-region ³⁵ ? (yes/no)
SEC	SEC	Nominal	Sector affiliation (2 digit)
OWNER	OWNER	Ordinal	Ownership (100%, 50-99%, 30-40% foreign owned)
EMPLOY99	EMPLOY01	Metric	Number of employees at the end of 1999/2001
TRAIN99	TRAIN01	Metric	Share of training expenditure as % of sales in 1999/2001
ASSET99	ASSET01	Metric	Total fixed assets as of 12/1999 / 12/2001 in million Bhat
DOMES99	DOMES01	Metric	Percentage of domestic sales in 1999/2001
EXPORT99	EXPORT01	Metric	Percentage of export sales in 1999/ 2001
P2Q10A	P2Q10A	Metric	% of sales to parent/ associate company overseas
P2Q10B	P2Q10B	Metric	% of OEM sales
P2Q10C	P2Q10C	Metric	% of ODM sales
P2Q10D	P2Q10D	Metric	% of OBM sales
ISO9001	ISO9001	Nominal	Certificated according to ISO 9001 (yes/no)
ISO9002	ISO9002	Nominal	Certificated according to ISO 9002 (yes/no)
ISO14000	ISO14000	Nominal	Certificated according to ISO 14000 (yes/no)
P3Q13A	TECHAC1	Nominal	Tech. activity: Acquisition of external technology (yes/no)
P3Q13B	TECHAC2	Nominal	Tech. activity: Adaptation of external technology (yes/no)
P3Q13C	TECHAC3	Nominal	Tech. activity: Reverse Engineering (yes/no)
P3Q13D	TECHAC4	Nominal	Tech. activity: Basic design (yes/no)
P3Q13E	TECHAC5	Nominal	Tech. activity: Detailed design (yes/no)
P3Q13F	TECHAC6	Nominal	Tech. activity: Testing (yes/no)
P3Q13G	TECHAC7	Nominal	Tech. activity: Quality control (yes/ no)
AGE	AGE	Metric	Age of firm
EMPLOYAP	EMPLOYAP	Metric	% of university graduates of total employment
EMPLOYBP	EMPLOYBP	Metric	% of vocational school graduates of total employment
EMPLOYCP	EMPLOYCP	Metric	% of secondary school graduates of total employment
EMPLOYDP	EMPLOYDP	Metric	% of primary school graduates of total employment
SALEMP99	SALEMP01	Metric	Sales per employee in 1999/2001 (Bhat)

³⁵ Consisting of the following provinces: Bangkok, Nonthaburi, Pathum Thani, Nakhon Pathom, Samut Sakhon, Samut Prakan, Ayutthaya, Chachoengsao, Chon Buri and Rayong.

Figure 5.2: Decision Tree for advanced foreign firms in Thailand (2002)



with: Korr.W.-Wert = p-value; Chi-Quadrat = Chi-Square; D.F. = degrees of freedom; Knoten = node; Gesamt = Total; <fehlt> = missing

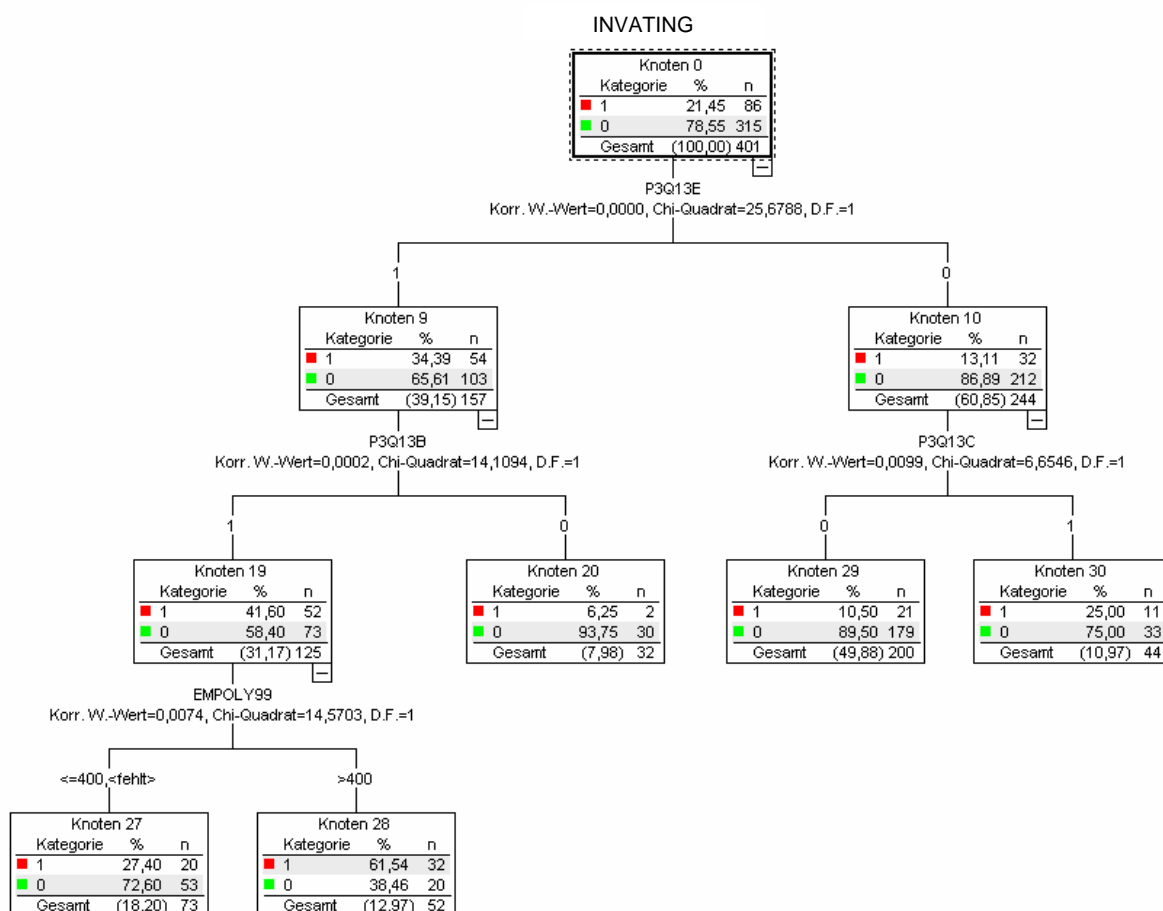
Tab. 5.50: Gains summary table for advanced foreign firms in Thailand - 2002 (sorted by hit rate)

Node	Detailed design	Acquisition of external technology	Reverse engineering	Employment (2001)	Hit rate (%)	Index (%)
8	yes	yes		> 700	74.2	415.2
7	yes	yes		<= 700	34.1	190.9
5	no		yes		19.1	106.6
4	yes	no			13.5	76.6
6	no		no		7.9	44.3

In order to support these findings, the 2000 data has been analysed (Figure 5.3). The automatic procedure results in different splitting variables. However, with the semi-automatic procedure most of the 2002-predictors can be manually selected, because they display equivalent p-values to the automatically chosen predictors. Consequently, a similar tree can be created (Figure 5.3), which actually displays a lower risk estimate (18.5%) than the automatic procedure (18.7%).

The highest hit rate is shown for firms that carry out detailed design and adapt external technology (Tab. 5.51). Furthermore, larger firms are more likely to be advanced. Compared to the 2001 data, the adaptation rather than the acquisition variable exerts a strong influence on the splitting.

Figure 5.3: Decision Tree for advanced foreign firms in Thailand (2000)



with: Korr. W.-Wert = p-value; Chi-Quadrat = Chi-Square; D.F. = degrees of freedom; Knoten = node; Gesamt = Total; <fehlt> = missing

Tab. 5.51: Gains summary table for advanced foreign firms in Thailand- 2000 (sorted by hit rate)

Node	Detailed design	Adaptation of external technology	Reverse engineering	Employment (1999)	Hit rate (%)	Index (%)
28	yes	yes		> 400	61.5	286.9
27	yes	yes		<= 400	27.4	127.7
30	no		yes		25.0	116.6
29	no		no		10.5	49.0
20	no		no		6.3	29.1

In conclusion, the acquisition and adaptation of external technology as well as detailed design activities are the most important factors for advanced foreign firms. Also, size matters: firms with more employees have a higher likelihood of conducting R&D or being innovating firms. Consequently, these findings support the notion that technical change in late-industrialising countries is strongly related to the acquisition and adaptation of external technology available in advanced countries (see 2.1.2). Moreover, it underlines the proposition that firms need to cumulate certain basic and intermediate capabilities, before they become successful innovating firms. Namely, they must have access to technology (acquisition) and understand how it works as well as how to – incrementally – change it (adaptation). The latter capability can also be achieved by

designing specific details of products after key features have already been determined (which may have been completed by the customer or component supplier).

Hence, from a political point of view, it is first and foremost important to foster foreign firms' access to external sources of technology and to improve their capability to acquire either embodied (e.g. machinery) or disembodied (e.g. blueprints) technology. Many foreign firms are expected to have easy access to these technologies via their corporate networks. Consequently, rather than enhance TNC-affiliates' capabilities directly, this instead becomes a question of influencing the strategies of TNCs. Providing a favourable business environment or system of innovation can be a means to achieve this. In addition, it is essential to foster foreign firms' design capabilities, which are a prerequisite for R&D, product and process innovations.

5.5.3 Key characteristics of embedded TNC-affiliates

Embeddedness in this section does not relate to flows of goods or services, but to cooperation in the fields of R&D and innovation. Firms that are strongly embedded in international and domestic cooperation and knowledge networks are of major significance for the potential diffusion of internationally available knowledge and technology within the Thai NSI. In order to use explorative statistics to determine key characteristics of these embedded foreign firms a '**collaboration intensity index**' (CII) has been computed.

The analysis is restricted to foreign R&D and potentially innovating firms, because only these firms were asked about the intensity of collaborations with external partners on R&D, product and process innovation. The surveyed firms specified the intensity of their cooperation with each partner on any of these three activities (see chapter 5.4). This intensity was measured on a five point Likert-Scale. For the analysis the first two categories of 'not at all' and 'hardly intensely' have been recoded as 1, the median answer of 'quite intensely' as 2 and 'intensely' and 'very intensely' as 3. Missing values are coded as 0. Next, the variable **CII** has been created by summing up the values for the ten possible collaboration partners (nine in 2000, because 'other government agencies' was not offered as a partner category) and the three possible activities. Hence, a firm could score a maximum of 90 points (81 in 2000).

This **first step** of the index displays the general embeddedness of foreign firms in **any type of network**. In the 2002 dataset, the actual minimum is nil, the maximum 67 and the average 19.8 points (median: 17). For 2000 the minimum is again nil, maximum is 71 and the average 25.2 (median: 27) points. For the application of the answer tree, the intensity variable was classified into two groups: weakly embedded firms (with a below average 2002-CII of ≤ 19) and strongly embedded firms (CII of ≥ 20). The 2002 dataset includes 62 weakly and 49 strongly embedded foreign firms, while for 2000 44 weakly and 53 strongly embedded foreign firms were identified. In addition to the variables named in Tab. 5.49, several other variables on R&D and innovation activities are included into the analysis (see Appendix A8). The minimum size of main nodes has been reduced to 20 and for final nodes to 10, because of the limited sample size.

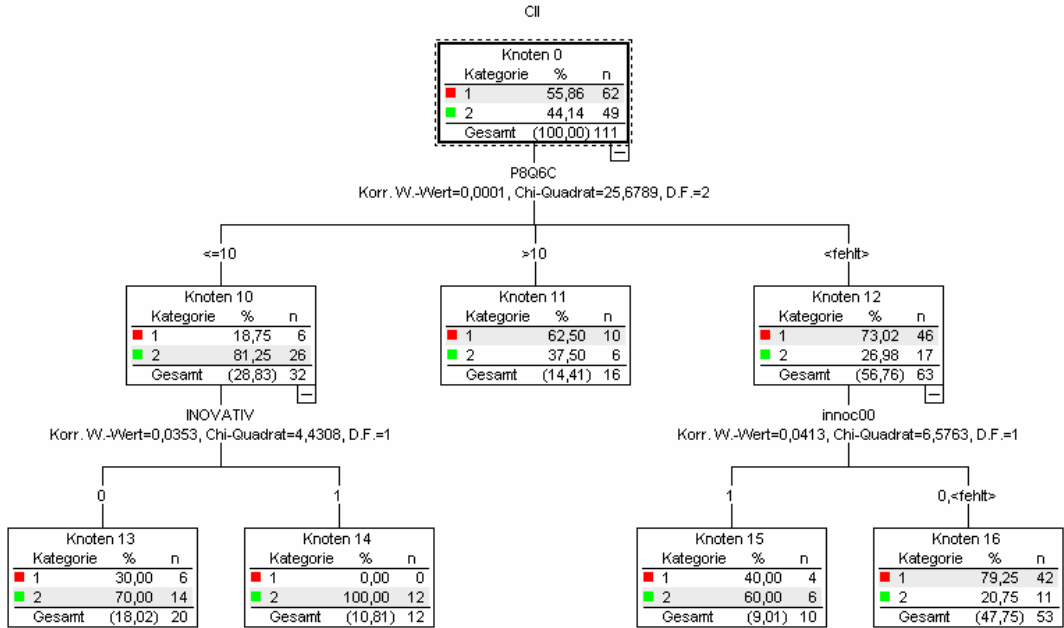
The **second step** concentrates on collaboration with collaboration partners, which are presumably located within Thailand. Hence, it tries to capture key variables influencing the **embeddedness of**

TNC-affiliates within the Thai-NSI. In this case, the possible maximum score is 45, while the actual maximum is 30. Again, the intensity variable was classified into two groups: weakly embedded firms (with a below average 2002-CII of ≤ 9) and strongly embedded firms (CII of >9). The 2002 data entail 40 strongly embedded and 71 weakly embedded foreign firms, while the 2000 dataset records 49 weakly and 48 strongly embedded TNC-affiliates.

Embeddedness of TNC-affiliates in R&D and innovation networks

In 2002, one of the most influential variables in the distinction between strongly (category 2) and weakly embedded (1) foreign firms (see Figure 5.4 and Tab. 5.52) is the share of R&D-expenditure spent on basic research (labelled P8Q6C). Firms that spend less than 10% on basic research and, consequently, more on applied research and experimental development have a higher likelihood of being strongly embedded. This is especially true for those firms that are at the same time innovative (INOVATIV), i.e. which achieve at least 25% of sales with new products or produce at least 25% of their production with new processes. A high share of those foreign firms that either did not perform R&D or did not report the distribution of their R&D-spending, is strongly embedded when it performs ‘industrial design and engineering linked to innovation’. Despite being the ‘best possible’ model, the risk estimate of 24% (standard error: 0.04) is fairly high with one in four cases predicted wrongly.

Figure 5.4: Decision Tree for strongly embedded foreign firms in Thailand (2002): all partners



with: Korr.W.-Wert = p-value; Chi-Quadrat = Chi-Square; D.F. = degrees of freedom; Knoten = node; Gesamt = Total; <fehl> = missing

These findings indicate that, of all R&D- and potentially innovating foreign firms, those that focus on applied research and experimental development collaborate most intensely. Apparently, these activities provide more opportunities for collaboration than basic research. Particularly, innovative firms that achieve a high percentage of sales with new products or which realise a high percentage of production with new processes are considered intense ‘networkers’. This suggests a mutual

causality: innovative firms collaborate intensely and are therefore innovative. Additionally, design and engineering, when linked to innovation, has a positive impact on collaboration. The tree for 2000 is less conclusive, but shows that firms that evaluate know-how transfer as an important reason for collaboration have a higher propensity to collaborate closely. Moreover, the commitment to innovation and R&D, indicated by carrying out training for innovation, financing R&D-activities with own funds, and spending money on non-R&D innovation activities, are positively related to collaboration intensity.

Tab. 5.52: Gains summary table for strongly embedded R&D and potentially innovating foreign firms in Thailand - 2002 (sorted by hit rate)

Node	% share of R&D exp. on basic research	Innovative	Industrial design and engineering linked to innovation in 2000	Hit rate (%)	Index (%)
14	<=10%	yes		100.0	226.5
13	<=10%	no		70.0	158.6
15	missing		yes	60.0	135.9
11	>10			37.5	84.9
16	missing		no	20.8	47.0

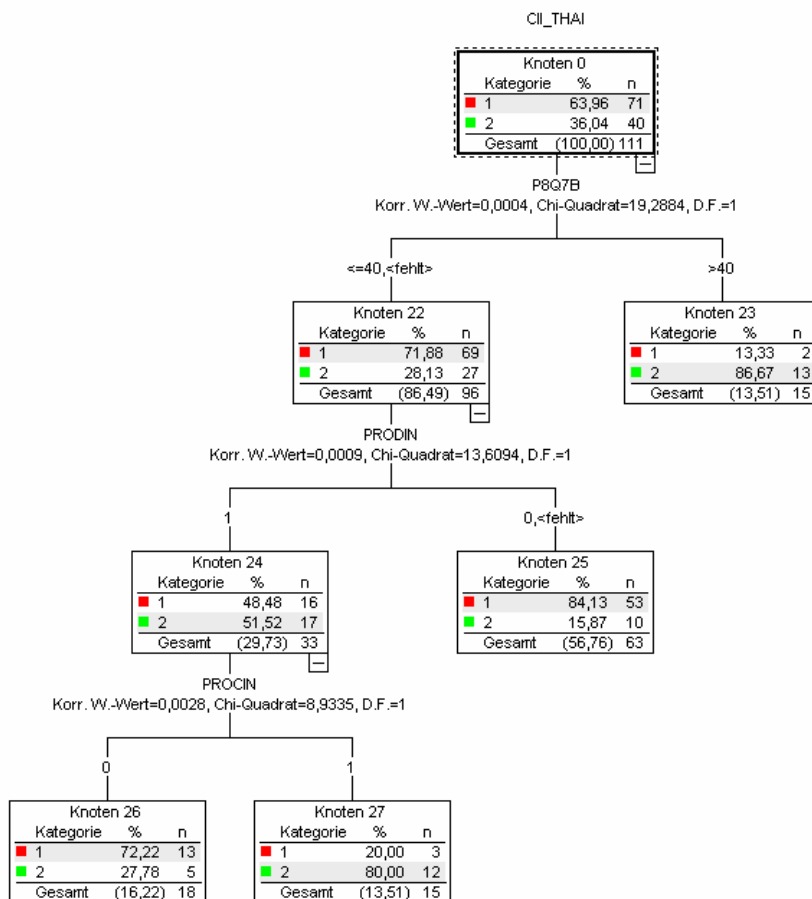
Embeddedness of TNC-affiliates in R&D and innovation networks within Thailand

Before presenting the respective analysis, a ‘word of caution’ is necessary: the questionnaire in Thailand did not request that firms specify the location of their collaboration partners. Therefore, this analysis is based on assumptions concerning the prevailing location of collaboration partners (see 5.4). The following partners tend to be based within the Thai NSI: locally owned suppliers, government agencies, technical and business service providers, as well as research institutes and universities. Due to the speculative character of this analysis, the results should be regarded with caution.

The CHAID analysis from the 2002 data (see Figure 5.5 and Tab. 5.53) shows that firms which assign more than 40% of their R&D-expenditure to process-related R&D and those that are innovating firms have the highest inclination to be strongly embedded in the Thai NSI. The risk estimate for this model is 18% (standard error 0.04). This result is not surprising. Obviously, TNC-affiliates that have been assigned development and innovation functions by their headquarters both see the need and show the commitment to collaborate with local partners. It seems that intense cooperation with local partners is more common in process innovation, which is reasonable: As will be shown in the in-depth interviews (chapter 6), there is more scope for TNC-affiliates to build up process R&D rather than product R&D and development capabilities. Many foreign firms reported that product development takes place predominantly at their home base, whereas (incremental) process related R&D is more closely connected to the site of volume-production. However, this picture is not supported by the quantitative data on R&D-spending, which indicates the predominance of TNC-affiliates in terms of product-related R&D (see Tab. 5.37). Nevertheless, the disaggregated collaboration frequencies for local and foreign firms (see Appendix A9) also support these findings, since, especially in the field of process innovation, a high share of foreign firms reported intense collaboration with local partners. For the 2000 data (Figure 5.6 and Tab. 5.54)

there is additional evidence for a positive impact from product and process innovations. Here, the successful market introduction of a new product is the most influential splitting variable, followed by process and R&D-related products or process innovations. However, because one in four cases is mismatched, this tree is not very reliable (25.7%; standard error: 0.04).

Figure 5.5: Decision Tree for strongly embedded foreign firms in Thailand (2002): domestic partners



with: Korr.W.-Wert = p-value; Chi-Quadrat = Chi-Square; D.F. = degrees of freedom; Knoten = node; Gesamt = Total; <fehl> = missing

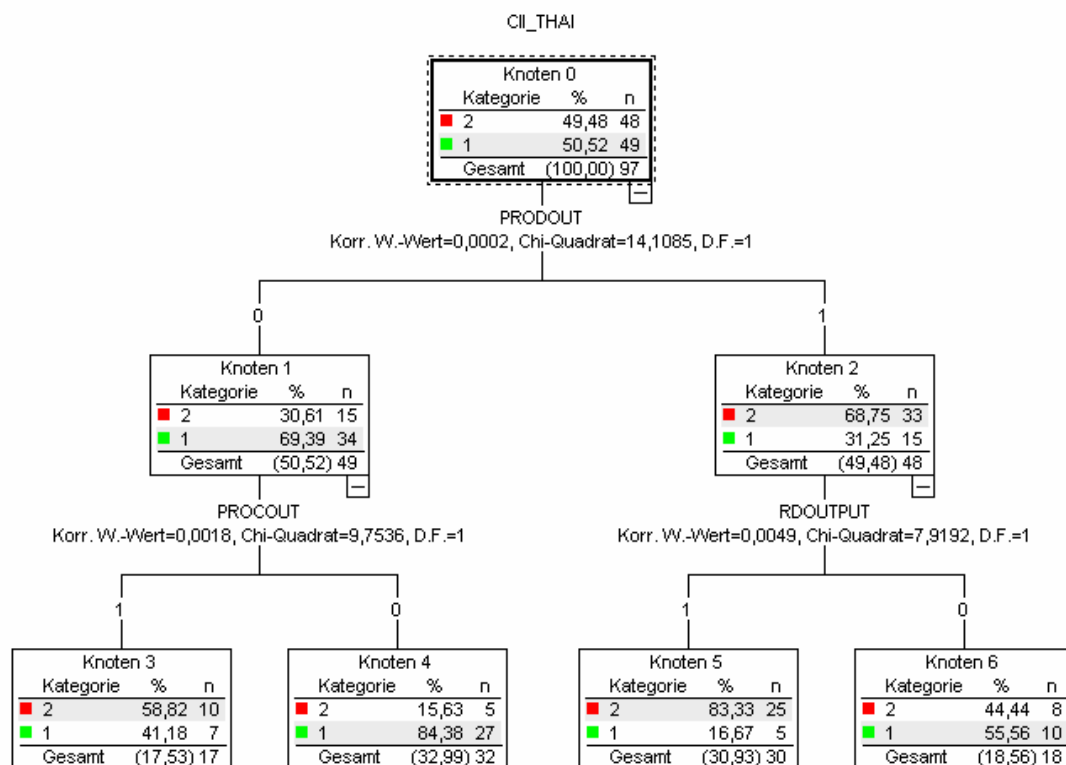
Tab. 5.53: Gains summary table for strongly embedded R&D and potentially innovating foreign firms in Thailand - 2002 (sorted by hit rate)

Node	%of process-oriented R&D (P8Q7B)	Process innovation? (PROCIN)	Product innovation? (PRODIN)	Hit rate (%)	Index (%)
23	>40			86.7	240.5
27	<= 40, missing	Yes	yes	80.0	222.0
26	<= 40, missing	No	yes	27.8	77.1
25	<= 40, missing	No	no	15.9	44.0

In summary, foreign firms in Thailand are generally strongly embedded in R&D and innovation-related networks, particularly when they perform more applied research or experimental development, and when they are innovative. It can be assumed that the variables are interrelated: successful innovating firms see the need for intense collaborations and the benefits that arise from these.

The same conclusion holds for the local embeddedness of TNC-affiliates: Foreign firms that are innovating and that spend a substantial part of their resources on process-related R&D collaborate intensely with external partners located in Thailand. Ultimately, innovating firms tend to be more embedded – globally as well as locally.

Figure 5.6: Decision Tree for strongly embedded foreign firms in Thailand (2000): domestic partners



with: Korr.W.-Wert = p-value; Chi-Quadrat = Chi-Square; D.F. = degrees of freedom; Knoten = node; Gesamt = Total; <fehlt> = missing

Tab. 5.54: Gains summary table for strongly embedded R&D and potentially innovating foreign firms in Thailand - 2000 (sorted by hit rate)

Node	Product innovation? (PRODOUT)	Process innovation? (PROCOUT)	Products or processes innovation as a result of R&D? (RDOUTPUT)	Hit rate (%)	Index (%)
5	yes		yes	83.3	168.4
3	no	yes		58.8	118.9
6	yes		no	44.4	89.8
4	no	no		15.6	31.6

5.6 Internal and external obstacles and conditions for innovation

The analysis of factors that hamper innovation and the quality of business environment conditions as perceived by the surveyed firms can bring about insights into the technological capabilities and absorptive capacity of firms as well as their assessment of strengths and weaknesses of the system of innovation. Hence, this section relates to Q3: “What are major bottlenecks within the Thai system of innovation as perceived by local and foreign firms?” In the following section, the limiting factors for R&D as well as those for other innovation activities and the evaluation of specific environment conditions are presented.

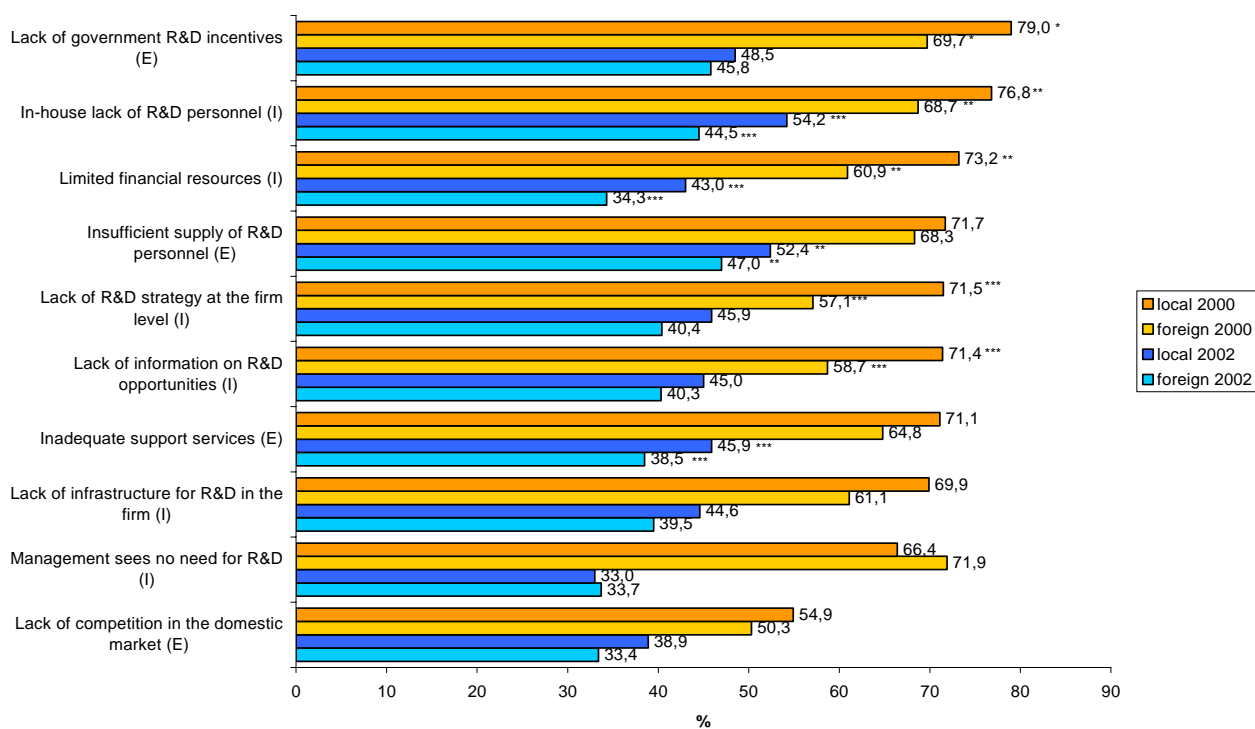
Factors limiting R&D and innovation

First, the most important limiting factors for R&D as perceived by firms in Thailand (Figure 5.7) are a lack of government R&D-incentives, lack of R&D-personnel in-house and insufficient (external) supply of R&D-personnel. Consequently, the lack of capable human capital is a key concern for both local and foreign firms (see also 4.2.2.2). However, significantly fewer TNC-affiliates have evaluated the lack of R&D-personnel as either important or very important. Obviously, foreign firms suffer from a lack of human capital, but experience fewer problems in finding adequate staff compared to local firms. This is due presumably to the higher wages paid by foreign firms (see 4.1.4). Furthermore, a higher share of local firms assesses almost all factors as more severe than foreign firms. This is especially true for the availability of financial resources, the lack of an R&D-strategy and information on R&D-opportunities (2000), as well as for the availability of suitable support services (2002). Evidently, TNC-affiliates have better access to funds and information and can, consequently, make up for some of the external weaknesses.

Strikingly, TNC-affiliates suffered from the fact that the management did not see the need for R&D, which ranked as the most significant problem in 2000. In 2002, this hardly remains an issue – this perception is in line with the observed increase in R&D-activities in foreign firms (see chapter 5.1 and 5.2). Generally, fewer firms perceived of these problems as either important or very important in 2002.

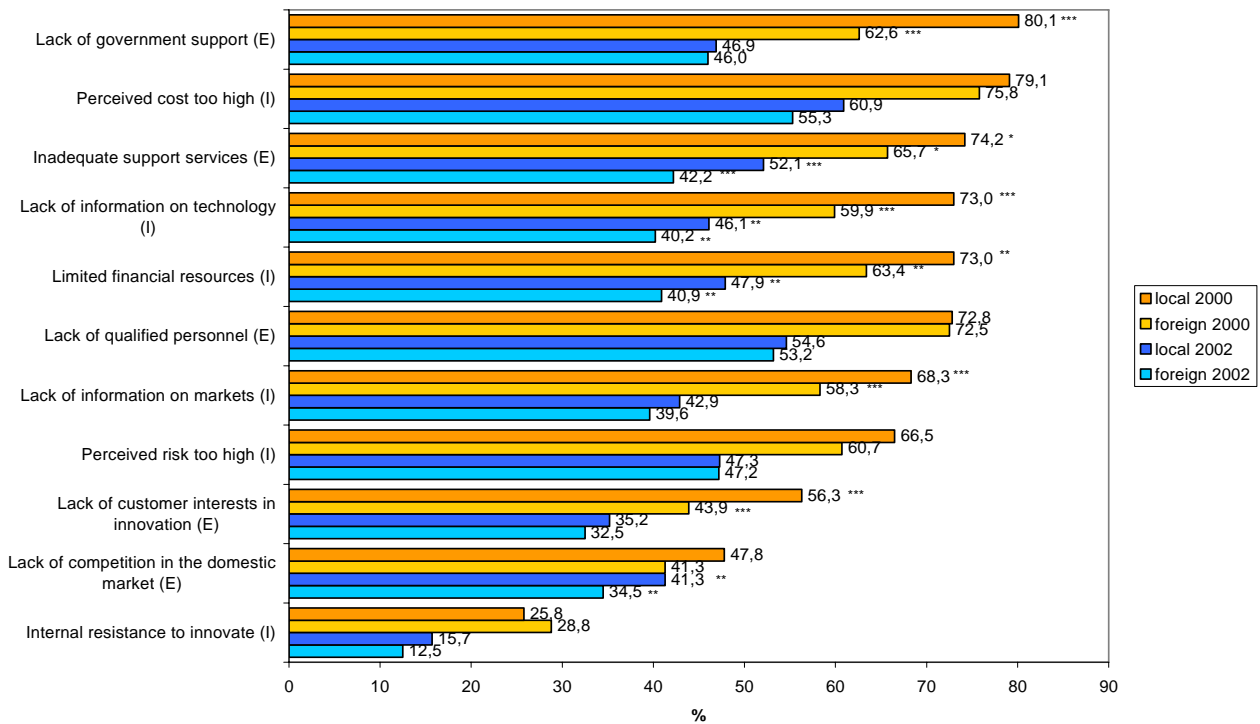
Second, important obstacles for innovation activities other than R&D (Figure 5.8) are the perceived costs and risks, a lack of qualified personnel and government support as well as inadequate support services. Again, local firms have evaluated most factors more negatively foreign firms. In contrast to R&D, the lack of human capital and the role it plays in limiting innovation is perceived similarly.

Figure 5.7: Percentage of firms that named the following as important or very important factors limiting R&D



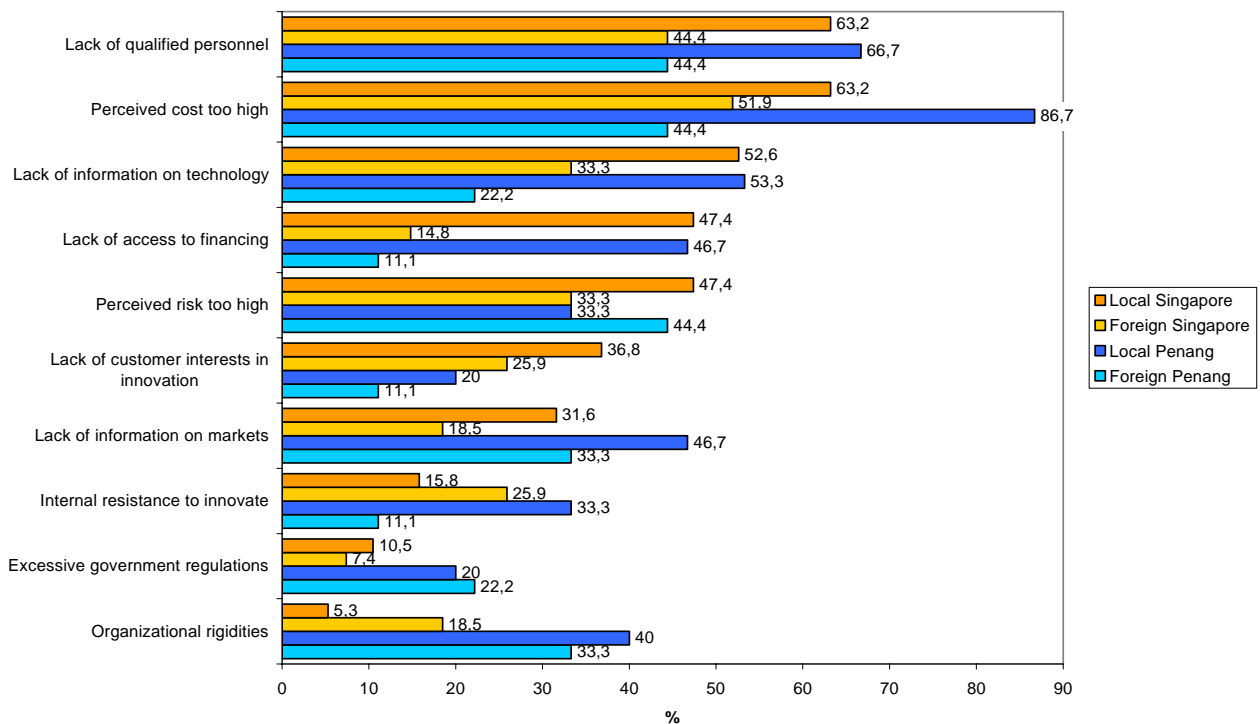
*** significant at 1% ** significant at 5%; * significant at 10% level (Pearson's Chi-Square Test); I = internal factor; E= external factor

Figure 5.8: Percentage of firms that named the following as important or very important factors limiting innovation activities other than R&D



*** significant at 1% ** significant at 5%; * significant at 10% level (Pearson's Chi-Square Test, based on 3x2 crosstabs (ownership x importance of factor (not/ not very important, neutral, important/ very important); I = internal factor; E= external factor

Figure 5.9: % of firms in Singapore and Penang, encountering problems in innovation projects, that named the following as important or very important limiting factors for innovation



Despite significant differences in limiting factors, rankings between foreign and local firms in Thailand are fairly similar. Comparing the concerns of advanced and basic firms, only a few conspicuous differences can be detected. Regarding the rank, advanced firms see the lack of information on markets and technologies as more, and financing as less, problematic.

In terms of technological capabilities this suggests that about 70% (2000) and 45% (2002) of the surveyed local firms cannot conduct R&D as they would like to, because they lack the personnel, infrastructure, financial means and a clear strategy. However, a very positive trend is also revealed, as many firms have overcome these problems from 2000 to 2002. In respect to external factors, neither government support for R&D nor support services seem to be sufficient to make up for in-house weaknesses.

Moreover, local firms clearly lack the capability to access information on technology and markets necessary for innovation on a larger scale. Additionally, they more often experience difficulty in financing these activities. Both aspects are easier for TNC-affiliates to tackle, due to the availability of funds and thanks to technology and market scanning mechanisms within the corporate network.

In conclusion, TNC-affiliates clearly seem to possess higher capabilities than local firms and/or have a different perception of factors limiting their R&D-activities. Therefore, TNC-affiliates could support technological learning and innovation in local firms by facilitating access to information on technology and markets, by educating personnel that may spill over to local firms, and by assisting local firms in finding capital for R&D and innovation. From a political perspective, these issues must be addressed. Alongside this, the human capital base must be improved via a reformation of Thailand's education system.

However, the matters that concern firms in Thailand also pose as obstacles for innovation in Penang and Singapore (Figure 5.9). Here, only advanced firms that had encountered serious problems in an innovation project were asked about limiting factors for innovation. Therefore, the sample size is very small (19 local and 27 foreign firms in Singapore and 15 local and 9 foreign firms in Penang). Nevertheless, similar factors show prominence: perceived risk and costs, lack of qualified personnel and of information on technology and finances. Like in Thailand foreign firms report of less problems in finding qualified personnel and funds for innovation.

Perception of the business environment

According to the surveyed firms, the most pressing problem in Thailand is the 'availability of government incentives for innovation'. Since the surveys were commissioned by NSTDA, which is a government agency under the roof of the Ministry of Science, it can be assumed that this assessment reflects a certain 'strategic behaviour' on behalf of the surveyed firms. This, however, does not mean to suggest that this is not a valid problem among firms in Thailand, though it may be overstated, since firms can expect that the government will react to the results, perhaps offering up more incentives (Figure 5.10 presents figures for 2002).

The remaining top four problems in 2000 were, respectively, the availability of human capital in S&T, the acceptance of failure, the regulatory environment and the availability of funds for innovation. In 2002, the most pressing problems relate specifically to innovation collaboration

opportunities: Firms find fault with the availability of local universities and R&D-institutes for technical support and R&D-collaboration. Furthermore, the unavailability of technical support services and difficulty concerning the requirements of the stock exchange are mentioned. However, it has to be kept in mind, that the total share of firms evaluating conditions as poor or very poor has dropped remarkably from around 40-60% in 2000 to 14-36% in 2002 – hence, this is a sign that conditions are improving.

While in general patterns of evaluation were fairly similar between local and foreign firms, there were some striking differences:

- In 2000: the availability of S&T-personnel, technological sophistication of local suppliers, local universities as cooperation partners and the openness of government and regulatory authorities are more often named by foreign firms, whereas listing requirements of the stock exchange, the regulatory environment and the openness of suppliers for innovation have been more frequently criticised by local firms.
- In 2002: the availability of business personnel and local universities for potential collaboration were named by foreign firms as severe problems, while local firms assessed the regulatory environment, ICT services and access to funding as poor.

In conclusion, firms would like to begin to increase collaborations with local universities and research institutes. Apparently, however, the S&T-infrastructure is seen as major weakness. This might be due to a lack of quality or quantity, a technological mis-match between companies' needs and universities competences and/or a lack of incentives within research institutes and universities to foster university-industry linkages (see Schiller and Mildahn, forthcoming).

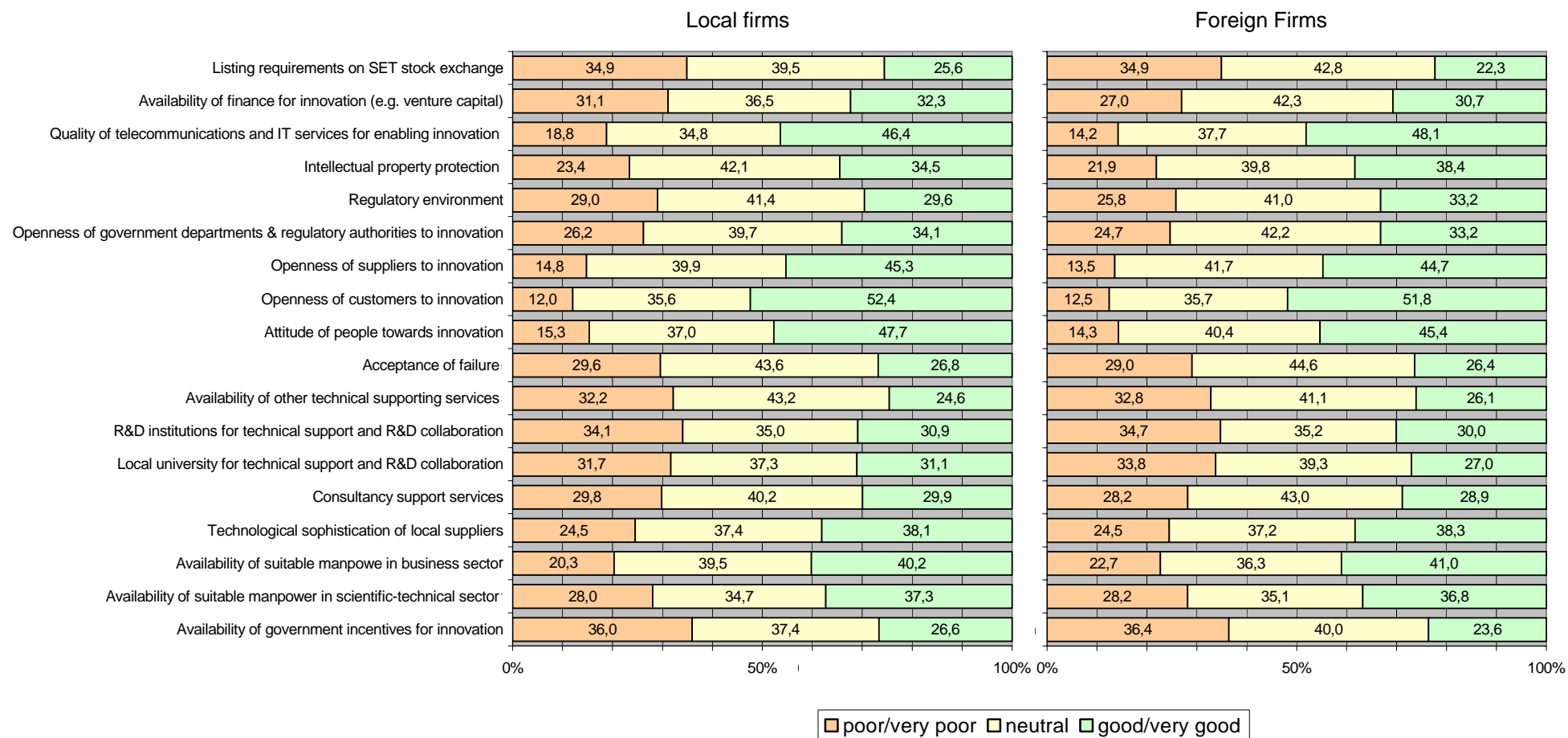
Furthermore, these aspects were more frequently criticised by foreign firms, which can compare the situation in Thailand with other systems of innovation. Skilled human capital is, once again, identified as a problem despite a more positive evaluation in 2002.

The perceived problems in Penang and Singapore are similar: Availability of manpower, missing tolerance for failure and the availability of technical support services are a major concern in Singapore. Firms in Penang criticise the government for offering too few innovation incentives, and are unsatisfied with local universities and R&D institutes as collaboration partners and service providers. Also, the technological sophistication of local suppliers raises concern, primarily for foreign firms.

In summary, main bottlenecks for further R&D and innovation in the Thai NSI are the lack of suitable personnel, lack of government support and incentives. Moreover, essential problems with finding suitable 'horizontal' collaboration partners, namely technical support services, local universities and R&D institutes have been expressed. Having said this, there is a remarkable improvement in the assessment of these environmental conditions from 1999 to 2001 from both local and foreign firms.

The most important internal factors – and consequently aspects of firm capabilities – are the reluctance to take the risks and costs associated with innovation and a lack of R&D-strategy within the firm. A missing absorptive capacity at the firm level is of medium importance, indicated by the lack of skilled personnel and of information on either R&D-opportunities or technology.

Figure 5.10: Perception of the business environment in Thailand - 2002 (% of all firms)



6 Case studies: the impact of TNC-affiliates in selected industries on the Thai system of innovation

The analysis of quantitative data in chapter 5 provides the insight that TNC-affiliates in Thailand do not generally have higher technological capabilities, but that in recent years tangible upgrading seems to have taken place. Nevertheless, TNC-affiliates possess more ‘basic operation capabilities’ and intermediate ‘technological capabilities’, such as quality control, testing, acquisition and adaptation of external technology. Moreover, TNC-affiliates are better endowed than local firms in terms of absorptive capacity. As a consequence, TNC-affiliates can be suitable partners for local firms in learning basic operation and intermediate technological capabilities. Furthermore, the analysis emphasises that advanced TNC-affiliates are particularly beneficial for strengthening the Thai NSI. Advanced foreign firms acquire technology and knowledge more frequently abroad, either via embodied or disembodied technology transfer, acquisition of R&D-services, own R&D-activities abroad, customer-related information, etc. Additionally, advanced foreign firms display a stronger degree of embeddedness in international as well as domestic knowledge networks than advanced local firms. In conclusion, particularly advanced TNC-affiliates can potentially foster technological upgrading of the Thai NSI and technological learning in domestic firms, by transferring new technology and knowledge to Thailand and diffusing it within the Thai NSI.

This diffusion is partly reflected by the fact that clients are important sources of information and powerful collaboration partners for local firms. At least some of the clients are TNC-affiliates located in Thailand that source locally. However, it is difficult to establish the type of technology and knowledge that is really transferred and which mechanisms are used on the basis of quantitative data. Consequently, this chapter will use qualitative data to enquire further into the mechanisms of technology and knowledge transfer between TNC-affiliates and other actors in the Thai NSI. Moreover, it tries to pinpoint technological capabilities and problems of the NSI as perceived by the interviewed firms.

The remainder of the chapter is structured as follows: Chapter 6.1 considers the automotive industry in Thailand. It gives an overview of the industry and presents the key findings of the interviews. Chapter 6.2 looks at the hard disk drive industry in Thailand, displaying key characteristics and the main findings on technological capabilities and embeddedness.

6.1 Automotive industry

6.1.1 Overview of the automotive industry in Thailand

The automotive industry is Thailand’s third largest industry, employing about 200,000 people and having an annual production capacity of more than 1 million cars and trucks (see Tab. 6.1) (Office of Industrial Economics, 2002). The country hosts 15 car assemblers, of which six are majority-owned by Thai-capital. Nevertheless, these firms are also dependent on the TNC they operate for (Brooker Group, 2002b). Additionally, there are six motorcycle assemblers, of which one is Thai-owned (Tiasiri, 2003). Total output of the industry was about 740,000 cars and trucks and 1,9

million motorcycles in 2003 (Bank of Thailand, 2004b). In 2002, the share of motor vehicles on manufacturing GDP was 7.4% (National Economic and Social Development Board, 2002). Vehicle, parts and accessories accounted for about 6% of total manufacturing exports in 2003 (ca. US\$4 billion), of which passenger cars and parts represent about 40% (Bank of Thailand, 2004a).

Tab. 6.1: Car assemblers operating in Thailand

Assembler	Brand	Since	Capacity 2001
Thonburi Automotive Assembly Plant Co Ltd*	Mercedes Benz	1961	15,000
Siam Motors and Nissan Co Ltd*	Nissan, Suzuki	1962	31,200
Isuzu Motors Co (Thailand) Ltd	Isuzu	1963	160,000
Toyota Motor Thailand Co Ltd	Toyota	1964	240,000
MMC Sittipol Co Ltd	Mitsubishi	1966	187,000
Hino Motors (Thailand) Ltd	Hino, Toyota	1966	21,600
Bangchan General Assembly Co Ltd*	Jeep	1968	21,000
YMC Assembly Ltd*	Audi, Peugeot, VW	1972	12,000
Thai Rung Union Car Plc*	Isuzu, Nissan	1973	13,000
Thai-Swedish Assembly Co Ltd	Volvo, Land Rover	1976	10,000
Siam Nissan Automobile Co Ltd*	Nissan	1977	80,200
Honda Automobile (Thailand) Co Ltd	Honda	1984	70,000
AutoAlliance (Thailand) Co Ltd	Ford, Mazda	1998	135,000
General Motors Assembly Center	Chevrolet	2000	130,000
BMW Manufacturing (Thailand) Co Ltd	BMW	2000	10,000
Total			1,136,000

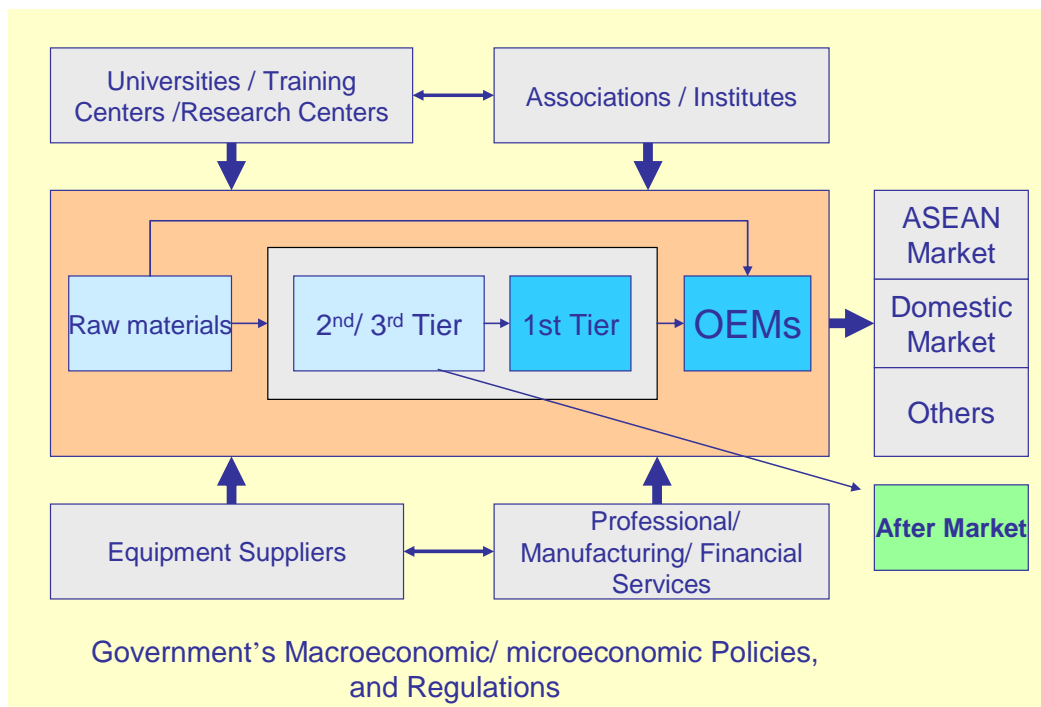
* Thai majority ownership

Brooker Group, 2002b

Especially in the production of pickup trucks, Thailand has established itself as the world's second largest producer behind the USA. Toyota, Isuzu, Mitsubishi, Nissan, Mazda and Ford use the country as their global production base. Output in pickup trucks was 470,000 in 2003 and most assemblers (plan to) invest in the extension of their capacities: Ford US\$500m, Nissan US\$ 440m, Toyota US\$ 750m, Mitsubishi US\$ 525m (The Economist, 2004a). Toyota and Isuzu will set up R&D-centres (Bangkok Post, 2003) and Mercedes Benz has established a regional R&D-office (Praiwan, 2004a). Pickups and commercial vehicles account for about 66% of total vehicle exports (Jaiimsin, 2004).

Generally, large, transnational car assemblers such as Toyota or General Motors (GM) head the assembly system in the automotive industry. These firms are termed OEMs, Original Equipment Manufacturer, in the automotive industry – actually, this term has a very different meaning from the OEMs described in chapter 2.1.4 and 5. Consequently, in what follows this term will not be used for car assemblers but rather for subcontractors as defined in chapter 2.1.4. Each assembler is heading its own production system, consisting of 1st tier or systems suppliers that procure e.g. transmissions, components (2nd tier), parts (3rd tier) and raw material (4th tier). Frequently the assembler only deals with the first tier suppliers and expects them to coordinate the lower tiers. Some suppliers sell parts and components also to the aftermarket, providing e.g. spare parts.

Figure 6.1: Sectoral innovation and production system: Thai automotive industry



Source: Tiasiri, 2003

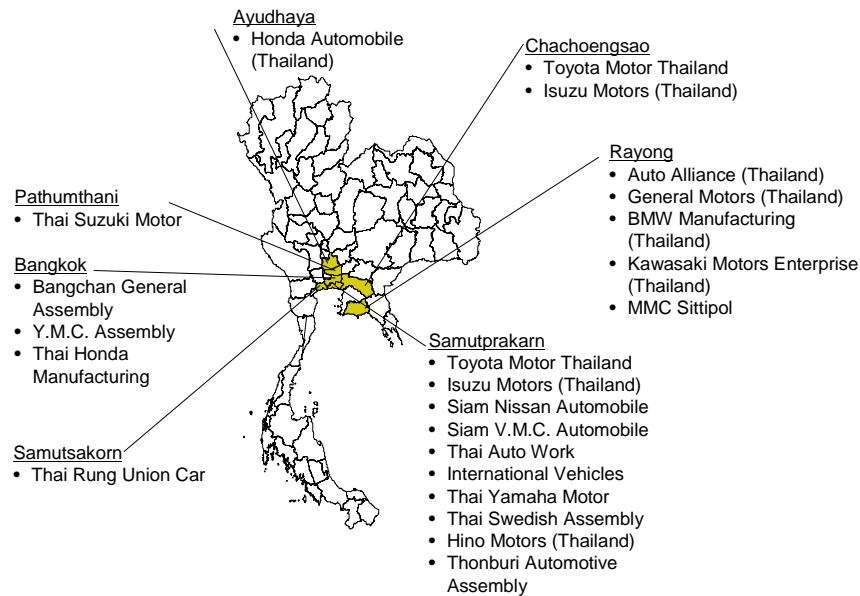
Figure 6.1 depicts the sectoral innovation and production system. The value-chain is encircled by supporting industries and services, public institutes, industry associations and is subject to government policies.

Reasons for the success of the automotive industry in Thailand are seen in an attractive industrial, tax and duty policy (especially for pickup trucks), BOI privileges, good infrastructure, a sufficiently large domestic market with profitable prospects on the AFTA (Asian Free Trade Area) market and the growth of the local components industry (The Economist, 2004a, Torok, 2003; on policy see also Terdudomtham, 2004).

The latter was essentially fostered by industrial policy that enforced local-content requirements from 1972 until its abolishment in 2000 (Office of Industrial Economics, 2002: 10). Intarakumnerd et al. (2002: 1450) assert that this has been virtually the only selective policy in Thailand and has proved to be successful. Local content continued to rise even after the abolishment of the official requirement to ca. 80% for pickup trucks, 55% for passenger cars and almost 100% for motorcycles in 2002 (Office of Industrial Economics, 2002: 15).

This was only possible because many suppliers are located in Thailand. Additionally, Thailand hosts about 700 1st tier suppliers of which 290 are TNC-affiliates, 60 are Joint Ventures (with Thai majority) and about 350 are wholly Thai-owned suppliers. Furthermore, the country contains about 1,100 2nd tier suppliers, which are mainly Thai-owned (Tiasiri, 2003 and Interview Tiasiri). Nearly the entire industry is clustered in the Bangkok/ Eastern Seaboard region (see Figure 6.2). While the first wave of investment targeted Bangkok, expansions and new investments in the 1990s were located for the most part in the Eastern Seaboard region (Lecler, 2002). The same spatial pattern can be observed for suppliers, of which 232 are sited in Bangkok, 158 in Samutprakarn, 39 in Phatum Thani, 55 in Chonburi and 41 in Rayong (Tiasiri, 2003).

Figure 6.2: Distribution of automotive manufacturers in Thailand



Source: Tiasiri, 2003

About 80% of the production capacity belongs to Japanese firms. Consequently, most of the follow-source suppliers (see chapter 2.3.4) are also Japanese. However, due to investment by GM, Ford and Chrysler in the mid 1990s, many non-Japanese first tier suppliers, such as TRW Automotive, Delphi Automotive Systems or Visteon, have recently set up production facilities in Thailand (Office of Industrial Economics, 2002: 15, Brooker Group, 2002c: 2-6). A study on the part procurement systems of Japanese and American assemblers in Thailand found that these systems are fairly similar, but that American firms lean towards more price-oriented market transactions, whereas Japanese firms are rather dedicated to long-term relationships (Charoenporn, 2001).

Despite its success, the quality of the industry is disputed: Government sources emphasize that the quality of the automotive parts in Thailand was rated best among ASEAN countries by the Japan Automobile Manufacturers Association (cited in Office of Industrial Economics, 2002: 15). However, scholars such as Abbott (2003: 145) state that “one of the biggest problems facing the Thai automotive industry is that after decades of protection it is simply uncompetitive in the global market”. A recent study by Porter (2003) assesses the productivity and level of automation in Thailand’s automotive industry as very low, with low labour costs compensating for this weakness. Only pickup trucks, as well as tires and rubber-related products, display a comparative advantage. He points out that “the potential for growth will be limited until Thailand significantly improves its sophistication and technology” (ibid.: 32).

Similarly, in 1996 a TDRI study determined that Thailand had only a revealed comparative advantage in parts for trailers and trucks, but not in automotive, auto-parts, van, truck and special purpose vehicles (cited in Abbott, 2003). Moreover, the Massachusetts Institute of Technology found in 1998 that the “actual local content, i.e. real value added of vehicles assembled in Thailand, is much lower than the official 54-70%, closer to 20%” (cited in Doner et al., 2004: 41).

In particular, Thai-owned firms show low levels of sophistication. Doner et al. (2004) underscore the fact that only 30% of auto-part exports originated from Thai-owned firms in 1999. Moreover, a

1995-study by UNICO International, a Japanese consultant firm, determined that the level of production technology in Thai-owned firms corresponded to a rating of “C+” and, hence, below the international OEM-requirement of “B” (cited in *ibid.* and Abbott, 2003: 145).

Moreover, Laosirihongthong et al. (2003) identified divergences between local and foreign-owned companies in the implementation of new manufacturing technologies. Due to limited resources, Thai-owned companies more often opt for ‘stand alone technologies’ such as CAD/ CAM and CNC.

A report by the Brooker Group (2002a: pp. 2-14) asserts that local auto-parts makers have low technological capabilities and are largely dependent on technology provided by JV-partners or licensors, but also that they cannot absorb the transferred technology due to a lack of skilled labour. However, Japanese firms with financial support of the Japanese government have primarily invested in human resource development, resulting in an improvement in the availability of skilled labour in recent years (Poapongsakorn, 2004: 182).

Techakanont (2002, 2003) reports on the subject of related evidence: TNC-affiliates are actively transferring technology via information sharing and advising to local suppliers. Thereby, the content of the inter-firm technology transfer had gradually enhanced from simple ‘operational technology’ to a higher level of ‘process engineering technology’. According to his research, there has been another shift towards ‘product engineering capabilities’ since the year 2000. However, only a number of local suppliers with long-term relationships to assemblers, willingness to participate in product developments in Japan and own efforts in human resource development, are given the opportunity for higher-level technology transfers.

Despite the above named shortcomings of domestic suppliers, Ito (2004) was not able to find pervasive productivity differentials between foreign and local plants in the Thai automobile industry. Porter’s (2003: 32) assessment suggests that this is due to lower productivity by TNC’s operations in Thailand and not an indication of a successful catch-up by local firms.

Since the abolishment of local content requirements in 2000, domestic suppliers face stronger competition, with new opportunity for assemblers to source globally. Hence, the current challenge for Thai-owned firms is to develop R&D, design and product development capabilities in order to safeguard their current position within the supply chain (Techakanont, 2003: 39, Abbott, 2003: 145, Brooker Group, 2002a: 2-15). However, due to high costs and the ‘traditional’ procedure of customers providing product drawings, samples and specification, firms display a certain reluctance to develop these capabilities (Brooker Group, 2002a: 2-15, Terdudomtham, 2004: pp. 46).

6.1.2 TNCs in Thailand’s automotive industry: capabilities, linkages, spillovers

First, this chapter gives an overview of the interviewed firms and their central business activities (6.1.2.1). Second, it explores their embeddedness in the value-chain and external collaborations with a focus on domestic linkages. Third, it presents the findings in regard to technological capabilities and the organisation of R&D and innovation processes. Furthermore, the firms’

perception of the current business environment in terms of collaboration partners and availability of human capital is reported.

6.1.2.1 The interviewees in the automotive industry and their embeddedness – value-chain and cooperation

The results presented in this chapter are based on ten firm interviews conducted by the author with five TNC affiliates and five local firms.

Of the foreign firms **TNC1**, **TNC2** and **TNC3** are **assemblers** and (partly) producers of key components for their own vehicles and sometimes other assemblers. **TNC 4** and **TNC5** are **first tier suppliers** of which one supplies some of the surveyed assemblers. Of the Thai-owned firms **LC1**, **LC2** and **LC3** are **suppliers** at different positions in the value chain. One is a pure parts supplier, while the other two supply OEM parts to several assemblers. Moreover, **LC4 and LC5** are included, both operating in the **aftermarket**, designing and producing accessories and add-ons.

The first section of each interview examines the basic production process, as well as the location of the main customers and suppliers. Tab. 6.2 presents this information and gives additional data on external collaborations. It can be seen that the majority of surveyed firms produce essentially for the domestic consumer or intermediate market. However, most firms also state that they are either currently trying to increase their export share or commence exporting to ASEAN countries.

For procurement, most firms follow a localisation strategy, i.e. they try to source as many inputs as possible locally. The rationale behind this strategy is to decrease currency exchange rate risks, import/export taxes and transport costs, to ease supply chain management and to exert control over key suppliers e.g. by plant visits. However, certain high-precision parts must be imported, even though the firms would like to supply them locally, either because there are no suitable suppliers in Thailand or because local suppliers lack the necessary skills.

Tab. 6.2: Embeddedness of the surveyed automotive firms: Value-chain and external collaboration

Firm	Supplier	Customer/ Market	External linkages (beyond pure market based)
TNC1	Target: 100% local content; currently 30% of components manufactured in-house. 85-95% of components from local suppliers. 80% of domestic suppliers are JV between Thai and Japanese firms, 20% wholly Thai-owned.	Currently 90% of production sold in domestic market, but strong increase in export expected, due to new production strategy.	Supplier: TNC1 Supplier club: advice & training on system, QC, Kaizen, cost reduction, good practice. In the future: R&D cooperation. Universities/ R&D institutes: Cooperation on curricula, staff lectures at institutes, joint research projects with e.g. graduates.
TNC2	Local content 40%. 60% CKD from home base. 20% of parts procured locally, 20% in-house assembly. Most local suppliers are foreign-owned/ JV follow source supplier.	70% for domestic market, 30% export to neighbouring countries.	Supplier: Giving technical assistance to meet specifications and requirements (QC, ISO). Universities/ R&D institutes: internship/ practical projects, cooperation on traffic safety Competitors Allow competitors to use its CMM machine (testing/QC).
			... cont. next page

TNC3	Local content about 45%, remaining parts are imported. 60% of local suppliers are Thai-Japanese JV, 10% Tai-European JV and 30% wholly Thai-owned.	75% to 100% domestic market, some export to Australia/ NZ	Customer: Cooperation restricted to cost cutting plans etc. Supplier: TNC3 supplier club, frequent cooperation on minor product improvement. When TNC3 Thailand gets new requirements from the HQ its R&D engineers work together with local suppliers to meet the requirements.
TNC4	Local content different for every model. On average 40%. 60% CKD from home base. 90% of local suppliers are Thai-Japanese JV, 10% wholly Thai-owned. Ca. 30% follow source supplier.	95% domestic, 5% export.	Supplier: Some cooperation on local parts development. Some informal visits by engineer teams. Universities/ R&D institutes: sometimes broken parts are sent to MTEC for testing/ analysing. Competitors Some cooperation on production issues; Hence informal visits by engineer teams. Automotive Industry Club: important as information source about new regulations
TNC5	Target for 2004: 80% local content; currently 75% locally procured. 75% of local suppliers are JV mainly (90%) between Japanese and Thai firms, 25% wholly Thai-owned.	30% exported; 70% domestic market	Customer: Cooperation with main customer, but restricted to Audit/ Quality control. Training of employees. Supplier: Encouraged by customer, TNC5 provides training on JIT, waste reduction, cost cutting, quality control to its suppliers. Universities/ R&D institutes: Some calibration is done at Chualalongkorn.
LC1	90% local suppliers of which 40% JV (mostly Japanese-Thai), 60% wholly Thai-owned. More sophisticated parts supplied by JV.	90% for domestic market	Customer: Cooperation/ Information on cost reduction, QC, ISO and joint product development. Supplier: Cooperation on parts development. Universities/ R&D institutes: Collaboration with university for a new management system; receiving some information on new material from MTEC/ NECTEC.
LC2	Ca. 80-90% locally sourced. components mainly procured by associate firms in the group, raw material outsourced. 10-20% imported completely knocked-down cars.	More than 90% for domestic market	Customer: Cooperation/ Information on cost reduction, QC, ISO and joint product development; training of employees. Supplier: Cooperation on parts development. Competitors: Some informal information exchange with LC1
LC3	40% locally sourced; 60% imported	74% domestic, 26% export markets. Of domestic market about 90% of customers TNCs	Customers: cooperation on product development, training of employees Supplier: Intense cooperation with material supplier Universities/ R&D institutes. R&D collaboration with KMUTT; Professor as private consultant, e.g. for new plant layout.
LC4	About 75% local suppliers	70% exports	Customer: Long-term relationship to foreign customer, cooperation on product improvements. Supplier: Firm sometimes receives training by specialised Singapore based suppliers.
LC5	Maximum 20% local content	100% of sales domestic, 80% either licensed or trade products, 20% own developments	European JV partners/ license sellers: Important source of knowledge, cooperation on implementation. Universities/ R&D institutes: Some cooperation with NSTDA; KMUTT professor as private consultant.

Source: Author's interviews

In summary, the embeddedness of foreign and local firms in the Thai NSI in terms of product flows is fairly strong, whereas additional linkages (collaboration in respect to product/ process development and improvement, human resource training etc.) are very limited in number and

intensity. Often, the strongest linkages are with customers and/ or customer HQs in Japan (for more details see subsequent sections; and Tab. 6.2).

6.1.2.2 Technological capabilities in the automotive-industry

In order to investigate firms’ technological capabilities (see 2.1.2), the TC-framework developed by Afzulpurkar (see chapter 3.2.2 and Tab. 3.9) is utilised. The interviewees were asked to indicate in which ‘box’ they would place their firm. Several interviewees found it difficult to indicate only one box, but stated that their firm had, for example, basic but also some intermediate capabilities. Tab. 6.3 takes this into account by including additional ‘in-between’ levels.

Tab. 6.3: Self assessment of technological capabilities by firms in the automotive industry

	Investment	Manufacturing			Innovation	Linkages
		Process Engineering	Product Engineering	Industrial Engineering		
Basic			LC 1 LC 4 TNC 2 TNC 3 TNC 5	LC 3 LC 4	LC 1 LC 4 TNC 4 TNC 5	LC 1, LC 2 LC 3, LC 4 TNC 3 TNC 5
	LC 4 TNC 5	LC 4	LC 3 TNC 4	LC 1 TNC 2 TNC 4	LC 3 TNC 2	TNC 4
Intermediate	LC 1 LC 3 LC 5 TNC 1 TNC 3	LC 1 LC 5	LC 2 TNC 1	LC 5	LC 2 LC 5 TNC 1 TNC 3	LC 5 TNC 1 TNC 2
	LC2 TNC2	LC 3 TNC 2 TNC 3		LC 2		
Advanced	TNC4	LC 2 TNC 1 TNC 4 TNC 5	LC 5	TNC 1 TNC 3 TNC 5		

Source: author’s interviews

Even though this self-evaluation might show a bias towards an over-optimistic profile, it can be seen from Tab. 6.3 that the surveyed firms remained quite critical, displaying a fairly consistent pattern: Process engineering capabilities are the most advanced for the majority of firms. Industrial engineering is strong in three of the TNC-affiliates (TNC1, TNC3 and TNC5), because they strongly replicate their parents’ industrial organisation. Two others TNCs (TNC2 and TNC4) exhibit visibly lower capabilities in this respect, relating to their simpler production objective. The same is true for locally owned suppliers, which possess more or less intermediate skills. Investment capabilities are generally intermediate, whereas product engineering, innovation and linkage capabilities are lowest.

Process technology

For most **TNC-affiliates** the parent firm has chosen the initial process technology and for the most part all technology is imported. Furthermore, parent firms' engineers had initially set up the production line. However, in subsequent upgrading phases the level of input from Thai engineers has markedly increased and these perform some minor/ incremental improvements. But, for major overhauls, the headquarters still make the decisions regarding technology and provide engineers for joint installation. Production, furthermore, is more labour-intensive and less automated than in the home country.

For the **Thai-owned component suppliers**, the procurement of process technology is done entirely by the firms' engineers. Sometimes, customers give advice regarding – especially advanced – technology. The bulk of machinery is imported from either Taiwan or Japan. Local engineers set up the production lines, adapt it to local conditions, maintain it and perform incremental improvements themselves.

The **part suppliers** and **firms in the aftermarket** are not directly comparable, because they are located outside from the inner production networks of the assemblers. For example, the parts supplier is currently using outdated, second hand equipment, but will upgrade to modern machinery when moving to the new plant site. Nevertheless, this firm is fairly active in implementing ISO, TQM as well as preventive maintenance. Moreover, it frequently executes incremental process and organisational innovations of a fairly basic scale (e.g. pre-forming of the material to reduce waste, construction of a stamp that is more suitable than the imported machine etc.). The firms in the aftermarket generally perform assembly, which is to a certain extent labour oriented rather than technology intensive.

Product development

TNC-affiliates report that R&D and product development is performed in Japan. Operations in Thailand have small R&D-units in order to implement and/or adopt new product specifications and blueprints provided by the parent company. Additionally, they improve or adapt new products and processes incrementally. For example, engineers from TNC5 have adapted the Japanese air-conditioning to the tropical climate. The customer and/or the headquarters must approve of this kind of change.

Accordingly, R&D-cooperation is normally conducted in Japan. The common procedure is that, for example, the headquarters send a 'request for design development' to their respective affiliate in Thailand, which then passes it on to its Thailand-based supplier. This supplier would then send it on to its R&D department in Japan, where the actual innovation cooperation between the two firms takes place. Less than 10% of Thai-owned suppliers are included in this process, since – according to TNC1 – they lack the necessary R&D-capabilities.

Having said this, there are also some local developments: either an assembler develops new product ideas or requirements and sends these to local suppliers or – less frequently – local suppliers come up with an improved product (e.g. advanced leather tanning for seats).

On the other hand, there are also TNC-affiliates whose main objective is to assemble the imported, 'completely knocked down' (CKD) cars. These firms were set up to avoid the high import taxes and tariffs and related regulations. In order to fulfil the (former) local content requirement, they assemble some components (e.g. engines) locally and procure other parts (e.g. seats and windows) from domestic suppliers.

For the **Thai-owned suppliers**, the majority of products (70-90%) are pure OEM-products that are produced according to customers' specifications. However, two firms have underlined a recent shift towards more self-developed products and towards R&D.

For example, LC1 has conducted R&D informally since 2002 and established an R&D-department consisting of 12 engineers in 2003. It carries out R&D on motorcycle- and car-parts and has recently developed a golf car by itself. The R&D-unit for motorcycles is the larger and more established of the two. It was set up by LC1-engineers who received training from a motorcycle company in Japan. Currently, LC1 works together with its main customer on product developments. At the initial stage the customer sends Japanese engineers to LC1, who develop ideas and plans for the improvement of existing parts jointly with LC1-engineers. Once the basic concept is established, LC1-engineers go on alone to implement the concept. Since the customer is currently extending its R&D-activity in Thailand, it is requiring LC1 to enhance its R&D-effort, too. In the car segment, the R&D-team is both smaller and newer. R&D in this industry is more difficult, because parts are technologically more sophisticated and competition is stronger. At the moment, LC1 is, for example, developing a new footboard (new form and material) for pickup trucks. The Japanese customer provided the initial idea. At the conceptual stage LC1-engineers worked together with Japanese engineers from the customer in Thailand and Japan as well as with engineers from its suppliers. Once the prototype was developed and approved by the customer's Japanese HQ, it was transferred to the customer's Thai affiliate, which then developed the pilot line for mass production. According to the interviewees such activity does not help to develop new parts for other customers, but the general learning experience is seen as very beneficial to further upgrading. One prominent result is the development of a golf car. Only the wheels and the engine are procured from other firms. For this new product LC1 cooperates intensely with its suppliers and, in terms of design-software, with Chulalongkorn University.

Similarly, LC2 is currently setting up an R&D-department, in which 50 engineers will eventually work. The firm sees the need to have development capabilities in order to qualify for global sourcing and to compete with overseas (Japanese) suppliers of its main customers. Due to the implementation of the IVM project by Toyota (see 6.1.2.3), LC2 feels the need to commit itself to R&D. The product development process e.g. for a fender liner begins with the customer sending either the drawing or the body of a car. Thereafter, LC2-engineers begin developing the fender, thereby frequently collaborating with engineers from the customers' factory in Thailand. Essentially, the plant in Thailand acts as an interface with the TNC-headquarter. There is no direct interaction with the Japanese headquarters, even the approval of the prototype is received via the TNC-affiliate. LC2 emphasises that at the development stage the cooperation with suppliers is as

intensive as with the customer. The joint work is done alternately in the facilities of LC2, the customer or the suppliers.

LC3, LC4 and LC5 produce mainly according to customer specifications. However, all firms state the need for their own product development, due to either eroding comparative advantage or the loss of important customers, which have in many cases moved to China. This forces the companies to upgrade their skills and to enter the OBM-market with their own product developments (e.g. LC3) (see notion of crisis construction for intensity of effort chapter 2.1.3.4). Means to achieve this goal include the recruitment of retired foreign R&D-engineers, licensing, joint ventures with European firms and intensified cooperation with customers. Moreover, information of international exhibitions is also considered important (for example the president of LC5 took photos of products in Germany and the UK, which the engineering department then reproduced using simpler technology and at a lower cost). Additionally, firms utilise external knowledge, e.g. from designers or universities in order to develop – in a first step rather technologically simple – OBM-products.

The importance of proximity in joint development

Most interviewees stated that proximity in joint development and improvement of parts is beneficial, because it makes face-to-face contact both easier and cheaper. This increases the frequency of interaction. However, since R&D and product development is not (yet) of high relevance for Thai based firms, proximity is seen as more important for logistics (JIT) and ‘urgent cooperation’, i.e. emergency troubleshooting requiring joint engineering teams. As one manager stated “We do not go to our customers for product developments daily, but we supply them three to four times a day”. Moreover, some managers assert that they experienced no problems in product developments with remote cooperation partners for example in Japan, since travelling is considered an appropriate substitute for proximity.

S&T-infrastructure and human resources

Most firms had only minor collaborations with the S&T-infrastructure, such as universities or NSTDA’s R&D-institutes. Moreover, some explicitly expressed that they are unsatisfied with science-industry cooperation opportunities, because the science sector is not efficient enough (LC3), the staff lacks practical experience (LC5) and the right equipment (TNC5).

In respect to the availability and quality of human resources as an important pre-requisite for technological capabilities, the firm interviews support the findings from the quantitative data (chapter 5.5) that skilled labour is in short supply. Several firms experience problems with finding suitable engineers, high turnover rates and head-hunter activities. Their perception of the quality of available personnel is mixed. While some firms do not consider them problems, others complain about the lack of foreign language proficiency (English and Japanese) and engineering skills. The capability to “think outside the box” is especially missed: interviewees criticise that most engineers tend to think in a hierarchical and functionally separated manner and stick to one solution instead of questioning it further. Furthermore, one firm underlined the mismatch between university curricula and industry requirements. Consequently, all firms provide further in-house training (on the job) –

from two months to three years. Additionally, firms send their engineers to parents' or customers' facilities abroad, primarily to Japan, to receive further training (for up to three years). Moreover, some firms make use of external training courses provided, for example, by the Thailand Automotive Institute, the Association for Overseas Technical Scholarship (AOTS), a Japanese non-profit organisation to promote technical cooperation, the Thai-German Institute, an independent training centre for industrial technologies, or the Thailand Productivity Institute under the Ministry of Industry.

6.1.2.3 Excursus: the case of Toyota Motor Thailand³⁶

Toyota is both the major pioneer and 'anchor' of the automotive industry in Thailand, and is currently shifting significant R&D and development capabilities to Thailand. This chapter will briefly summarise these recent developments, bringing to the forefront the ways in which TNC-affiliates can contribute to a major upgrading of segments of the Thai NSI.

Toyota Motors Thailand (TMT) opened its first plant in Thailand in 1964. A second plant was added at the original location in Samut Prakarn in 1975. In 1994, TMT opened the Gateway City Plant in Chachoengsao. TMT operates in the car and the pickup truck markets. It is the country's largest vehicle assembler and has dominated the Thai vehicle market for the last three decades (Brooker Group, 2002b). Localisation of supplies is essential for TMT, in order to avoid currency exchange uncertainties and enhance control over suppliers. Moreover, TMT depends on a reliable supply chain (JIT) and wants to foster cooperation to stimulate technical change. Since most Thai suppliers are not sophisticated enough to become 1st tier suppliers, car assemblers such as TMT ask home-base suppliers to follow them to the host region. Additionally, TMT is forced to import parts that it cannot procure locally because local suppliers lack the necessary high precision skills (interview with Thailand Automotive Institute).

A recent example is Toyota's Innovation and International Multipurpose vehicle (IVM) project, which started in mid-2004 and will see Toyota make Thailand its global export production base for one-ton pickup trucks, multi-purpose vehicles, diesel engines and parts (Toyoda, 2003). This relocation of the pickup production from Japan to Thailand induces at least 56 companies to move to Thailand (Thailand Automotive Institute interview). The IVM project will create 10,000 new jobs at TMT alone. The export value is supposed to rise to approximately US\$ 1.2 billion per year (Toyoda, 2003).

TMT has established the Toyota cooperation club for first tier suppliers, where it gives assistance to the Toyota production system, quality assurance, kaizen³⁷ and cost reduction. Furthermore, it encourages 'best practice' suppliers to teach fellow suppliers and encourages first tier suppliers to set up similar supplier clubs. About 80% of the suppliers are follow-source suppliers (mostly organised as Joint Ventures), 20% are wholly Thai-owned. Altogether, there are ca. 130 1st tier suppliers of parts and components and 50 material suppliers. The Thai-owned suppliers clearly both

³⁶ In addition to the cited sources this part is based on information gathered in several firm interviews by the author.

³⁷ A system or philosophy of continuous improvement, similar to incremental innovations see (Imai & Nitsch, 2001)

need and get more assistance, since most of the follow-source suppliers are accustomed to the Toyota production scheme.

As with other assemblers, TMT expects its suppliers to constantly reduce costs. Moreover, suppliers have a strong sense of competition with e.g. Japanese based suppliers but also see the opportunity to qualify as 'global suppliers', delivering parts for other production sites. These mechanisms drive locally based suppliers to increase their efforts in respect to product and process optimising and in setting up R&D-units. The latter is especially true for TMT's plan to set up a Toyota Technical Centre Asia Pacific in Thailand and Australia. The centre is part of the IVM project and will be Toyota's third R&D-centre outside of Japan (other locations are Arizona, USA and Brussels, Belgium (Toyoda, 2003)). The new facility is intended to develop the new Soluna Vios passenger car and Hilux Pickup truck. The scope of work for the centre in Thailand includes R&D in product design, testing and evaluation, material evaluation and painting, engine-R&D, market surveys and evaluation and the distribution of technology-related information within the region (Santivimolnat, 2003). TMT will therefore recruit 500 engineers of which 200 are Japanese and 300 mostly Thai. Since innovation and R&D are interactive processes (see chapter 2.1.3), TMT pushes its Thai-based key suppliers to set up their own R&D-facilities, in order to create the capabilities necessary to collaborate with TMT on product development. Traditionally, this collaboration has been taken place between Toyota and its suppliers in Japan. This development represents the present climax of a process that has been ongoing for years: While the first Thai-specific Soluna passenger car was completely developed in Japan, input from Thai engineers towards the development of its later generations has increased permanently. Hence, by gradually shifting more development tasks to Thailand, TMT has developed the technological capabilities considered necessary to establish large scale R&D-operations.

In conclusion, Thailand is currently experiencing a wave of R&D-activity in its automotive industry. For Thai-owned suppliers this is both an opportunity and a threat: They have the opportunity to become integrated into Toyota's R&D-system, yet if they fail to develop the required capabilities soon, they may also be forced out of business and replaced by other follow-source suppliers (Thailand Automotive Institute interview).

6.1.2.4 Mechanism by which TNCs in the automotive industry contribute to the system of innovation

In summary, the findings of the interviews in Thailand's automotive industry lead to the following conclusions about the mechanisms through which TNC-affiliates positively influence the TCs of local firms and the Thai-SI as such:

a) TNCs are very demanding and lead to crises among supplier firms. This can trigger an increase in the intensity of effort on behalf of upgrading and learning.

TNCs provide either product specifications or simply the requirement forms, which shift responsibility to the suppliers' engineers to develop the detailed product. Moreover, they demand continuous cost reductions (e.g. 3% per year), which push supplier firms' engineers to look for new materials, new suppliers and new processes. Additionally, TNCs are exceptionally demanding in

terms of quality and environmental standards (ISO 900x, ISO 14000) as well as production and supply chain organisation (JIT, kaizen, TQM).

b) TNCs help their suppliers to develop technological capabilities, if it is in their self-interest.

Firms in Thailand receive advice from their TNC-parents or -customers with the production technology. Sometimes parents or customers support local firms in the procurement and assembly of the production technology. Moreover, they counsel local suppliers about the procurement of inputs. In addition most large TNC-affiliates operate supplier clubs in Thailand, which organise training and/ or information exchange for – at least first tier – suppliers. Within the clubs, capable follow-source suppliers are frequently asked to train or assist locally owned suppliers. This mechanism also works on an international scale: TNCs establish the contact between local firms and suppliers in Europe, Japan or North America, in order to initiate technical assistance and ‘good practice’ training. Moreover, TNCs frequently provide direct technical assistance, for example, by sending their own engineers from plants in Thailand or abroad to the locally owned suppliers, who train the personnel or collaborate on product or process improvements. TNCs also invite Thai engineers to their home plants for training courses. Additionally, TNCs enable ‘learning by visiting’, e.g. plant visits allow Thai engineers to get a feeling for state-of-the-art production processes.

c) TNCs provide local firms an opportunity to access markets.

TNC-affiliates in Thailand are mostly dedicated to localisation strategies and, therefore, seek local suppliers. Although they frequently bring in follow-source suppliers, there is – at least in principle – scope for local firms to become part of the global TNC-production network. Hence, TNC-affiliates in Thailand act as an interface between the corporate production and R&D-networks and Thai suppliers. Consequently, if suppliers prove themselves, they can be given the opportunity to become a global source for the TNC-operations. Some may use existing customers as references, or win new customers thanks to increased performance (see a).

d) TNCs enrich the SI by bringing new actors with them.

Firstly, TNC-affiliates are actors in their own right. Additionally, they bring in follow-source suppliers. Although these can potentially drive local firms out of business, they are more likely to fill a segment in the economy that did not exist before. The involvement of these new actors within the SI is strongly dependent on the commitment of the TNC, the autonomy of the TNC-affiliate and – fairly often – the number of years that the affiliates has been operating in Thailand.

e) TNCs improve the S&T-infrastructure and the human capital basis.

TNCs cooperate with universities, sponsor institutes, design industry-relevant curricula, provide teachers for lectures and give opportunity for internships, student projects, and joint research for master students and – in principle – for applied research. Moreover, some have advanced in-house human-resource-development programs and most send engineers abroad. As indicated by TNC1’s

claim to have a high turnover of engineers, these skills seem to spill over to other companies. However, it remains unclear whether or not local firms benefit from these spillovers, if personnel mobility is essentially restricted to TNC-affiliates.

6.2 Hard disk drive industry

6.2.1 Overview of the hard disk drive industry in Thailand

Thailand is the world's second largest hard disk drive producer behind Singapore in terms of output, and third largest in terms of value, with an overall market share of about 17% (KRC, 2003) to 24% (Runckel, 2004) in 2003. Currently, four of the top five HDD-assemblers have major operations in Thailand, namely market leader Seagate, Western Digital, Hitachi Global Storage Technologies (result of the 2003 merger of IBM's and Hitachi's disk drive operations) and Fujitsu (Runckel, 2004). A fifth assembler is Union Technology, a Thai-owned affiliate of the Saha group, which operates for Hitachi. According to Runckel (2004), the industry includes 50-60 manufacturers of parts, employing more than 90,000 workers.

A recent study by Afzulpurkar and Brimble (2004), in which the author participated, surveyed and mapped about 25 firms within the HDD-cluster (see Tab. 6.4, Figure 6.3). Almost all firms in the HDD-cluster are either wholly foreign-owned or joint ventures (see also Runckel, 2004, McKinsey, 2002). Most of the firms are located in the provinces surrounding Bangkok (Brooker Group, 2002a), although BOI zoning policies have led some large HDD-assemblers to locate in zone 3 (see chapter 4.1.4.4). For example Hitachi owns a plant in Prachinburi and one of Seagate's two factories is located in Korat (Nakhon Ratchasima), each about two hours by car from Bangkok.

In 2004, the industry experienced large investments of over US\$ 600m (Afzulpurkar & Brimble, 2004: 11), after Seagate relocated its assembly plant from Singapore to Thailand (Wiriyapong, 2004b) and Hitachi, Fujitsu and Western Digital expanded their production markedly (e.g. Wiriyapong, 2004a, Bunyamane, 2004, Runckel, 2004). As a result the market share was supposed to have increase to over 31% in 2004 (KRC, 2003).

According to the BOI (2002) the export of HDDs and HDD-parts accounted for US\$ 4.5 billion in 2001. A market survey by Runckel (2004) and a study by Afzulpurkar and Brimble (2004) estimate exports worth US\$ 5 billion in 2003. Hence, the HDD-industry accounts for ca. 63% of total computer and peripheral exports (McKinsey, 2002). According to these figures HDD-related exports would represent about 7.5% of manufacturing exports (based on figures by Bank of Thailand, 2004a). Kasikorn Research Center (2003) guesstimated that one half of the HDD-components is exported, while the other half is supplied to domestic HDD-plants.

In terms of GDP, the aggregated 'office, accounting and computing machinery' sector produces about 5.3% of manufacturing GDP in 2002 (National Economic and Social Development Board, 2002). As the HDD-industry dominates this sector, a share of 2.5 – 3% would be a reasonable 'best guess'. Based on a local content estimation of 31%, Afzulpurkar and Brimble (2004) calculate a local-value added of about US\$ 1.6 billion, which would approximate 3.3% of manufacturing GDP and 1.16% of total GDP. Other sources assume a higher local value-added, e.g. Runckel (2004) and

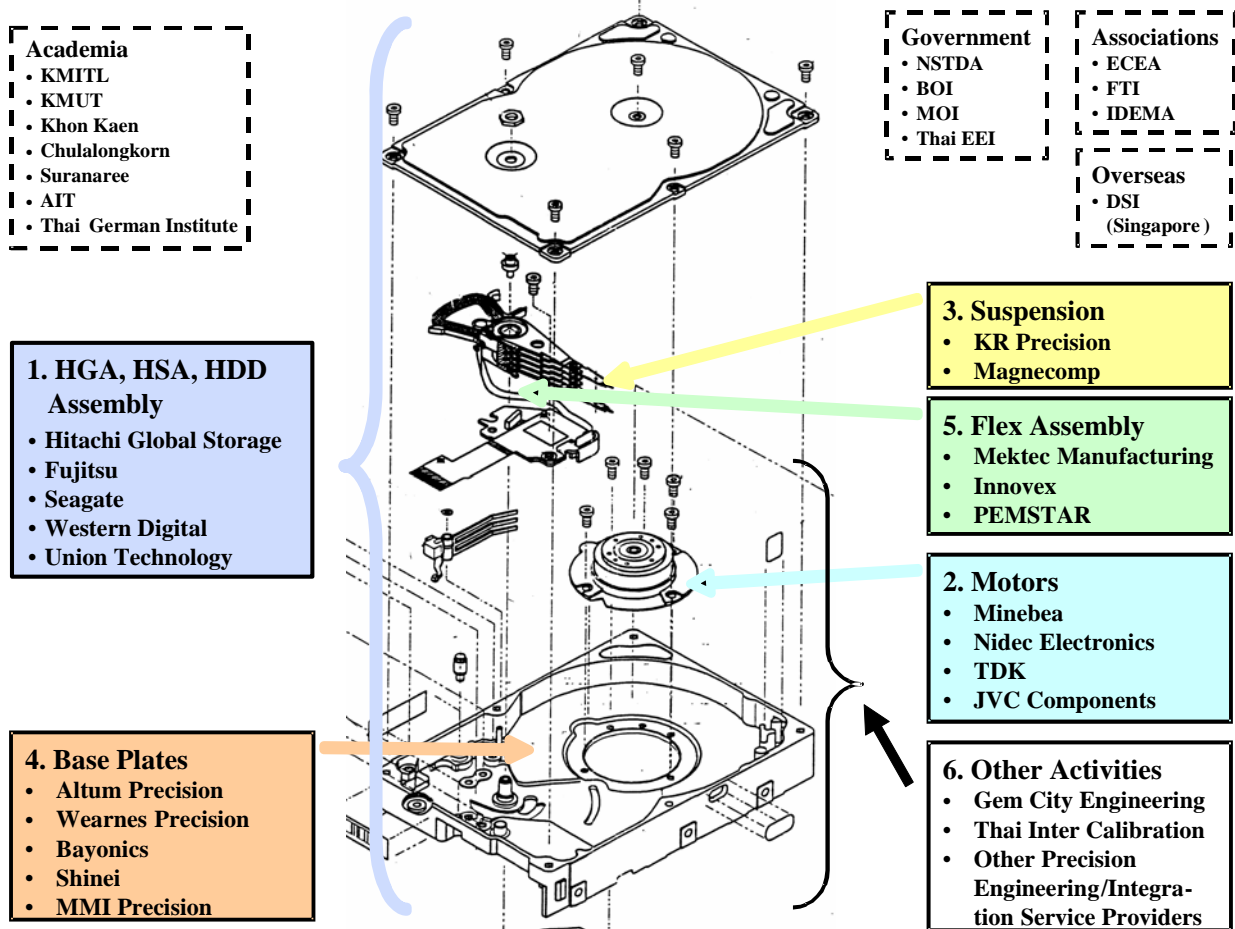
KRC (2003) mention a margin of 37-46%, which would equal 1.3 – 1.6% of GDP in 2002 (KRC, 2003).

Tab. 6.4: Firms in the Thailand's HDD-industry

Company	No. of employees	Total Investment (Mio. Bhat)	Export Values in 2003 (Mio. Bhat)
HGA/ HSA/ HDD Assembly			
Fujitsu	2,863	719	24,504
Hitachi GST	7,081	31,200	72,569
Seagate Technology	13,000	2,605	57,829
Western Digital	10,630	2,800	29,151
Union Technology	5,010	NA	NA
HGA Components			
K.R. Precision	1,550	200	280
Magnecomp	573	NA	974
Head Stack Components			
Belton	3,400	1,200	3,000
LTEC (Fujikura)	3,552	4,059	1,383
Mektec	2,316	1,033	2,461
San-Ei	13,500	35	NA
Totoku	181	110	5
Spindle Motors			
JVC Components	4,728	NA	7,000
Minibea (20% HDD related)	6,000	33	NA
TDK	NA	NA	NA
Nidec Electronics	10,773	19,107	19,000
PCB/ FSA			
Innovex	1,800	NA	1,300
Agere	1,050	NA	NA
Cal-Comp Electronics	1,400	202	NA
HDD Mechanical Parts			
Fuji Shinsei	228	20	4
NHK Spring (20% HDD related)	240	40	1,200
NOK Precision Component	538	149	707
Texchem-Pack	132	46	14
Altum Precision	215	NA	153
Z. Kuroda	710	250	300
Clean Room Supplies/ Services			
Adampak	72	35	64
Prima Clean	85	30	NA
Riverstone Resources	110	50	80
Union Microclean	105	NA	NA
Other			
3M	520	NA	NA
Gem City Engineering	20	10	NA
TOTAL	92,382	83,273	221,977

Source: Afzulpurkar & Brimble, 2004: 30

Figure 6.3: Visualisation of the Thai HDD-cluster



Source: Brimble, 2003b

Technical abbreviations

- HDD Head Disk Drive
- HGA Head-Gimbal Assembly
- HSA Head-Stack Assembly
- Flex Flexible circuits

Actor abbreviations:

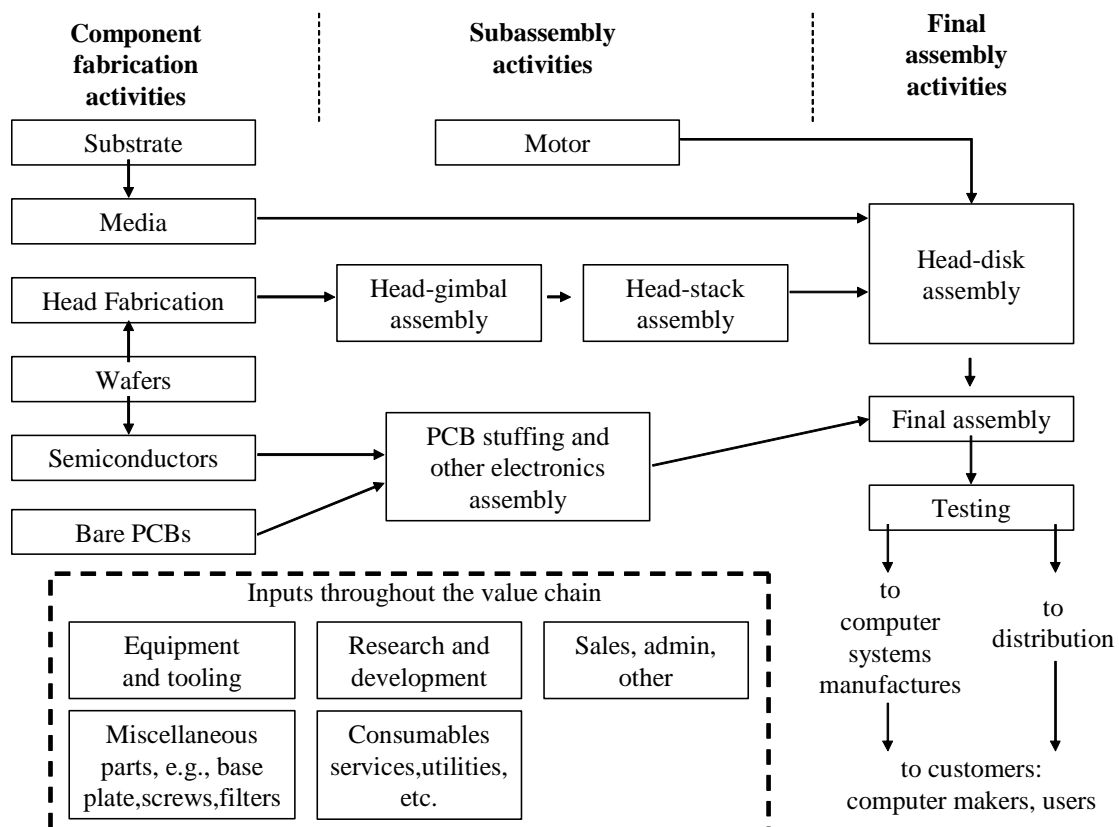
- KMITL King Mongkut's Institute of Technology Ladkrabang
- KMUTT King Mongkut's University of Technology Thonburi
- AIT Asian Institute of Technology
- NSTDA National Science and Technology Development Agency
- BOI Board of Investment
- MOI Ministry of Industry
- EEI Electrical and Electronics Institute
- ECEA Electronics and Computer Employers Association
- FTI Federation of Thai Industries
- IDEMA The International Disk Drive Equipment and Materials Association
- DSI Data Storage Institute

Value-chain

HDDs are the most complex components of a computer. The basic manufacturing process consists of four subassembly (1-4) steps and one final assembly (5) step (see Figure 6.4):

1. Assembling read/write heads: First wafers are made, which are subsequently fabricated into sliders. Sliders are very small read/write elements that are attached to a suspension, a small arm holding the head above the disk. This process is called head-gimbal assembly (HGA). Several of these arms are stacked together, combined with actuators and circuitry in a process called head-stack assembly (HSA).
2. Producing media/ disks: Disks are made out of aluminium or glass and store the data. Normally a HDD contains several disks.
3. Assembling motors: The motor spins the media. They include a shaft, a rotator, ball bearings and lubricants.
4. Producing the electronics: These include mainly semiconductors, printed circuit boards (PCBs) and flexible circuits, which connect the PCB to the other components of the HDD. These components coordinate the operation of the motor, heads and actuators.
5. Head-Disk Assembly (HDA): All components, which are typically assembled in separate plants, are finally brought together in head-disk assembly. The HDA is then placed in a base plate. The final step is the servo writing, an electromechanical technique to control the positioning of the head, and testing of the HDD (based on McKendrick et al., 2000: pp.22).

Figure 6.3: Hard disk drive industry value-chain



PCB: Printed Circuit Board

Source: McKendrick et al., 2000: 21

According to (Afzulpurkar & Brimble, 2004) the main competence of HDD-firms in Thailand is the subassembly of components, especially heads as well as the final assembly.

History

Thailand's development towards a major HDD-producer began when Seagate relocated its HSA from Singapore to Thailand in 1983 and grew "in tandem with the development of the regional production network" (McKendrick et al., 2000: 186), which had its centre in Singapore. From 1988 onwards, Seagate pulled other TNC-affiliates into Thailand. In the first phase essential locational advantages included a large pool of labour close to Singapore, low factor costs (especially wages), favourable tax and tariff policies, Thailand's political and macroeconomic stability and a non-interventionist government approach (McKendrick et al., 2000: pp. 186). While these conditions remained important, Thailand developed additional agglomeration benefits, such as access to trained manpower, a cluster of internal and external suppliers and industry-related facilities. As the president of K.R. Precision stated: "Thailand's key advantage is its 'technical infrastructure', the cadre of engineers and technicians that has gradually built up" (cited in McKendrick et al., 2000: 198). Many of these technicians were trained at Seagate. However, McKendrick et al. (ibid.) point out that the quality of the human capital base should not be exaggerated, since many high-skill activities have not been performed in Thailand.

Another advantage was the speed with which firms could start their production, due to available personnel and, sometimes, even plant facilities. This is also true for ramp-up and -down, which is essential in the HDD-industry, due to extremely short product-life-cycles and product specific production technology. The HDD production process in Thailand has gradually extended over the years, including now several production steps: In the beginning, for instance, Seagate's products were brought to Singapore for debugging. At the end of the 1990s, all the pilot and preproduction work for HGAs was performed by Seagate Thailand.

However, information spillovers are low: "Here we don't share anything, not even epoxy" (Read-Rite³⁸ executive cited in McKendrick et al., 2000: 198). Several attempts to create advanced industry-specific facilities, such as an industry training program, a centre for testing and failure analysis, a tool and die institute or a centre for magnetic testing have failed (ibid.). A new initiative is currently underway to establish these kind of projects within the cluster (see Afzulpurkar & Brimble, 2004).

Generally, the hard disk drive industry is characterised by strong price competition, constantly increasing quality demands and short product-life-cycles, which make short lead-times a necessity. These developments go hand in hand with a rapid change in process technology and increasing pressures for automation, in order to meet the high precision standards. This development leads to a decreasing demand in labour but an increasing demand for technical service providers, a strong supplier base and highly skilled technicians and engineers (Afzulpurkar & Brimble, 2004, HDD Industry Thailand, 2002, KRC, 2003).

³⁸ Read-Rite went insolvent in 2003 and Western Digital bought the Thailand operations of Read-Rite.

Another development, which challenges Thailand as a production site for HDD, is the recent move of many large PC-assemblers to China. Almost all interviewees reported experiencing ‘strong forces’ to re-locate to China in order to have operations close to their main customers.

The impact of this challenge is multiplied by the weaknesses of Thailand’s HDD-cluster:

- A key concern is that the HDD-industry in Thailand is focused too much on assembly. Important, high value-adding steps such as R&D, design and the fabrication of disk media and wafer are not performed (Panichapat & Kanasawat, 1999: 18, Afzulpurkar & Brimble, 2004:7, McKinsey, 2002: 175).
- Thailand lacks high-technology laboratories for testing. Consequently, most testing of final HDDs is performed in either Japan, the US or Singapore. Additionally, the infrastructure poses a certain obstacle, for example unreliable power supply can sometimes cause problems during testing (a process which takes up to 46 hrs.). (Afzulpurkar & Brimble, 2004: 7, McKendrick et al., 2000: 196, Panichapat & Kanasawat, 1999:18).
- Furthermore, there is a persistent lack of highly skilled engineers (ibid.).
- The fairly low local content originates from the lack of local suppliers, low quality of domestic components and a rather complicated process of selling between domestic plants (Afzulpurkar & Brimble, 2004: 6). The latter is the direct result of BOI tax incentives, which require suppliers to export their products in order to receive raw material import tariff exemptions. “If the manufactured components are not exported, as declared by the BOI, the suppliers must submit papers declaring the value of indirect exports that may be considered as domestic sales for payment of the raw material import duties” (ibid.: 6). Hence, suppliers frequently export parts and components to Malaysia or Singapore, before assemblers re-import these as raw materials (ibid.; see also Sukhpisarn, 2002).
- There is little involvement of domestic, Thai-owned firms in the industry. Also, there are few linkages within the industry and between the HDD-industry and other electronics industries (KRC, 2003, Afzulpurkar & Brimble, 2004, Panichapat & Kanasawat, 1999: 18).
- Customs procedures take too long for smooth JIT production methods, controls too often cause damage to the products, and BOI incentives do not match the characteristics of the industry (e.g. the constant modernisation of existing production lines is not sufficiently covered by the BOI policy of privileging new projects) (McKendrick et al., 2000: 196, HDD Industry Thailand, 2002: 5; Afzulpurkar & Brimble, 2004: 14).

Recently, there have been some policy activities, focusing particularly on the HDD-industry. Firstly, the BOI has declared HDD a ‘priority industry’ in spring 2004 with some additional benefits especially for firms committed to R&D, training, and subcontractor development (see chapter 4.1.4.4). Secondly, NSTDA is currently trying to create a HDD-cluster through the provision of a cluster development manager and supporting specific cluster strengthening projects (Afzulpurkar & Brimble, 2004: pp.11).

6.2.2 TNCs in Thailand's HDD-industry: capabilities, linkages, spillovers

In accordance to chapter 6.2.1 this section begins by introducing the interviewed firms and their core business activities. Secondly, it displays the firms' embeddedness in the value-chain and external collaborations. Thirdly, it reflects upon the self-assessment of technological capabilities and reports on the organisation of the R&D and innovation process as well as the perception of the business environment.

6.2.2.1 The interviewees in the HDD-industry and their embeddedness – value-chain and cooperation

Together with Dr. Peter Brimble of Asia Policy Research, and Dr. Nitin Afzulpurkar, Professor at the Industrial Systems Engineering Program, School of Advanced Technologies, Asian Institute of Technology, the author conducted interviews with eleven firms in the HDD-industry, which encompass **five** HDD/HGA/HSA **assemblers**, of which all but one are TNC affiliates (HDD1, HDD2, HDD3, HDD4, HDD5) and **five key suppliers** (SP1, SP2, SP3, SP4, SP5), of which all but one are again TNC affiliates.

In the first part of the interviews the basic production process, as well as the location of the main customers and suppliers, were established. Tab. 6.5 presents this information and gives additional data on external linkages. The HDD-assemblers supply mostly the main PC- and laptop-assemblers abroad, but differ in the degree of local sourcing. While HDD1, HDD3 and, to a certain extent, HDD4 have a fairly high rate of local sourcing, HDD2 and HDD5 rely heavily on global sourcing and imports. The first and second tier suppliers on the other hand import almost all critical inputs. They sell to a varying degree to domestic customers.

Tab. 6.5: Embeddedness of the surveyed HDD-firms: Value-chain and external collaboration

Firm	Supplier	Customer/ Market	External linkages (beyond pure market based)
HDD1	Over 90% of suppliers are located in Thailand. According to newspaper sources local content is 70%.	Export to either the main PC assemblers or end user market.	Suppliers: Frequent collaborations on product development with Thai-based suppliers Universities: Three ambitious programs: a) automation engineers program with 5 universities; b) coursework for master's courses in three universities, c) providing laboratory facilities in 2 universities (see text)
HDD2	Generally global sourcing. All suppliers are Japanese-owned, with plants in Japan, Malaysia, Singapore, China, Thailand etc. Of key components only spindle motors are supplied locally. Qualified local suppliers would be welcomed as backup for global sourcing.	Export to large PC assemblers.	Customers: Visits from customers for quality auditing. Suppliers: long term relationships, but most suppliers are from overseas.
HDD3	70% of suppliers are located in Thailand (in terms of value 50%): Spindle motors, and FSA/ PCB are sourced locally. All local suppliers foreign-owned/ JV; mostly Japanese.	Contract manufacturer for another assembler	Suppliers: some interaction with suppliers, e.g. supplier meetings, audits, source inspection – but generally external linkages are dominated by customer.
HDD4	Some local supplies, e.g. spindle motors and FSA/PCB; no figures given	Export to large PC assemblers	Suppliers: Collaboration on product development. Universities: Professors as local lecturers for internal training

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HDD5	80% of inputs are imported, mainly from Japan. 20% locally sourced: cover, base plate, spindle motors, actuator and magnet plates. HGA come from Japan. Locally owned companies only account for 2-4% of supplies – these are non-critical parts such as packaging. HDD5 would like to have more local suppliers, but cannot convince Japanese suppliers to locate in Thailand.	100% of production is exported, mainly to China.	Suppliers: Some minor collaboration with Thai based suppliers.
SP1	All critical components are supplied from firms in the USA and Japan.	30% of sales domestic, 70% export (i.e. China)	Customers/ suppliers: very strong collaboration on product development; same intensity with Thai and foreign based firms Universities: Research linkages with MTEC and Chualalongkorn, but also to DSI (Singapore) and universities in USA, Japan and China
SP2	Main supplies are low beams and fixtures from Japan and China; additionally mountplates from the USA. Local suppliers only for non-critical parts, such as packaging.	50% domestic; 50% export (China).	Customers: Some information exchange in Thailand at the initial stage of a new/improved product; during volume production only quality audits/troubleshooting. Public services: Uses service of Department for Vocational Training for in-house training.
SP3	Main inputs are castings, which are supplied from Malaysia; almost no local supplies.	100% domestic.	Customers: quality audits, feedback on product Universities: Sometimes using university laboratory for testing.
SP4	Only very few part supplies; firm strategy: 'make yourself'; hence mostly raw material	More than 90% export	Customers: quality audits, feedback on products, information exchange Universities: Allows universities to use on of its high-end machines in the R&D department, because it is the only one of its kind in Thailand.
SP5	Key input is only produced in Japan and the USA and hence supplied from there. Other material from US, Japan, Taiwan; Only some metal parts can be supplied locally; ca. 10 suppliers in Thailand producing according to SP4's specifications.	70-80% domestic; export to Malaysia, Singapore and China.	Customers: Frequent interaction, mostly about quality control, audits and customer requirements.
SP6	Try to procure locally, but experience difficulty, e.g. because of premiums demanded by monopoly-like domestic suppliers. Importing is often cheaper.	About 40% HDD related, total export 20%;	Customers: Core business is identifying bottlenecks and custom-tailored automation process equipment, which requires intense collaboration with customers.

Source: Author's interviews

Consequently, the Thai HDD-cluster gives the impression of having a fairly good presence of first tier suppliers, allowing at least some assemblers to create a partial production network in Thailand. This is not true for the 1st and 2nd tier suppliers, which often require high-technology inputs that are not available locally. Moreover, most firms would favour a stronger supplier-base in Thailand. Several firms, suppliers as well as assemblers, expressed the intention to source more locally, but could not find suitable domestic suppliers. This is either because the technology necessary to produce the input is not accessible in Thailand, for example, flexible Polyimide (reported by SP5) or die casting and e-coating (SP3), the precision and/or quality is not sufficient, e.g. for etching (SP2), or the suppliers are not price competitive and have lead times that are too long (SP3, SP5).

In order to overcome such structural problems, several firms tried to attract their foreign suppliers to Thailand (SP2, SP1, HDD5), but did not succeed. In consequence, firms either keep on importing or begin to integrate their production steps (e.g. SP1, HDD1).

Concerning external linkages, most companies are linked to the value-chain in Thailand and share related information (e.g. on QC). However, only very few firms work together with suppliers or customers on product-, process- or human-resource- development in Thailand (for more see 6.2.2.3). Accordingly, innovation-related vertical links are weak.

Still, innovation-related horizontal linkages to universities, R&D-institutions, service providers or competitors are even scarcer. Hence, most surveyed firms can be regarded as 'islands' within the Thai NSI. Their linkages are restricted to partners abroad.

Only a few firms can be considered locally embedded. These are either headquartered in Thailand or display a 'commitment' to the location based on firm strategy and a long history in Thailand.

6.2.2.2 Technological capabilities in the HDD-industry

As for the automotive-industry, the interviewees in the HDD-industry were asked to evaluate their firm's technological capabilities according to the framework presented in chapter 3.2.2.

2nd tier suppliers, such as SP3, and contract manufacturers, such as HDD3, have the lowest capabilities, whereas most of the assemblers and SP1 score fairly high. In general, investment, industrial and especially process engineering capabilities are high, while product and especially innovation and linkage capabilities are in most cases more basic. As a matter of fact, some interviewees state that their firms are "not even basic" (SP4) in terms of linkage capabilities, whereas HDD1 and SP1 exhibit high linkage capabilities, which is in line with their degree of embeddedness.

Process technology

The process engineering capabilities of the **HDD-assemblers** are high but not uniform. Two types of firms can be distinguished:

First, firms whose process-layout the headquarters or customer develops. The process technology is imported. The volume-production line is set up in cooperation between Thai and foreign engineers, either working for the parent firms or the equipment supplier (HDD2, HDD3, HDD5). While some of these firms even have pilot-lines in Thailand (HDD5), others run pilot-lines at the headquarters, but carry out extensive tests on the production line in Thailand before approving volume-production (HDD2). Even contract manufacturers have maintenance and troubleshooting capabilities and report successful process improvements, such as scrap reduction and workflow optimisation (HDD3). Furthermore, all of these firms report rising capabilities within their engineering teams, e.g. HDD2 engineers have developed robots for a production line entirely in-house.

Second, firms with more advanced capabilities perform most of the process development in Thailand (HDD1, HDD4): "Our engineers in Thailand start with concepts on paper about new equipment which will be used in 2-3 years time" (HDD1). In doing this they closely cooperate with

equipment suppliers in other Asian countries (e.g. Japan, Singapore, Malaysia), because there are no suitable suppliers available within Thailand.

The **suppliers**, whose capabilities are similar to those of less capable assemblers, share these characteristics. They also import all of the process technology, mainly from Japan and the USA. Frequently, the parent firm in the USA or Japan develops the process, the pilot-line is implemented in Japan or China, and then the turnkey production technology is transferred to Thailand (SP2, SP5). Joint Thai-foreign engineering teams are responsible for setting-up the volume-production line. Once the process is established, local engineers may perform some minor, incremental process improvements from time to time (SP3, SP5). Only the one supplier headquartered in Thailand does advanced process development in Thailand.

Tab. 6.6: Self assessment of technological capabilities of firms in the HDD-industry

	Investment	Manufacturing			Innovation	Linkages
		Process Engineering	Product Engineering	Industrial Engineering		
Basic	SP3 HDD3	SP3	SP2 SP3 SP4 HDD3		SP2, SP3 SP4, SP5 HDD3	[SP3, SP4]* SP2, SP5, HDD2, HDD3, HDD5
						HDD4
Intermediate	SP2 SP5 HDD5	HDD3	SP5 HDD1 HDD2 HDD4	SP2, SP3 SP4 SP5 HDD3	HDD1 HDD4 HDD5	
						HDD1
Advanced	SP1 SP4 HDD1 HDD2 HDD4	SP1, SP2, SP4, SP5 HDD1,HDD2 HDD4 HDD5	SP1 HDD5	SP1 HDD1 HDD2 HDD4 HDD5	SP1 HDD2	SP1

* less than basic; NB due to its particularity, SP5 was not asked to evaluate its TCs; Source: author’s interviews

However, there are some indications that a certain degree of upgrading in assembler and supplier firms has taken place. For example, SP2 reports that it plans to move process development functions to Thailand, as it expects a higher efficiency through the concentration of process development teams, pilot- and volume-production lines in the same location. Moreover, it states that customers expect this kind of commitment close to their operations. HDD3 reports that new products are now launched on its own pilot-line rather than in Japan. In addition, HDD2 expresses the intention to gradually move more process and equipment development facilities from Japan to Thailand.

Product development

As in process development, two groups of **assemblers** can be distinguished: Firstly, firms that receive detailed product specifications, blueprints and/ or ‘ready to manufacture’ products from

their headquarters or either customers in Japan or the USA. Accordingly, collaboration on product development takes place between parents, customers and suppliers at the home base of the TNC (HDD2, HDD3).

The second group has higher responsibilities for product development. For example, HDD1 has its R&D-departments for product development in the USA, Singapore and Northern Ireland. However, as soon as a working prototype has been developed and the new HDD has entered the “pure conceptual proven stadium” (HDD1) it is transferred to Thailand where all further development takes place. Consequently, HDD1 reports on its interacting frequently and intensely with its suppliers in Thailand regarding product development.

The development process at HDD5 seems to be even more advanced: Basic research and initial product design is conducted in Japan in intense cooperation with suppliers. As soon as this initial phase is concluded the design is transferred to Thailand, where the engineering team develops the prototype. However, HDD5 reports that the entire development process in Thailand is performed in-house, without any external cooperation partners. Similarly, HDD4 performs product development in Thailand, but declined to give further details.

The **suppliers** demonstrate a product development process similar to that of the first named assembler group. Their parent firms perform product development either at their headquarters or in R&D-departments in the USA, Japan and/ or Singapore (SP2, SP3, SP4, SP5), where they closely cooperate with the R&D-departments of customers and suppliers. Consequently, only the volume production is taking place in Thailand.

However, there are various minor R&D-activities situated in Thailand: For example SP4 runs an R&D-facility, even though its main objective is analysing and testing. Nevertheless, it was recently involved in the development of a new fluid dynamic bearing, collaborating with its parent firm and the customer. In this process the Thai-unit developed a cheaper and qualitatively better product by itself, which is now used for production. Moreover, the department is improving this product further at the moment.

SP1's products are developed in the US and Thailand. The purpose of the department in the USA is intense collaboration with customers during the initial stage of development. Soon after, R&D-staff transfer the knowledge from the US to the R&D-department in Thailand, where further research and development is executed. During this process R&D-personnel is sometimes collaborating with the customers' regional headquarters in Singapore.

The importance of proximity in joint development

Many interviewees stated that proximity is important for supply-chain-management (HDD1, HDD5, SP1), but absolutely essential for joint product development, because of very short lead-times in the industry: “Time to knowledge is greatly enhanced by being co-located” (HDD1, similarly SP1). Consequently, some firms experience problems with collaborations, because customers and suppliers are located abroad. For example, SP1 reports in relation to the need to be close to its customers, which have established facilities in China, and the unwillingness of its Japanese suppliers to move to Thailand. These suppliers would sooner follow to China. Hence, in

order to achieve proximity to customers and suppliers SP1 would need to re-locate to China. Currently, firms create proximity either by having R&D-laboratories close to their most important collaboration partners – at least for the initial stage of the development process, or through the frequent travelling of R&D-personnel.

Other interviewees confirm that proximity would ease supply-chain-management, but that global sourcing is normally no obstacle for JIT (HDD2).

S&T-infrastructure and human resources

Most firms had almost no collaborations with the S&T-infrastructure in Thailand. Some low-scale examples include the use of university laboratories for testing (SP3) or the provision of own equipment for universities' research (SP4).

Of the interviewed firms, only SP1 and HDD1 display signs of more intense linkages. However, SP1 is very unsatisfied with the domestic education and science system, stating that it lags 10 years behind most other Asian systems and needs major reforms.

On the other hand, HDD1 is at the moment actively trying to foster the indigenous knowledge base by pursuing the following three programs with universities:

- **Automation engineers program:** Together with five universities HDD1 developed the program, providing the curriculum, basic course structure and material. Moreover, HDD1 gives instructions to the universities on how to train the automation engineers. The program is very much oriented towards the requirements of HDD1's applications.
- **Coursework:** HDD1 has developed three fully accredited courses among the masters courses for microelectronic/ industrial engineering called "recording and technology" and "competitive manufacturing and leadership" at the Asian Institute of Technology, the King Mongkut's University of Technology Thonburi and the Khon Kaen University. Furthermore, HDD1 staff teaches these courses.
- **Donation of laboratories:** HDD1 has provided Khon Kaen University with an HDD-laboratory, including a clean room, and Suranaree University of Technology in Korat (Nakhon Ratchasima) with a mechanical engineering laboratory.

In respect to the availability and quality of human resources the firm interviews offer contradictory evidences: Most firms complain about the quality and number of (S&T) university graduates (HDD2, HDD5, SP1, SP3, SP5, SP6) and some report high turnover and poaching within the HDD-cluster. According to SP6 the main problem with Thai engineers is that they lack problem solving and interdisciplinary capabilities ('thinking outside the box'), which are not fostered by the education system. On the other hand, there are also firms that are satisfied with the available pool of skilled labour and did not report any problems (HDD1, SP2, SP4).

There are several mechanisms that firms can utilise in order to cope with shortages of skilled labour:

- **Overseas training:** Many firms send their engineers to Japan or other foreign locations for further training (HDD2, HDD4, HDD5, SP1, SP5)

- **Internal training:** Several firms provide extensive in-house training to cater to the industry/firm specific requirements (HDD2, HDD4, SP2, SP5). This service is at times provided by incoming university professors (HDD4).
- **Hiring of foreign engineers:** Because Thailand lacks professionals in certain fields, firms hire expatriates. For example, engineers with precision tooling skills appear to be in short supply, leading two firms to hire Indian engineers (SP1, SP2).

However, these investments in human-resource development are frequently sunk costs for the individual firm, because engineers leave the company soon after the training (e.g. they are ‘poached’ by other firms) (HDD5, SP1). Some firms also experience problems in attracting and keeping high skilled engineers, because of their plant’s location in the BOI zone 3, which lacks the ‘soft location-advantages’ sought by high-skilled professionals (HDD2).

An exceptional case is HDD1: The interviewee emphasised that the high technology, automated process technology requires highly educated staff. Nevertheless, HDD1 does not experience problems in finding and sustaining its engineer base. It attributes this to its long history in Thailand, which resulted in many “home-grown talents” and a stable workforce. Actually, HDD1 perceives the technical expertise of the human capital as the “single most important competitive advantage of Thailand”, which would be difficult to replicate in new locations like China.

6.2.2.3 Mechanism by which TNCs in the HDD- industry contribute to the system of innovation

The HDD-industry in Thailand incorporates only a few locally owned companies. Of the interviewed firms only two can be considered local: HDD3 and SP1. Consequently, this section does not reflect the impact of TNC-affiliates on local firms, but on other foreign firms and the SI as such.

a) TNCs are very demanding and hence lead to crises among supplier firms. This can trigger an increase in the intensity of effort on behalf of upgrading and learning.

Virtually all firms in the HDD-industry experience permanent demand for cost cutting and quality improvements. In many cases, customers formulate specific requirements, which have to be met by suppliers and which cause considerable upgrading and learning efforts from the suppliers.

b) TNCs enrich the SI by bringing with them or inducing the creation of new actors.

Several firms were asked by their customers to set up production facilities in Thailand (SP3, SP5). Additionally, SP6 created a subsidiary in Thailand, because proximity to its suppliers was required by one of its main customers. Nowadays, SP6 is one of very few companies in Thailand that operate in custom-tailored process-technology development.

Moreover, the establishment of SP1 was induced by a TNC, because it needed a second supplier to avoid dependence on its main supplier. This start-up has in the meantime developed into a global player within the HDD-industry.

Hence, all these firms fill a vacancy within the NSI, providing competences that were not available before. They therefore enhance the structure of the economy and the NSI. However, the presence

does not automatically improve the system of innovation, besides providing employment and taxes. Many foreign firms – at least in the HDD-industry – have limited domestic linkages, which are mostly restricted to the value-chain. Furthermore, the production networks are characterized by high entry barriers for local firms (at least for critical components) and can hence be seen as an example for a ‘parallel economy’, which must become further embedded in order to reap higher benefits for the NSI.

c) TNCs improve the S&T-infrastructure and the human capital basis.

Almost all interviewed TNC-affiliates provide either in-house or external training. Very often they sent engineers overseas for further training courses, either to Japan or the United States. This improves significantly upon the knowledge- and skill-base of the human capital in Thailand. As a matter of fact, the pool of skilled personnel is one important reason named by HDD-firms to locate in Thailand. Nevertheless, the existing pool and further supply of S&T graduates from university is considered too small and of too poor quality for current challenges and further expansion by most interviewees. This is supported by reports on the poaching of highly educated engineers within the industry. As a consequence, firms like HDD1 are actively involved in fostering the education of students in universities by providing state-of-the-art equipment, industry relevant curricula, experienced professionals as teachers and specific teaching material. These activities clearly advance the entire industry, since HDD1 does not absorb all of the trained engineers.

7 Summary, conclusions, and policy implications

Technical change in late-industrialising countries is sooner a process of acquiring and adapting technology and knowledge available in advanced economies than one of undertaking research and development at the technological frontier. It is a process that essentially consists of building technological capabilities through technological learning. The purpose of this thesis has been to enquire into the role of affiliates of transnational corporations in late-industrialising countries, in order to evaluate if and how they might foster these processes in the host economy and in domestic firms. This thesis presents the case of manufacturing firms in Thailand and benchmarks it with results from Singapore, Penang (Malaysia) and to some extent Europe.

The objectives of this thesis are:

- a) to determine the contribution of TNC-affiliates to the SI and the technological learning of firms in late-industrialising countries theoretically,
- b) to ascertain the current state of the Thai-SI,
- c) to assess the technological capabilities and knowledge-network embeddedness of TNC-affiliates in comparison to local Thai-firms, and firms in Penang and Singapore, in order to evaluate their suitability as collaboration partners and technology senders within the Thai-SI,
- d) to investigate the primary characteristics of advanced and embedded TNC-affiliates,
- e) to elaborate upon the key mechanisms by which TNC-affiliates improve the Thai-SI and foster technological learning within domestic firms,
- f) to identify weaknesses of the SI as perceived by firms and offer policy recommendations for strengthening the SI and the impact of TNC-affiliates.

These objectives are met with the following findings:

Theoretical contribution of TNC-affiliates

Chapter 2 makes it clear that the central challenge faced by (latecomer) firms in late-industrialising countries is catching up with their competitors in industrialised countries. The main objective hereby is to develop technological capabilities in order to upgrade the technological performance, to develop innovation capabilities and reap a higher share of the value-chain. The development of technological capabilities requires technological learning, which is a time consuming and costly exercise. Important inputs for technological learning include learning opportunities (learning by interacting), the development of absorptive capacity (especially via personnel training) and the utilisation of advanced technology from abroad via channels of technology transfer.

These efforts have to be set in the context of national, regional and sectoral systems of innovation, which strongly influence firm behaviour and opportunities. This SI-approach describes learning and co-operation opportunities through its evaluation of the stocks of the system, the quantity and quality of suitable partners, and its assessment of the flows within the system through the consideration of their linkages. Furthermore, it takes determinants of firm behaviour into account by

looking at incentives and support for learning and innovation in regard to policies, market conditions, available funds, prevailing attitudes and norms etc.

TNC-affiliates have an impact on these systems, because they are additional elements creating additional flows. This influence is important, because TNC-affiliates (can) display characteristics that domestic firms lack: TNCs possess by definition particular owner specific-advantages in terms of product and process technology, market access, resources, knowledge, etc. In addition, TNCs operate international production networks that tend to be dispersed over several countries and, consequently, have access to diverse external sources of knowledge on markets and technologies. Hence, TNC-affiliates in Thailand pose as an opportunity for domestic firms to tap into these knowledge networks, either directly or indirectly. In result, TNC-affiliates may potentially offer an advanced learning opportunity to local firms. However, the learning potential provided by TNC-affiliates varies markedly. It is determined by the type of technology applied, the kind of functions performed, the position of the TNC-affiliate within its corporate network, its autonomy and openness towards cooperation with local firms, etc. These determinates are decisive in regard to two aspects: First, they can influence whether or not local firms get an opportunity to interact and therefore learn directly from a TNC-affiliate, and second, whether or not functions, technologies, absorptive capacity and knowledge of local and foreign firms match to a degree that suggests (mutual) learning.

Since systems of innovation in late-industrialising countries are typically characterised by a weak knowledge base, a dichotomised economic structure and fragmented linkages, these learning opportunities and additional linkages provided by TNCs can greatly contribute to the upgrading of local firms and the SI as such.

Consequently, this thesis enquires into the functions and technological activities performed by foreign and local firms that aim to establish learning and collaboration potential. Furthermore, it analyses collaboration patterns, in order to determine whether or not TNC-affiliates in Thailand take part in intense R&D and innovation collaborations.

Besides improving the quality of local companies and linkages to these, TNC-affiliates can have further positive impacts on the system of innovation as such: They can bring in additional actors (e.g. follow-source suppliers) that enrich the system or increase the human capital base by providing training or contributing to the education system.

However, TNC-affiliates can also be indifferent to or even have negative impacts on the SI. They may exclude themselves from local cooperation networks, either creating an 'autonomous' economic structure by simply replicating home-base production networks, or concentrating on their external linkages to partners abroad. Furthermore, they may restrict the interaction between their local suppliers or associated companies with third parties. Additionally, TNCs can absorb scarce local resources (e.g. human capital, capital) and thereby diminish the development potential of local firms.

The current state of the Thai-SI

The review of secondary data and literature in chapter 4 leads to the conclusion that the current state of the Thai-SI is fairly poor. Financial and human resources committed to innovation are low, as is the output in terms of patents. Furthermore, there are major deficits among all three major actor-groups.

The firm-sector is characterised by a dichotomy: on the one hand fairly capable TNC-affiliates, some larger Thai-owned firms and some high-tech SMEs, and on the other, the bulk of SMEs struggling to attain even basic operation skills. Both groups lack innovative and R&D-capabilities, have limited product development and engineering capabilities as well as difficulties implementing advanced processes, such as automation or modern organisation modes like Just-in-time. Inter-firm links are limited, especially between TNC-affiliates and local SMEs.

The assessment of the knowledge-related public sector reveals that the output of the education and research sector is insufficient in terms of quality and quantity. Graduates lack essential skills, there are too few S&T-graduates, the education system is under-funded, and curricula are outdated and not oriented towards the needs of the industry. The same is true for scientific research, which is – in international comparison – at a fairly low level, as indicated by the number of journal articles. Hence, this sector is neither sophisticated enough to cater to the needs of the more capable firms, nor sufficiently oriented towards the more basic needs of the large group of less-capable SMEs. Consequently, there are large gaps between the education and research sector and the business sector leading to marginal linkages and interactions between these groups.

Finally, government policies and processes are deeply centralised, but at the same time characterised by a redundancy of organisations and programmes with similar objectives. This leads to a fragmented and inefficient support system.

Technological capabilities and embeddedness

In order to meet this objective, sections 5.2 – 5.4 test three hypotheses (for an overview of all tested indicators and the results see Tab. 7.1):

H1: TNC-affiliates are actors with higher capabilities than local firms. Consequently, they are suitable contributors to the upgrading of the host countries' SI.

In terms of **technological capabilities** the data analysis leads to the conclusion that TNC-affiliates in Thailand cannot generally be considered more technologically capable than local firms. They are more often certificated according to ISO-standards and they are more likely to carry out basic to intermediate technological activities such as testing, quality control, acquisition and adaptation of external technology. Nevertheless, TNC-affiliates do not perform R&D- and innovation-related activities more frequently than local firms (despite a slight increase in 2002). This is especially striking in contrast to the benchmarking regions of Penang and Singapore, where foreign firms carry out innovation activities much more often than local firms. This indicates a regional division of labour, with TNC-operations in Thailand restricted to assembly and manufacturing, whereas the facilities in Singapore and Penang more often having the responsibility for higher-order functions.

Tab. 7.1: Summary of the analysed indicators: Do they support the stated hypothesis (Y) or not (N)?

Indicator	TIS 2000	TIS 2002	PIS	SNIS	ERIS
<i>H1a: TNC-affiliates possess higher TCs than local firms.</i>					
MA to OBM framework	N	N	N	N	
ISO certification					
- 9001	Y	Y***	Y	Y***	
- 9002	Y***	Y***	Y***	Y***	
- 14001	Y***	Y***	Y***	Y***	
Technological activities					
- Quality Control	Y*	Y**			
- Testing	Y*	Y***			
- Acquisition of ext. technology	Y***	Y***			
- Adaptation of ext. technology	Y	Y***			
- Reverse Engineering	N***	N			
- Basic Design	N***	N			
- Detailed Design	N***	N			
Innovation					
- R&D	N	Y	Y	Y***	N*
- other innovation activities	N	Y			
- R&D or other innovating activities	N	Y			
- patents	Y	N**	Y	Y***	Y***
- product innovations	N*	Y	Y**	Y***	Y***
- process innovations	N	Y	Y**	Y***	Y**
- innovating	N	Y	Y*	Y***	Y**
- innovative	N	Y	Y*	Y***	[Y]
<i>H1b: TNC-affiliates have a better absorptive capacity than local firms.</i>					
Qualification structure of workforce	Y***	Y***	Y***	Y***	
Training expenditure	N	Y***	Y*	Y***	
<i>H2a: Advanced TNC-affiliates possess higher TCs than advanced local firms.</i>					
MA to OBM framework	N	N	N	N**	
ISO certification					
- 9001	Y	Y***	Y	Y**	
- 9002	Y**	Y	Y***	Y**	
- 14001	Y***	Y***	Y	Y	
Technological activities					
- Quality Control	Y*	N			
- Testing	Y**	Y*			
- Acquisition of ext. technology	Y	Y**			
- Adaptation of ext. technology	Y	Y			
- Reverse Engineering	N	~			
- Basic Design	N	Y			
- Detailed Design	Y	Y			
Innovation activities					
Acquisition of machinery, equipment & software	N	Y	N*	Y	
Acquisition of external technology e.g. patents and licences	Y***	Y***	Y	Y	
Industrial design and engineering, market research, marketing expenses	Y	Y/N	N	N	
Training	Y	~	Y	Y	
Input-/ Throughput- /Output-indicators					
Innovation expenditure	N**	N			
R&D expenditure	N**	N/Y	N	N	
Innovation and R&D expenditure	N	N	Y	N	
Patents	Y	N	N	Y	
Innovative firms	N	Y*	Y	Y	[N]
<i>continuous on the next page</i>					

Indicator	TIS 2000	TIS 2002	PIS	SNIS	ERIS
<i>H2b: Advanced TNC-affiliates have a higher absorptive capacity than advanced local firms.</i>					
Qualification structure of workforce	Y	Y	Y	Y	
R&D-personnel intensity	N	N	N	N	
Training expenditure	Y	Y	N	N	
<i>H3: R&D performing and potentially innovating TNC-affiliates are suitable technology transfer partners for local firms, since they are strongly embedded into the host economy and have access to foreign/ external technology.</i>					
Collaboration					
- customer	Y	Y	Y**	N	Y
- locally-owned suppliers	N	Y	Y**	Y***	Y
- foreign-owned suppliers	Y	Y	Y		
- parent/associate	Y***	Y***	Y**	Y	
- R&D institute/university	N**	N	Y	Y	Y
- business services	N	~	Y	N	Y
- technical services	N	Y	Y***	Y	
- government agency		Y			
- competitors	Y	Y	Y	N	Y
- other firm	N	N	Y	N	
Acquisition of R&D services	Y	N	N	N	
- other firm in Thailand	~	N			
- public institute	N	N*			
- universities	N	N*			
- abroad	Y	Y			
Performing own R&D abroad	Y	Y			

*** significant at 1% level, ** significant at 5% level, * significant at 10% level

Y yes, N no, Y/N one year yes, another no (some questions cover two years in one survey), ~ ambivalent, [..] not entirely comparable

NB sometimes for aggregated indicators, e.g. MA to OBM, the presented significance is representing the tendency, not the exact result over all variables.

Hence, in Thailand there is no evidence for a higher performance by TNC-affiliates per se, from which local firms could benefit. However, there are indications that TNCs are beginning to change their strategy and beginning to upgrade their operations in Thailand.

In terms of human capital as a pre-requisite for **absorptive capacity**, TNC-affiliates are clearly more endowed than local firms: Their personnel possess a significantly higher qualification level. Moreover, foreign firms invest more money in training than local firms and hence are more devoted to the improvement of their absorptive capacity. Similar to other indicators, the expenditure on training by TNC-affiliates has increased in the 2nd survey, but is still low in international comparison.

Nevertheless, the share of highly qualified employees in Thailand has increased between 2000 and 2002, in part due to the higher enrolment rates in tertiary education in recent years.

H2: Even within the group of advanced firms, TNCs have higher capabilities than local firms.

Within the group of advanced firms, TNC-affiliates are clearly superior to local firms in terms of **technological and innovative capabilities**. Consequently, they are suitable candidates for technology transfer and collaboration.

Generally, advanced firms pursue technological activities at a higher frequency and variety than basic firms. Thereby, advanced TNC-affiliates perform high-order technological activities, such as

basic and detailed design, more frequently than their local counterparts. Moreover, they contribute much more to the international transfer of embodied and disembodied technology to Thailand than local firms. This underlines the importance of advanced TNC-affiliates as technology and knowledge suppliers to the Thai-SI.

However, compared to Singapore and Penang, firms in Thailand commit only very limited resources to R&D and innovation. In recent years, TNC-affiliates spent more on R&D, whereas local firms allocate more funds to other innovation activities. Furthermore, there is some indication for an increased R&D- and innovation- spending by TNC-affiliates. Most local and foreign firms assign the majority of funds to product development and experimental development. There are indications for a shift towards more applied and basic research. Still, the levels of investment remain much too low or too recent to result in new patentable products or processes. The number of patents in Thailand is minuscule. This is valid for Penang and Singapore, as well – their figures are only slightly higher. This underlines that TNCs still carry out basic research and R&D, which results in patents in their home-countries or in favourable locations in advanced economies, but not in late-industrialising countries in South-East Asia.

Nevertheless, TNCs have increased their input and, consequently, a higher share of advanced TNC-affiliates in Thailand has become innovative. The share of innovative foreign firms in 2002 is noticeably higher than in 1999 and clearly above the figures for local firms.

The most important objectives for R&D and innovation within local and foreign firms include product and market diversification, market position, cost reduction and – at least in Thailand – learning about new technologies. The latter aspect is remarkable, because it has been assessed by the firms as being much more important in 2002 than in 1999. This indicates a clear commitment to technological capability building and learning.

Additionally, advanced TNC-affiliates display a higher **absorptive capacity** than advanced local firms in respect to skilled labour and resources allocated to training and R&D. In addition, foreign firms exhibit a similar qualification structure, independent of their being basic or advanced.

Interestingly, local and foreign R&D-firms display similar qualification structures. Foreign non-R&D-firms are as well endowed with human capital as R&D-firms, whereas local non-R&D-firms exhibit fewer high-skilled employees. In conclusion, even non-R&D and basic foreign firms possess the potential to become R&D- or advanced firms – at least in terms of a qualified workforce. Hence, upgrading to R&D and innovation activities should be fairly easy for these firms. In contrast, basic and non-R&D- local firms do not display the human skill base that seems to be necessary for carrying out innovation and R&D. Consequently, they first need to enhance the qualification structure of their workforce in order to develop R&D and innovation capabilities.

Despite a similar qualification structure, local firms tend to display a higher R&D-personnel intensity than foreign firms. This may result from the larger size of TNC-affiliates in terms of employees and a similar sized R&D-department.

In contrast, the qualification structures in firms in Singapore and Penang are more differentiated between foreign/local, advanced/basic, R&D-/ non-R&D firms. This suggests that foreign advanced and R&D-firms in Thailand could employ more skilled personnel if the supply were improved.

Additionally, it supports the finding that TNCs in Thailand perform less sophisticated functions than their counterparts in Singapore and Penang.

While the R&D-personnel intensity in Thailand is as high as in Penang, it lacks behind firms in Singapore. This displays Singapore's advanced position within the regional division of labour, above all its function as a location for regional headquarters, which perform R&D, design and engineering.

H3: R&D performing and potentially innovating TNC-affiliates are suitable technology transfer partners for local firms, since they are strongly embedded in the host economy and have access to foreign/ external technology.

TNC-affiliates make better use of foreign sources of information for R&D and innovation, and source R&D-services more often from abroad. Moreover, about 30% of the foreign firms perform R&D elsewhere. In addition, TNC-affiliates have intense R&D and innovation collaborations with partners outside of the Thai-NSI. Consequently, R&D-performing and potentially innovating TNC-affiliates acquire and learn about technology and knowledge abroad and transfer it to Thailand.

This is essential for local firms, because they rely much more on domestic sources of information. Since foreign firms are as often embedded into the Thai-NSI as local firms, TNC-affiliates are suitable interfaces for the diffusion of internationally available technology and knowledge in the Thai-NSI. Only exception is that TNC-affiliates cooperate far less often than local firms with research institutes and universities. This emphasises on the one hand, the low quality of research organisations, on the other hand, their irrelevancy to the functions performed by TNC-affiliates in Thailand. Nonetheless, the observed increase in R&D and innovation activities performed by TNC-affiliates will increase the demand for these respective collaborations.

Furthermore, it has to be underlined that foreign and local firms in Thailand (in 2002) often cooperate just as intensely as their counterparts in Singapore and Penang (in 1999). Technical service providers alone less often become partners, suggesting a lack of sophistication among the actors in this segment of the Thai economy.

In order to inquire into key characteristics of technologically advanced and embedded firms in Thailand, chapter 5.5 applies a CHAID-analysis. In order to perform this, the most significant independent variables capable of explaining dependent variables, such as 'being advanced' and 'being embedded', are established. For the latter a collaboration intensity index is calculated.

The analysis leads one to suspect that the acquisition and adaptation of external technology as well as detailed design activities are the most important factors for **advanced** foreign firms. Moreover, size matters: firms with more employees are more likely to be advanced. Consequently, these results support the notion that technical change in late-industrialising countries is strongly related to the acquisition and adaptation of external technology available in advanced countries. It also underlines the proposition that firms need to cumulate certain basic and intermediate capabilities, before becoming successful innovators. Namely, they must gain access to technology (acquisition) and, subsequently, understand how it works and how to – incrementally – change it (adaptation).

The latter capability can also be achieved by designing specific details of products after key features have already been determined.

Strongly **embedded** TNC-affiliates are characterised by the fact that they perform applied research or experimental development rather than basic research. Moreover, innovative firms, i.e. firms that achieve a high share of sales with new products or a high share of production with new processes, tend to be more strongly embedded. It can be assumed that innovativeness and embeddedness are interrelated: innovative firms see the need for intense collaborations and through these become even more innovative.

The same conclusion holds for the **local embeddedness** of TNC-affiliates: Foreign firms that spend a substantial part of their resources on process related R&D and are successful product or process innovators collaborate strongly with partners, which are assumed to be predominantly Thailand based. Consequently, innovating firms tend to be more embedded – generally as well as locally.

Technological capabilities and key mechanism by which TNC-affiliates improve the SI in the case study industries

Chapter 6 presents the results from the in-depth interviews in the automotive and HDD-industries. The aim of the interviews was to further investigate mechanisms by which TNC-affiliates foster technological learning in local firms and enhance the SI as such.

The interviews found that, in both sectors, the TNC-production networks present high entry barriers for local firms. This is primarily due to the fact that TNCs tend to replicate their home-base production networks in the host country. Hence, there are relatively few domestic firms within the core group (assembler, 1st tier supplier) of these production networks. Nevertheless, the case studies show that local firms have the opportunity to become part of the value-chain. These opportunities are higher in the automotive than in the HDD-industry, simply because there are more parts and especially more basic, low technology parts in a car, offering windows of opportunities to local firms.

Not surprisingly, the technological capabilities of TNC-affiliates are for the most part higher than those of local firms. In both the automotive and HDD- industries, TNC-affiliates have high technological capabilities in investment, process engineering and to some extent industrial engineering. Capabilities in product engineering, innovation and linkages are generally much weaker. These findings are supported by the inquiry into the product and process innovation process. TNCs still overwhelmingly perform R&D and product design at their home bases and/or in preferable locations in other advanced markets, close to the R&D-departments of their key customers and/or suppliers. Nevertheless, they tend to shift responsibilities for process developments and innovations stepwise to production locations in Thailand. The interactive character of the innovation process can explain this. Upgrading is more efficient if development, the pilot line and the volume production line are close together. Moreover, this reflects the growing skills of the affiliates and their engineers.

Additionally, some product development takes place in Thailand. These are mostly small adaptations to local conditions, but increasingly also major development steps are assigned to TNC-

affiliates. For example, HDD-prototypes or even conceptual drawings are transferred to Thailand for final development and, additionally, new pickup truck models are on the brink of being developed within the country. These developments will lead to the advancement of many core partners in the respective production networks, because innovation requires collaboration between suppliers and customers. Moreover, spatial proximity was considered to be very important for innovation-related activities by many interviewed firms. For example TNC1's R&D-centre relies on its first tier suppliers to develop complementary R&D-capabilities in Thailand. However, it is difficult to evaluate the scale of upgrading that will take place in supplier firms at this point in time. Embeddedness in respect to the value-chain and external linkages is higher in the automotive industry than in the HDD-industry. This is partly due to the fact that HDD-parts are smaller, fewer and more sophisticated. Hence, they are either easier to import or have to be procured from abroad anyway. However, in both industries there are good examples of seemingly 'committed' TNC-affiliates with a long local history that actively seek linkages to horizontal partners such as R&D-institutes and universities.

In conclusion, TNC-affiliates foster the capabilities of actors in the Thai-NSI by enhancing their own capabilities and, consequently, either forcing or convincing related (first tier) suppliers to follow suit. Additionally, the interviews identified the following mechanisms by which TNC-affiliates improve the SI of the host economy. **TNC-affiliates:**

- **Create crises** among locally based local and foreign suppliers, by permanently increasing requirements in terms of price, quality, and improvements. This triggers intensified upgrading effort by suppliers, making them more competitive and attractive for other customers as well.
- **Give assistance** to suppliers to meet these requirements, for example by providing training, establishing contact with more capable suppliers, operating supplier clubs etc.
- **Provide opportunities to enter production networks.** The entry barriers in TNC organised production networks are fairly high, at least for key components and parts. However, these production networks are 'there' and aim for a localisation strategy – consequently this provides opportunities for local firms to become part of them. This creates both a market and learning possibilities for local firms. Once integrated into the production network local firms can prove themselves and may be asked to source TNC-affiliates in other countries as well.
- **Attract new actors** (firms) to Thailand and the Thai NSI. These frequently fill gaps in the economic structure, making the fragmented system more mature. Subsequently, local firms can also benefit, for instance, from a technical service provider brought in by a TNC, allowing for technological upgrading and collaboration opportunities.
- **Improve the human capital base** by providing in-house training and training at TNC-facilities abroad. Furthermore, TNCs improve the standards of universities by providing equipment, curricula, lecturers and information on industry-relevant content. Moreover, TNC-affiliates can act as practical training grounds for graduate students (internships/student projects).

- **Create demand for highly skilled graduates.** The demand should create extra-supply. The education system could be expected to offer additional S&E courses, students should be attracted to these courses by promising career opportunities with TNCs. However, as long as the demand is not satisfied by the supply of the education system, TNC-affiliates can cause a shortage of skilled personnel in domestic firms, reducing their potential to develop technological capabilities. Poaching is another downside within the industry, which reduces the incentives for investment in further training and can pose an obstacle for steady upgrading.

Weaknesses of the SI as perceived by the surveyed firms

In order to detect important weaknesses within the Thai-SI, chapter 5.6 analyses firms' assessment of factors impeding R&D and other innovation activities as well as their perception of the business environment.

These indicators point out the following main obstacles for further R&D and innovation: Lack of suitable personnel, lack of government support/ incentives and problems with the availability of suitable 'horizontal' collaboration partners, namely technical support services, local universities and R&D-institutes. While the lack of human capital is one of the most pressing problems for both TNC-affiliates and local firms, the absolute share of local firms suffering from insufficient skilled personnel supply is much higher. Contemplating these bottlenecks and the qualification structures of foreign and local firms (see above), it can be concluded that TNC-affiliates are indeed worsening the situation of local firms by attracting the bulk of scarce skilled personnel.

The most important internal factors hindering R&D and innovation – and consequently aspects of firms' capabilities – are the reluctance to take the risks and costs associated with these endeavours and a lack of R&D-strategy at the firm level. Missing absorptive capacity at the firm level is also perceived as a problem, indicated by a lack of in-house R&D-personnel. Since the lack of information on R&D-opportunities and technology, as well as lack of R&D-infrastructure, can also be seen as indicators for missing absorptive capacity, this poses a noteworthy problem, considered important by more than 40% of foreign and 45% of local firms in 2002.

Having said this, the assessments of the conditions for R&D and innovation have improved markedly from 1999 to 2001. Additionally, the factors that concern firms in Thailand tend to be serious problems for firms in Singapore and Penang as well.

Policy recommendations

Based on these findings, the following policy suggestions can be derived in order to strengthen the SI as such, to foster technological learning in local firms and technological upgrading in TNC-affiliates, as well as to further embed TNC-affiliates in the Thai-SI. Hereby, it is essential to point out that upgrading is a circular process: improving the business environment and system of innovation will lead to upgrading within both TNC-affiliates and local firms, which in turn will further strengthen the SI, triggering even more activities, etc.

1. **Strengthen the human capital basis** (especially in S&T)

The lack of human capital is a major obstacle to R&D and innovation in foreign and local firms. TNC-affiliates, who presently tend to employ a better-educated workforce, seem to absorb skilled human capital that is urgently needed for upgrading in local firms. Hence, the education system needs to be improved, and in tertiary education especially. More money needs to be allocated, curricula need to be modernised and adapted to industry needs, incentive schemes need to be developed that attract students to S&T-courses, collaborations between industry and universities have to be developed in order to inform universities of state-of-the-art developments in industry and to provide students and researchers with opportunities for practical-oriented joint projects. Furthermore, initiatives for reverse ‘brain drain’ of highly skilled expatriate Thais should be developed. Additionally, the government should provide assistance and financial support for the recruitment of foreign R&D-experts to act as a foundation for building up R&D-departments in Thai-based firms and training of employees.

2. **Increase the quality, industry-relevance, and openness of R&D-institutes and universities**

Advanced foreign and local firms miss partners in the S&T-infrastructure for collaboration and technical support. This is especially true in the current upgrading phase. Moreover, when moving from the catching-up to the keeping-up strategy (2.1.1), TNC-affiliates and local firms start to look for suitable cooperation partners in the public S&T-sector – this opportunity to embed TNC-affiliates stronger into the Thai NSI should be seized. Therefore, it is necessary to offer high quality, reliable and relevant research and to create incentives for public S&T-staff to seek industry collaborations. Financial incentive programs can support these activities. Moreover, public S&T-institutes should also take the needs of basic local firms into account and try to custom-tailor low-scale training and joint-research programs.

3. **Go for production network flagships:** The results of the interviews underline the power aspect in production networks. This could be utilised as a lever for location and upgrading policies. Policy could target flagships explicitly (such as HDD1, TNC1) and ‘convince’ them with custom-tailored incentives to locate in/ upgrade their operations in Thailand. Once convinced, these flagships will exercise power over their suppliers, pulling them to Thailand or pushing them to set up their own R&D-facilities. At this stage, supporting policies for suppliers’ upgrading/ relocation should be implemented. An improved system of innovation with a large pool of skilled labour is, of course, a strong incentive for such moves.

4. **Identify missing links in the economic structure of specific industries**

The survey data showed that a lack of technical support services pose a problem for many firms. Moreover, many interviewees in both focus industries stated that there are several parts they would like to source locally, but must import because no local suppliers are available. If these market chances are not seized by local firms due to information asymmetries, public actors could act as intermediaries. For example public agencies could try to identify these gaps (e.g.

high precision tool and die in the HDD-industry) and encourage local firms or start-ups to enter these niches. Additional support such as seed capital, co-financing/ loan-schemes for training and acquisition of equipment could be provided. This would create new actors and linkages within the NSI and would further bind and embed TNC-affiliates.

5. Alternatively, **support firms in bringing their suppliers to Thailand**. If it is not possible to fill essential vacancies in the value-chains of the vital industries with local firms, it makes sense to support firms in their effort to attract their suppliers to Thailand. Some firms reported trying to convince suppliers to relocate to Thailand and having failed. Government incentive programs could enable these activities.
6. **Link incentive schemes for TNCs to specific requirements** in terms of technological content, R&D-activities, training expenses, assistance of/ collaboration with suppliers and universities on assistance, education, etc. The recent introduction of R&D-requirements for higher BOI privileges should be extended further, complementing BOI-zoning policies. However, this is only possible if the basics for such activities are sufficient (see 1. and 2.).
7. **Support explicitly technological capability building in local firms**. Many local firms stated their intentions to begin R&D and product development capabilities or to increase existing capabilities. However, the analysis of the absorptive capacity shows that many local firms lack the necessary human capital base to create R&D and product development capabilities. Hence, government policies need to support upgrading activities by providing more qualified graduates (see 1.) and further training programs (e.g. Thai-German Institute), by fostering internships for Thai professional in advanced firms in leading markets, by facilitating the recruitment of experienced R&D-personnel from advanced countries, by providing tax incentives or loan schemes for the costly creation of these capabilities. Subsidies for these activities can be justified, because these capabilities are a pre-requisite for the qualification as first-tier suppliers in TNC-production networks, which would bring with them higher shares of local value-added activity.
8. **Support product and process development capabilities in foreign firms as well**. The analysis points out that many foreign firms have the necessary pre-requisites for R&D and innovation in terms of human capital. Moreover, it shows that foreign firms, which are committed to product and process innovations, are more strongly embedded in the Thai-SI. Hence, must be implemented that trigger these TNC-affiliates to utilise their potential and become real innovating firms. Fostering these capabilities would result in stronger embeddedness among foreign firms, which in turn would lead to more diffusion of technology and knowledge to local firms – facilitating further embeddedness of TNCs and upgrading in local firms. Consequently, this would justify policies that target TNC-strategies and support capability building in TNC-affiliates as well.

9. **Support the acquisition and adaptation of external technologies, as well as design, activities of foreign firms**, because these have been identified as key characteristics of advanced TNC-affiliates, which are appropriate collaboration partners for interactive learning with and upgrading within local firms. Moreover, this could enhance the basis for domestic technology diffusion. Hence, the regulatory (intellectual property rights, customs, etc.) and S&T-environment should be mainstreamed further in order to ease acquisition of external technology. Financial and tax incentives should be assigned for design activities.
10. **Intensify programs, such as BUILT, that attempt to foster linkages** between domestic suppliers and (foreign) customers, e.g. in the form of industry cluster policies. Follow a proactive policy strategy that tries to create networks: Listen to industry needs, learn about competences of domestic (foreign and local) firms and bring together firms that might benefit from working with each other.

Limitation and need for further research

The study asserts that TNC-affiliates contribute to international technology transfer by acquiring external embodied and disembodied technology. Since advanced TNC-affiliates are as embedded in domestic R&D and innovation networks as local firms, they are – potentially – suitable interfaces for the transfer and diffusion of internationally available knowledge and technology in the Thai-SI. Data from the R&D/Innovation surveys as well as findings from the interviews support the assumption that essential knowledge is exchanged along these networks. However, it is not clear how much and what type of external knowledge and technology is really being transferred along these networks, and whether intentionally or unintentionally. Hence, future research should explore the specific types of knowledge and technology that are a) acquired by TNC-affiliates, b) transferred to domestic partners, and c) actually missing in local firms, in order to evaluate the benefits of TNC-affiliates in the SI more profoundly. Essentially, this is a matter of knowledge and technology-matching between TNC-affiliates and domestic firms. As a means to answer this question, either questionnaires with more detailed answer categories or firm interviews that are accompanied by professional engineers would deliver valuable results.

The same is true for the classification of technological activities. This thesis assumes, for example, that two firms carrying out ‘detailed design’ have sufficient common ground for collaboration; and that a local firm without ‘adaptation of external technology’ capabilities can learn from a TNC that is performing this kind of activity. However, this is not inevitably the case, since these categories are often fairly broad and can encompass different activities. Consequently, future research needs to apply more detailed, perhaps even industry specific, categories.

Having said this, the R&D/ Innovation survey questionnaire is a well-adopted empirical tool for the particularities in late-industrialising countries, because it contemplates innovation activities that have not resulted in new products or processes. In the future, researchers should consider how this part of the questionnaire could be improved in order to retrieve even more information on these essential activities. In addition, data reliability would increase if innovation surveys in late-

industrialising countries applied trained interviewers (e.g. graduate students) to assist firms in filling out the standardised questionnaires, rather than implementing a postal survey. Many of the questions can lead to uncertainties among respondents who are not entirely familiar with innovation and R&D, although their firm may carry out minor improvements. Certainly, this depends on the ability to receive available funds for such a survey.

In addition, the R&D/ Innovation surveys consider collaboration patterns of advanced firms only. These firms possess high capabilities by definition. In contrast, basic firms, which make up the majority in Thailand, do not carry out R&D or other innovation activities and, yet, need to build up more fundamental capabilities. Access to advanced knowledge and technology that resides with TNC-affiliates is a sound learning opportunity for them. Hence, it is necessary to analyse general collaboration patterns of basic firms, in order to ascertain – based on a broad sample – whether or not TNC-affiliates (can) foster their upgrading.

Furthermore, the results from the case study interviews presented in this thesis identified and/or confirmed important mechanisms by which TNCs foster technological upgrading and technological capability building in local firms. Two aspects are noteworthy in this respect. First, can the measurement of TCs be optimised? Currently, it is based either on self-assessment or requires the costly assignment of experts to evaluate capabilities in surveyed firms. Therefore, a topic for future research could be the design of a ‘check-list’ that ascertains easy to answer detailed, factual information on all major activities, such as “are you implementing TQM”, “do you use Kanban”, etc. Based on this list a TC-index could be calculated that gives a detailed, accurate and objective picture of firm level TCs.

Second, the mechanisms by which TNCs foster the advancement of local firms and SI upgrading are mostly ‘anecdotal evidences’. More quantitative research would be vital to any evaluation of how relevant these mechanisms really are for late-industrialising economies and latecomer firms. Moreover, detailed case studies could move beyond existing research by enquiring deeper into the means through which local firms have developed technological capabilities. It would be worthwhile trying to measure the contribution of different learning sources for the development of technological capabilities, such as TNC-affiliates, local research-institutes, external experts, etc. It should also be kept in mind that the contribution may be TC-specific: e.g. industrial engineering may benefit from sources other than product engineering. This may even be level-specific, e.g. intermediate product engineering capabilities might require collaboration and learning partners other than advanced product engineering capabilities. These kinds of results could form a basis for thorough and efficient custom-tailored policies. The presented research can only be a first step in these respects.

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Appendix

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A1: Lall's Illustrative Matrix of Technological Capabilities

DEGREE OF COMPLEXITY	FUNCTIONAL					
	INVESTMENT		PRODUCTION			
	Preinvestment	Project Execution	Process Engineering	Product Engineering	Industrial Engineering	Linkages within Economy
BASIC SIMPLE, ROUTINE (Experience based)	Prefeasibility and feasibility studies, site selection, scheduling of investment	Civil construction, ancillary services, equipment erection, commissioning.	Debugging, balancing, quality control preventive maintenance, assimilation of process technology	Assimilation of product design, minor adaptation to market needs	Work flow, scheduling, time-motion studies. Inventory control.	Local procurement of goods and services, information exchange with suppliers
INTERMEDIATE ADAPTIVE, DUPLICATIVE (Search based)	Search for technology sources. Negotiation of contracts. Bargaining suitable terms, Info. Systems.	Equipment procurement, detailed engineering, training and recruitment of skilled personnel.	Equipment stretching, process adaptation and cost saving, licensing new technology.	Product quality improvement, licensing and assimilating new imported product technology.	Monitoring productivity, improved co-ordination	Technology transfer from local suppliers, co-ordinating design , S&T links
ADVANCED INNOVATIVE RISKY (Research based)		Basic process design. Equipment design and supply.	In-house process innovation, basic research.	In-house product innovation, basic research.		Turnkey [supply] capability, co-operative R&D, licensing own technology to others.

Source: Lall, 1992: 166

A2 : Technological Capability Framework by UNIDO

Nature of capacity building strategy and effort	Investment		Production			Technology		Marketing	
	Pre-investment	Project execution	Process engineering	Product engineering	Industrial engineering and HRD	Domestic	Foreign	Domestic	Foreign
Basic									
<i>Simple, routine: based mainly on internal effort and experience</i>	Pre-feasibility and feasibility studies, site selection, scheduling, arranging finance	Routine engineering of civil works, ancillary services, erection and commissioning	Debugging plant; routine process coordination; quality management; routine maintenance; process quality certification	Assimilation of basic product design; product quality management and certification; minor adaptations to meet market needs	Workflow scheduling; time/motion studies; innovative management and optimization; skill upgrading and training	Local procurement systems and procedures, drawing in available knowledge from institutions	Foreign sourcing; information from suppliers; industry networking; accessing public information	Market research; distribution and servicing systems; some advertising	Export market analysis; links with buyers and other export channels. Design/ packaging capability
Intermediate									
<i>Adaptive, duplicative: based on search, experimentation and inter-firm and other cooperation</i>	Search for sources of technology, equipment. Contract negotiation	Equipment procurement, detailed engineering staff recruitment and training	Capacity stretching; adapt/improve technology; use new , techniques (JIT, TQM, etc.); routinized process engineering; preventive maintenance	Product quality/ design improvement; licensing new technology; reverse engineering; continuous monitoring of global technologies	Continuous and systematic productivity analysis and benchmarking; skill audit and formalized training; supply chain/logistics management; advanced inventory control	Technology transfer to and from local suppliers/buyers; coordination in design and manufacture; links with technology and other institutions. Capacity to take collective action	Vertical technology transfer; systematic coordination of international knowledge sources; links with technology institutions overseas	Dedicated marketing department. Systematic monitoring, feedback analysis. Branding and differentiation	Systematic market building and analysis of foreign markets. Alliances and networks abroad. Brand introduction. OEM arrangements
Advanced									
<i>Innovative, risky: based on purposive effort, R&D and advanced forms of collaboration</i>	Own project outline and design capability. World class project management capabilities	Basic process engineering, equipment design and start up. Turnkey capability design methods.	Continuous process improvement; process innovation; basic research; use of new process Organizational capacity for generating, codifying, socializing knowledge	Mastery of product design methods; new product innovation; basic research. Strategic alliances. Organizational capacity for innovation and risk taking	World-class industrial engineering and supply chain capabilities, training systems, inventory management	Continuous links with R&D institutions and universities. Licensing own technology to others. Deep innovative links with other firms. Specialization in context of networks and clusters	Cooperative R&D; strategic alliances; advanced leveraging strategies for new technologies. Foreign acquisitions, direct investment	Advanced brand creation; coordination with retailers/ buyers; advanced distribution systems abroad	Brand deepening. ODM and OBM arrangements. Own marketing and design channels and affiliates

Source: UNIDO, 2002: pp. 96



THAILAND R&D/INNOVATION SURVEY – 2000



**Technical Information Access Center
and National Science and Technology Development Agency**

in association with

Federation of Thai Industries and Board of Investment

Implemented by The Brooker Group plc

The first decade of the 21st century will be characterized by major changes in the way in which we do business. And there is no doubt that R&D and other innovation activities will be the critical determinant of Thailand's future competitiveness. World-renowned business professor, Michael Porter of Harvard University, characterizes the next competitiveness challenge as being one of developing innovative capacity. He states convincingly that: "Innovation drives the rate of long-run productivity growth and hence future competitiveness."

At the macro level, little is known about the technological innovation capabilities of Thai enterprises. This makes it very hard for Thai policy makers to formulate appropriate measures and programs to raise the levels of innovation in the Thai economy, and for private firms to access the information they require to improve productivity.

Through the Thailand R&D/Innovation Survey – 2000, the National Science and Technology Development Agency will compile an information base on R&D and innovation in Thailand's manufacturing sector. The survey results will be used to intensify NSTDA's efforts to stimulate creativity and innovation in Thailand – and in the business sector in particular.

Please note that this will greatly benefit all Thai-based companies – *including yours* – through improved policies and measures to support competitiveness, R&D and other innovation activities. In addition, all firms that complete the survey will receive NSTDA's path-breaking publication on *Thailand's Science and Technology Vision 2020 free of charge* as well as copies of the final reports on the Thailand R&D/Innovation Survey – 2000.

It must be emphasized that all information outside the public domain that is obtained from this questionnaire will be treated in complete confidentiality by the National Science and Technology Development Agency.

Please return the completed questionnaire before 12nd of February to: The Brooker Group PLC, Harindhorn Building, 16th Floor, 54 North Sathorn Road, Silom, Bangrak, Bangkok 10500, Thailand, Tel: (662) 229-3111 or [(662) 267 9222 after **February 28th**]; Fax: (662) 229-3127. If you have any queries, especially on the R&D and innovation definitions in the questionnaire, please do not hesitate to contact our helpful research team, Oranee Sritongin or Mope Giwa at the number above.

Information on Company and Respondent

Name of company that is being reported upon	
Name of Respondent(s) and their position(s)	
Direct telephone line	
E-mail address	
Fax number	

A. General Information

1. Please name your company's three main product(s) or product group(s) in Thailand and indicate their approximate % contribution to your production sales in 1999:

1.		%
2.		%
3.		%

2. Year of establishment: _____

3. Please indicate your company's ownership status:

a)	Wholly locally owned company	[]
b)	More than 70% locally owned	[]
c)	More than 50% to 70% locally owned	[]
d)	50% or less locally owned company (Nationality of largest owner:)	[]
e)	Wholly foreign-owned company (Nationality of largest owner:)	[]

4. Total employment (headcount) at end of:

1997	persons	1999	persons
------	---------	------	---------

5. Please indicate your company's employment structure as of December 1999 (numbers of employees):

a)	University graduates, of which	
	1. scientists	_____
	2. engineers	_____
	3. others	_____
b)	Vocational school graduates, of which	_____
	i) technical	_____
	ii) non-technical	_____
c)	Secondary school	_____
d)	Primary school	_____
Total Employees		_____

6. Expenditure on training as percent of sales in:

1997	%	1999	%
------	---	------	---

7. Total fixed assets of your company as of December 1999:

[Fixed assets includes land, buildings and civil works, leasehold improvements, equipment and machinery (including installation costs)]

1999	Baht	Million
------	------	---------

8. Please indicate the total sales of your company for the following years:

1997	Baht	Million
1999	Baht	Million

9. What percentage of your total sales were from:

	1997	1999
Domestic Market	%	%
Export Market	%	%
Total	100 %	100 %

10. Please indicate the approximate % of your firm's sales according to the following categories:

a)	Products manufactured by your company according to design specifications provided by parent company or associate in the corporate group (" manufacturing arm of parent company ")	____%
b)	Products manufactured by your company according to design specifications provided by external buyers (" original equipment manufacturing " or OEM)	____%
c)	Products developed and designed by your company according to performance requirements of buyers (" original design manufacturing " or ODM)	____%
d)	Products developed and designed by your company and sold under your own brand (" original brand manufacturing "/OBM)	____%
e)	Others (please describe):	____%
Total		100%

11. How important are the following characteristics for the sales success of your products?

(0 – not relevant, 1 – not important, 5 – very important)

a)	Price	0	1	2	3	4	5
b)	Quality	0	1	2	3	4	5
c)	On time fulfillment	0	1	2	3	4	5
d)	Customer service	0	1	2	3	4	5
e)	Flexibility upon customer request	0	1	2	3	4	5
f)	Novelty of products	0	1	2	3	4	5
g)	Large production capacity	0	1	2	3	4	5
h)	Short delivery time	0	1	2	3	4	5
i)	Environmental acceptability	0	1	2	3	4	5
j)	Design and appearance	0	1	2	3	4	5

12. Has your company qualified for any of the following certifications or quality standards?

a)	ISO9001	[]
b)	ISO9002	[]
c)	ISO14000	[]
d)	Others (please specify)	[]
		[]

13. During the three-year period 1997 to 1999, please indicate whether or not your company carried out any of the following technological activities in Thailand:

		Yes	No
a)	Acquisition of external technology		
b)	Adaptation of external technology		
c)	Reverse engineering (studying competitors' products by breaking down product components)		
d)	Basic design (designing key features of products)		
e)	Detailed design (designing specific features of products after key features have been determined)		
f)	Testing		
g)	Quality control		
h)	Others (please specify)		

14. Have any of your former employees started up companies in Thailand in the past 3 years?

Yes []; No []

If yes, please name the companies and their main product:

Name of company:
Main product:
Name of company:
Main product:
Don't know:

B. Research & Development Activities

For this section please note the following definitions:

Research and experimental development (R&D) in industry is defined as **creative work** which is undertaken on a **systematic basis** in order to create new or improved products, processes, services or other applications. R&D is distinguishable from other activities by the presence of a substantial **element of novelty** and by the **resolution of problems** and uncertainties using **scientific** or **technological** methods.

The three classes of R&D:

Basic Research: It is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts without any particular application or use in view.

e.g publications in scientific and engineering magazines

Applied Research: It is also original investigation undertaken

in order to acquire new knowledge. It is however directed at determining possible uses for basic research findings or finding new ways of achieving some specific predetermined objectives.

Experimental Development: It is systematic work, drawing on existing knowledge gained from research and practical experience that is directed at producing new materials, products, devices, installing new processes, systems and services or at improving substantially those already produced or installed.

Source: derived from the *Frascati Manual (OECD)*

Examples of the three classes of R&D

In the Biotechnology industry

Basic Research	Applied Research	Experimental Development
Mapping of the Human Genome i.e. the blueprint of a human being	Discovery of genes for breast cancer and diabetes using the human genome	Trial stage and development of drugs for breast cancer and diabetes

In the Food and Beverage Industry

Basic Research	Applied Research	Experimental Development
Study into the properties and structures of Thai herbs and plants	Research on discovered herbs and plants as health remedies	Production of health drinks for combating minor ailments and to increase vitality

In the Telecommunications Industry

Basic Research	Applied Research	Experimental Development
Study electromagnetic wave propagation at different frequencies	Study wireless technology emphasizing on cellular technology	Develop a mobile phone prototype

What is R&D?

• Development of prototypes	• Scientific and technical information services
• Construction of pilot plants	• Routine testing and standardization
• Trial production (if it implies full-scale testing and subsequent further design and engineering)	• Patent and licence work not related to any R&D project
• Industrial design and drawing directly linked to R&D	• General purpose data collection, including market research
• Technical activities carried out on new products & processes after they have been turned over to the production unit	• Feasibility and policy-related studies
• Industrial engineering and tooling up directly linked with the development of new products or improved products or processes	• Education, training, and after-sales services

What is NOT R&D?

Please call our helpful research team on (662) 229-3111 or **[(662) 267-9222 after February 28th]** if the activities carried out in your firm is not included above or you have any queries on the definitions and examples given.

1. Did your company carry out R&D activities in Thailand in 1999?

Yes []; No [] **if No, please go to question 12**

2. If **Yes**, please describe these R&D activities:

--

3. Please estimate your R&D expenditure for the following years:

1997	Baht
1999	Baht

4. Please indicate which of the following R&D activities was carried out in 1999:

		Yes	No
a)	R&D (in-house)		
b)	Acquisition of R&D services (contracted out to other units):		
	i) other firms in Thailand		
	ii) public institutes		
	iii) universities		
	iv) abroad		
c)	Other R&D-related activities (please specify: _____)		

5. Please indicate the % distribution of your R&D expenditure on the following categories in 1999:

a)	R&D personnel cost	____%
b)	Capital expenditure (land, plant, vehicles, machinery & equipment)	____%
c)	Other operating costs (all consumables, repairs and maintenance, others)	____%
Total		100%

6. Please indicate the % distribution of your R&D expenditure on the following categories of R&D in 1999 :

a)	Basic Research	____%
b)	Applied Research	____%
c)	Experimental Development	____%
Total		100%

7. Please indicate the % distribution of your R&D expenditure on the following activities in 1999:

a)	Product-oriented R&D	____%
b)	Process-oriented R&D	____%
Total		100%

8. In 2001 and 2003, R&D expenditure is expected to:

		2001	2003
a)	increase	[]	[]
b)	remain unchanged	[]	[]
c)	decrease	[]	[]

9. Please provide the number of R&D personnel as of December 1999 and the average % of their time spent on R&D?

	R&D Personnel	No. of Staff	Average % of time on R&D
a)	PhD researchers (Scientists and engineers with a PhD qualification)	_____	_____%
b)	Non-PhD researchers (Scientists and engineers with other degree level qualifications)	_____	_____%
c)	Technicians (Technically qualified personnel)	_____	_____%
d)	Managerial, administrative & clerical staff	_____	_____%
e)	Other R&D staff (machinists and electricians, etc)	_____	_____%
g)	Total R&D Personnel	_____	_____%

10. In 2001 and 2003, R&D personnel is expected to:

		2001	2003
a)	increase	[]	[]
b)	remain unchanged	[]	[]
c)	decrease	[]	[]

11. What were the sources of funding for R&D activities in 1999?

(Tick where applicable)

a)	Own funds	[]
b)	External funds	
	1. other companies, locally based	[]
	2. other companies, foreign based	[]
	3. government	[]
	4. other funds (please specify)	[]
		[]

12. During the three-year period 1997 to 1999, please indicate the number of patents applied for and obtained by your company:

		Thailand	Other Countries	Total
a)	Number applied	_____	_____	_____
b)	Number granted	_____	_____	_____

13. During the three-year period 1997 to 1999, did your company introduce or adopt any products or processes as a result of carrying out R&D activities?

Yes []; No [] if **No**, go to question 15

14. If **Yes**, please indicate the approximate % of the total annual sales from R&D related products & processes:

a)	Less than 10%	[]
b)	10% - 24%	[]
c)	25% - 49%	[]
d)	50% - 74%	[]
e)	75% and above	[]

15. During the three-year period 1997 to 1999, please indicate the degree of importance of the following as objectives for undertaking R&D activities: (0 – not relevant, 1 – not important, 5 – very important)

a)	Replace products being phased out	0	1	2	3	4	5
b)	Improved product quality	0	1	2	3	4	5
c)	Extend product range	0	1	2	3	4	5
d)	Open up new markets	0	1	2	3	4	5
e)	Increase market share	0	1	2	3	4	5
f)	Fulfill regulations & standards	0	1	2	3	4	5
g)	Improve cycle time	0	1	2	3	4	5
h)	Improve production flexibility	0	1	2	3	4	5
i)	Reduce production cost/improve yield	0	1	2	3	4	5
j)	Reduce energy consumption	0	1	2	3	4	5
k)	Reduce environment effects	0	1	2	3	4	5
l)	Improve work conditions for employees	0	1	2	3	4	5
m)	Learn about new technology	0	1	2	3	4	5
n)	Others (Please elaborate: _____)	0	1	2	3	4	5

16. Did your company carry out R&D elsewhere in 1999?

Yes []; No []

If Yes, please state the countries(s):

17. During the three-year period 1997 to 1999, please indicate the importance of the following as factors limiting R&D within your firm: (0 – not relevant, 1 – not important, 5 – very important)

Internal factors		0	1	2	3	4	5
a)	Lack of R&D strategy at the firm level	0	1	2	3	4	5
b)	Lack of infrastructure for R&D in the firm (space, equipment, etc)	0	1	2	3	4	5
c)	In-house lack of R&D personnel	0	1	2	3	4	5
d)	Limited financial resources	0	1	2	3	4	5
e)	Lack of information on R&D opportunities	0	1	2	3	4	5
f)	Management sees no need for R&D	0	1	2	3	4	5
g)	Others (please specify: _____)	0	1	2	3	4	5
External factors		0	1	2	3	4	5
h)	Insufficient supply of R&D personnel	0	1	2	3	4	5
i)	Lack of government R&D incentives	0	1	2	3	4	5
j)	Lack of competition in the domestic market	0	1	2	3	4	5
k)	Inadequate support services	0	1	2	3	4	5
l)	Others (please specify: _____)	0	1	2	3	4	5

C. Innovation Activities other than R&D

For this section please note the following definitions:

Product innovation:

Either the development of a **new product** whose technological characteristics or intended uses differ significantly from those of previously produced products, e.g. the development of a gel fuel from agricultural refuse to be used for cooking in poor agricultural countries; or the portable electronic dictionary that translates the English language into Thai ('Talking Dic')

Or an **existing product** whose performance has been significantly enhanced or upgraded, e.g. the environmentally - friendly motorcycle developed in Thailand, or the boosting of radio reception capacity to suit residents in remote areas.

Process innovation:

Adoption of technologically new or significantly improved production methods through the introduction of new process equipment or re-engineering of operational processes, e.g. the introduction of a robot in the spray painting unit in a car factory in order to increase efficiency of the production process, or the use of CAD/CAM to help assemble bicycle components to lower process times.

Source: derived from the Oslo Manual (OECD)

Please call our helpful research team on (662) 229-3111 or [(662) 267-9222 after February 28th] if the activities carried out in your firm is not included above or you have any queries on the definitions and examples given.

1. During the three-year period 1997 to 1999, did your company carry out innovation activities other than R&D in Thailand?

Yes [] ; No [] **if No, go to question 9**

2. If **Yes**, please indicate which of the following other innovation activities was carried out in 1999:

		1999	
		Yes	No
a)	Acquisition of machinery, equipment & software linked to product & process innovation		
b)	Acquisition of external technology linked to product & process innovation e.g. patents and licences		
c)	Industrial design and engineering, market research & marketing expenses linked to product & process innovation		
d)	Training directly linked to product & process innovation		

- ◆ **If you answered Yes to any of the options in Question 2, please carry on**
- ◆ **If you answered No to all the options in Question 2, please go to Question 9**

3. Please estimate your total expenditure on innovation activities other than R&D for the following years:

1997	Baht
1999	Baht

4. During the three-year period 1997 to 1999, did your company introduce into the market any product innovation developed in Thailand?

Yes [] ; No [] **if No, go to question 6**

5. If **Yes**, please indicate the **approximate %** of total annual sales of new/improved products:

a)	Less than 10%	[]
b)	10% - 24%	[]
c)	25% - 49%	[]
d)	50% - 74%	[]
e)	75% and above	[]

6. During the three-year period 1997 to 1999, did your company adopt any process innovation developed in Thailand?

Yes [] ; No [] **if No, go to question 8**

7. If **Yes**, please indicate the **approximate %** of your production volume using new/improved processes:

a)	Less than 10%	[]
b)	10% - 24%	[]
c)	25% - 49%	[]
d)	50% - 74%	[]
e)	75% and above	[]

8. During the three-year period 1997 to 1999, please indicate the degree of importance of the following objectives for undertaking innovation activities other than R&D:

(0 - not relevant, 1 – not important, 5 – very important)

a)	Replace products being phased out	0	1	2	3	4	5
b)	Improved product quality	0	1	2	3	4	5
c)	Extend product range	0	1	2	3	4	5
d)	Open up new markets	0	1	2	3	4	5
e)	Increase market share	0	1	2	3	4	5
f)	Fulfill regulations & standards	0	1	2	3	4	5
g)	Improve cycle time	0	1	2	3	4	5
h)	Improve production flexibility	0	1	2	3	4	5
i)	Reduce production cost/improve yield	0	1	2	3	4	5
j)	Reduce energy consumption	0	1	2	3	4	5
k)	Reduce environment effects	0	1	2	3	4	5
l)	Improve work conditions for employees	0	1	2	3	4	5
m)	Learn about new technology	0	1	2	3	4	5
n)	Others (Please elaborate: _____)	0	1	2	3	4	5

9. Please indicate the importance of the following as factors limiting innovation within your firm:

(0 – not relevant, 1 – not important, 5 – very important)

Internal factors							
a)	Perceived risks too high	0	1	2	3	4	5
b)	Perceived cost too high	0	1	2	3	4	5
c)	Limited financial resources	0	1	2	3	4	5
d)	Internal resistance to innovate	0	1	2	3	4	5
e)	Lack of information on technology	0	1	2	3	4	5
f)	Lack of information on markets	0	1	2	3	4	5
g)	Others (please specify: _____)	0	1	2	3	4	5
External factors							
h)	Lack of qualified personnel	0	1	2	3	4	5
i)	Inadequate support services	0	1	2	3	4	5
j)	Lack of government support	0	1	2	3	4	5
k)	Lack of customer interests in innovation	0	1	2	3	4	5
l)	Lack of competition in the domestic market	0	1	2	3	4	5
m)	Others (please specify: _____)	0	1	2	3	4	5

D. External Collaboration for R&D and Innovation

Please complete this section **ONLY** if you carried out R&D or other innovation activities from 1997-1999.

1. During the three-year period 1997 to 1999, please indicate the degree of importance of the following sources of information to your R&D and other innovation activities?

(0 – not relevant, 1 – not important, 5 – very important)

a)	Sources within the enterprise	0	1	2	3	4	5
b)	Parent/associate companies	0	1	2	3	4	5
c)	Clients	0	1	2	3	4	5
d)	Locally-owned suppliers	0	1	2	3	4	5
e)	Foreign-owned suppliers	0	1	2	3	4	5
f)	Universities or other higher education institutes	0	1	2	3	4	5
g)	Government or private non-profit research institutes	0	1	2	3	4	5
h)	Business Service Providers (management consultants, market researchers, etc.)	0	1	2	3	4	5
i)	Technical service providers	0	1	2	3	4	5
j)	Competitors	0	1	2	3	4	5
k)	Patent disclosures	0	1	2	3	4	5
l)	Fairs and exhibitions	0	1	2	3	4	5
m)	Professional conferences & meetings	0	1	2	3	4	5
n)	Specialist literature (journals, monographs etc.)	0	1	2	3	4	5
o)	Internet	0	1	2	3	4	5
p)	Others (Please elaborate: _____)	0	1	2	3	4	5

2. How intensely do you cooperate with any of the following external parties in your R & D and other innovation activities?

(1 – not at all, 5 – very intensely)

		<i>R&D</i>					<i>Product Innovation</i>					<i>Process Innovation</i>				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
a)	Customers, buyers	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
b)	Locally-owned suppliers	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
c)	Foreign-owned suppliers	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
d)	Parent/associate company overseas	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
e)	R&D institutes/ universities	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
f)	Business Service Providers (management consultants, market research, etc.)	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
g)	Technical Service Providers (engineering consultants, IT services, etc.)	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
h)	Competitors	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
i)	Other firms	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5

3. What reasons were central to your co-operation with other partners?

(1 – not important, 5 – very important)

a)	Share / reduce risk & cost	1	2	3	4	5
b)	Entering new technology fields	1	2	3	4	5
c)	Know-how transfer	1	2	3	4	5
d)	Faster time to market	1	2	3	4	5
e)	Pooling financial resources	1	2	3	4	5
f)	Establishing long term strategic partnership	1	2	3	4	5
g)	Others (Please elaborate): _____	1	2	3	4	5

4. During the three-year period 1997 to 1999, did your enterprise receive venture capital (investment provided at the preliminary business plan stage) or business angel investment (investment provided at the developmental stage of the business idea) for your R&D and other innovation activities?

Yes []; No []

E. R&D and Innovation Environment of Thailand

1. How do you assess the current business environment in Thailand for R&D and other innovation activities?
(0 –no opinion, 1 – very weak, 5 – very good)

a)	Availability of government incentives for innovation	0	1	2	3	4	5
b)	Availability of suitable manpower	0	1	2	3	4	5
	i) in scientific-technical sector						
	ii) in business sector	0	1	2	3	4	5
c)	Technological sophistication of local suppliers	0	1	2	3	4	5
d)	Consultancy support services	0	1	2	3	4	5
e)	Local university for technical support and R&D collaboration	0	1	2	3	4	5
f)	R&D institutions for technical support and R&D collaboration	0	1	2	3	4	5
g)	Availability of other technical supporting services	0	1	2	3	4	5
h)	Acceptance of failure	0	1	2	3	4	5
i)	Attitude of people towards innovation	0	1	2	3	4	5
j)	Openness of customers to innovation	0	1	2	3	4	5
k)	Openness of suppliers to innovation	0	1	2	3	4	5
l)	Openness of government departments & regulatory authorities to innovation	0	1	2	3	4	5
m)	Regulatory environment	0	1	2	3	4	5
n)	Intellectual property protection	0	1	2	3	4	5
o)	Quality of telecommunications and IT services for enabling innovation	0	1	2	3	4	5
p)	Availability of finance for innovation (e.g. venture capital)	0	1	2	3	4	5
q)	Listing requirements on SET stock exchange	0	1	2	3	4	5
r)	Others (please elaborate): _____)	0	1	2	3	4	5

2. Does your company have knowledge of any of the following government or related support networks and research granting agencies? And have you used any of their services/incentives?

	Government Support Networks/Research Granting Agencies	Knowledge of or familiarity with?		Has your firm used their services?	
		Yes	No	Yes	No
a)	National Science and Technology Development Agency (NSTDA)				
	i) Technical Information Access Center (TIAC)				
	ii) National Center for Genetic Engineering and Biotechnology (BIOTEC)				
	iii) National Metals and Materials Technology Center (MTEC)				
	iv) National Electronics and Computer Technology Center (NECTEC)				
	v) Industrial and Techno-Business Development Department (ICS, CD, IPS, STAMP)				
b)	National Research Council of Thailand (NRCT)				
c)	Thailand Research Fund (TRF)				
d)	Department of Science Services (DSS)				
e)	Technological Transfer Center				
f)	Board of Investment (BOI)				
g)	Health Systems Research Institute (HSRI)				
h)	Ministry of Industry (MOI) and related institutes				
i)	Thai-Japan Technological Promotion Association (TPA)				
j)	Thailand Institute of Scientific and Technological Research (TISTR)				
k)	Business association or industry group (please specify name) 1. _____ 2. _____				
l)	Others (please specify) 1. _____ 2. _____				

**** N.B. Question E2 was not asked in 2002 ****

3. Please indicate which, if any, of the services and incentive programs provided by the government agencies/support networks indicated above your firm has used for supporting R&D and other innovation activities:

Government Services and Incentive Programs		Yes	No
a)	Services provided by NSTDA (MTEC, NECTEC, BIOTEC, TIAC)		
	i. industrial consultancy services		
	ii. technology transfer arrangements		
	iii. loans and grants		
	iv. support for quality systems		
	v. testing and analytical services		
	vi. information services		
	vii. human resource development support (i.e training, scholarships, research fellowships, other)		
b)	Services provided by the Ministry of Industry		
	i. industrial consultancy services		
	ii. technology transfer arrangements		
	iii. loans and grants		
	iv. support for quality systems		
	v. testing and analytical services		
	vi. information services		
	vii. human resource development support (i.e training, scholarships, research fellowships, other)		
c)	Tax deductions for training programs (150% under the Ministry of Labor and Social Welfare)		
d)	Tax deductions for R&D activities (200% under the Department of Revenue)		
e)	University laboratory services (please specify which university(ies))		
	1. _____		
	2. _____		
f)	Others (please specify)		
	1. _____		
	2. _____		

4. What do you think the government can do to promote R&D and other innovation activities in Thailand?

Thank you for your valuable input and kind cooperation.
 * * * * *

A4: List of interview partners

Hard Disk Drive		
Western Digital (Thailand) Ltd.*	Don Blake, Vice President	08.09.2003
Hitachi Global Storage Technologies (Thailand) Limited	Masamitsu Horike, Managing Director	12.09.2003
Union Technology Company Limited	Yongyuth Pongvanit, General Manager	18.09.2003
Altum Precision Co. Ltd.	Bamroong Koolawonk, General Manager	24.09.2003
	Chua Khe Wie, Assistant General Manager,	
Magnecomp (Thailand) Ltd.	C.K. Cheung, Director, Operations/ Manufacturing Engineering	26.09.2003
	Thanathip Ratsameechand, Manager, Administration & Human Resource Department	
Seagate (Thailand) Ltd.	Brent L. Bargmann, Vice President	29.09.2003
Gem City Engineering Co., Ltd.	James W. Gibson, Managing Director	30.09.2003
	Dr. Chatree Homwongs, Director of Engineering Design	
KR Precision Public Co. Ltd.	Hank Pselos, Director of Asia Marketing & Sales	30.09.2003
	Jake Vigoda, Chief Financial Officer	
NMB – Minebea Thai Ltd.	Tosei Takenaka, Member of the Board, Senior Managing Executive Officer & Regional Director Group Operations in Asia	03.10.2003
Fujitsu (Thailand) Co. Ltd.	Hiroyuki Mase, President	10.10.2003
	Koji Hiroishi, Director Logistic Department	
	Suchit Vachiranapalai, Manufacturing Department Director	
Mektec Manufacturing Corporation (Thailand) Co., Ltd.	Hideki Hosoya, Director/ General Manager	16.10.2003
Electrical and Electronics Institute	Somboon Hotrakool Director, Administration Department	17.9.2003
Thai Embedded Systems Association	Apinetr Unakul, Association Secretary	01.10.2003
Silicon Craft Technology Co. Ltd.	Naiyavudhi Wongkomet Partner	19.09.2003
Automotive		
S.K. Polymer Co., Ltd.	Katawut Paramee, Export Sales & Marketing Division Manager	09.09.2003
Hino Motors Manufacturing (Thailand) Ltd.	Pisith Pongarchavakoson, Team Leader of Import & Export Team, Production Control Department	29.09.2003
	Suthee Khamvichit, Research & Development Team, Engineering Department	
Toyota Motors Thailand Co. Ltd.	Suparat Sirisuwannangkura, Vice President, Technical Division	03.10.2003
	Kiatsin Praveenvorakul, Deputy General Manager, Corporate Planning Office	
	Charnchai Suppayakorn, General Manager, Plant Administration Department (Samrong)	
	Panat Piyathummaporn, Chief Engineer, Plant Administration Department	
Denso (Thailand) Co. Ltd.	Montree Musitmanee, Assistant General Manager, Engineering Section	07.10.2003
Autotrim International Transaction Co., Ltd.	Prontip Hananekkhun, Export Department	08.10.2003
	Kornnika Udornchainit, Marketing Coordinator	
Royal Motor Works Co. Ltd.	Phichai Tinsuntisook, President	13.10.2003

Thai-Swedish Assembly Co. Ltd. (Volvo)	Jörgen Hakansson, Managing Director	16.10.2003
Summit Auto Seats Industry Co. Ltd.	Dr. Kosol Surakomol, Operations Director	20.10.2003
	Koson Ruangwongwit, Assistant Administrative Manager	
Thai Automotive Industry Co. Ltd. (Nissan)	Sangchai Hoonterdthai, General Manager Production Engineering Department	16.10.2003
Thai Summit Autoparts Industry Co., Ltd.	Mr Somporn , Purchasing Manager	15.10.2003
	Yongsuk Suttisri, Assistant Section Manager, Project & Marketing Department	17.10.2003
	Yongchai Onkvisessphiboon, Marketing Division Manager, Marketing Sales Department	
Thailand Automotive Institute	Vallop Tiasiri, Executive Director	13.10.2003
Background interviews		
GTZ, Industrial Environmental Management Project	Bernhard Meyhöfer, Advisor	19.08.2003
Deutsch-Thailändische Handelskammer	Dr. Paul R. Strunk, Hauptgeschäftsführer	26.08.2003
Board of Investment, Unit for Industry Linkage Development	Dr. Wisan Tanthawichian, Head of BUILD	10.09.2003
Office of Industrial Economics Ministry of Industry	Dr. Somsak Tambunlertchai, Field Project Director, UNIDO Integrated Programme for Thailand-Component 6:“Tracking Manufacturing Performance: Towards an Early Warning Mechanism Geared to the Real Economy”	12.09.2003
Board of Investment	Chokedee Kaewsang Director, Investment Facilitation Division	15.09.2003
	Yutthasak Kanasavat Senior Investment Promotion Officer, Investment Strategy and Policy Division	
Japan External Trade Organization (JETRO)	Kota Nagai, Investment Adviser Business Support Center in Thailand	10.10.2003
	Satoshi Kubota, Deputy Representative Institute of Developing Economies	
The Federation of Thai Industries	Phichai Tinsuntisook, Deputy Secretary General	13.10.2003
Frozen Food		
S.Chaivaree Cold Storage Co., Ltd./ Chaivaree Marine Products Co., Ltd.	Wichien Chantayasakorn Deputy Managing Director	08.09.2003
CFT – CO-OP Foods (Thailand) Ltd.	Sawat Khaimarn, Chief Operating Officer	11.09.2003
	Somchai Rojvirasingh, Legal & Logistics Officer	
Far East Cold Storage Co. Ltd.	Dr. Seksan Kiatsupaibul, Vice President – Business Development	25.09.2003

* Interview was led by Dr. Afzulpurkar and Dr. Brimble, the interview notes are available.

A5: Interview Guide for the interviews in the automotive industry

A) Introduction

- Introduction
- Background of study
- Confidentiality statement
- Structure of the interview

B) Company's main activities

- What are your company's main activities/ products
- Is your company a single-site operation, or part of a transnational corporation?
- If yes, please state other locations of that network?
What is Bangkok's/ Thailand's role within in the corporate network?
- How is the ownership structure of your company?
- What are your main **inputs** (raw material, components)?
- **Who** are your **main suppliers**? **Where** are they located?
- **Who** you are mainly selling to? **Where** are your customers located?:
- What is your market position (share) or your most important product/ product group?
- What are your **main challenges** at the moment?

C) Technological Capabilities

PRODUCT: What is your **product** like (specifications given by the customer vs. self developed product)?

In what way do you **improve or change** your product?

Do you conduct **market research/ technology scanning** in order to improve existing products or developing new ones?

What **kind of activities** do you pursue in order to improve or change your products (technology acquisition, reverse engineering, R&D)

PROCESS: Do you conduct **maintenance** and **troubleshooting** at the production process yourself?

Do you pursue TQM; JIT etc.?

In which way do you **optimise/ improve your production processes**?

Do you pursue process-related R&D?

NEW PROJECTS: How do you plan and implement **new projects** (new plants, expansion, modernization)?

What do you do yourself, what do you outsource, contract out? (example)

HRD: What kind training do you offer your personnel?

What HRD activities do you pursue? Why do you do this?

EVALUATE your capabilities with help of the TC matrix:

Do you see the need to **improve** some of your capabilities?

D) Linkage capabilities: External Collaboration

We would like to learn more about your cooperation partners and activities in respect to innovation activities and the development of technological capabilities...

List of partners:

Do you collaborate with any of these partners in

- a) product development
- b) process technology/ organisation development
- c) Training of HR

If yes:

- Please **name** (the most important) of your co-operation partners
- What do you do in these collaborations?
- Where are your co-operation partners **located (country, in Thailand: city)**?

Is it important for you that your cooperation partners are close by?

If yes, why is it important; if no, why is it of no importance?

- Are these **long standing** co-operations? How long?
- How did the **relationship** to the partner develop over time?
- How did you **choose** your partner **initially**?

- What kind of **problems** did you experience while collaborating?

A6: Interview Guide for the interviews in the HDD industry

1. Overview of perceptions of the competitive situation and major challenges facing the HDD industry
2. Overview of firm-level technological capabilities (following the classification below)
3. Elaborate a number of stories on firm-level efforts to “upgrade”
 - a. General measures
 - b. Training activities
 - c. R&D and innovation activities
 - d. Other “interesting” stories
4. Discussion of the nature and quality of linkages within the cluster:
 - a. With suppliers
 - b. With service providers – S&T and non-S&T
 - c. Educational institutes
 - d. Government agencies
 - e. Overseas agencies/institutions
 - f. Clients
5. Conclusion of the major constraints to HDD industry development in Thailand
 - a. General
 - b. Related to the players in the cluster
6. Ideas or comments on major “projects” or “initiatives” that can be developed to address the constraints:
 - a. Focus on specific projects that can be implemented relatively quickly
Such as:
 1. *Training Program for Automation Engineers and Technicians*
 2. *Revitalize the Certificate of Competence in Storage Technology (at AIT)*
 3. *Establish a Thailand Tool and Die Institute*
 4. *Implement the IDEMA Automation Project*
 5. *Establish a Disk Storage Institute*
 6. *Develop a New Investment Incentive Package for the HDD Industry*
 - b. Specify clearly roles of key players – especially the industry and the government

A7: Letter of request for an interview in the automotive industry

Dr. Chatri Sripaipan
Vice President of NSTDA

73/1 Rama VI Road, Rajdhevee,
Bangkok 10400

Dipl. Geogr. Martin Berger

University of Kiel, Institute of Geography
Currently: visiting researcher at NSTDA
Mobil: 09 – 07 52 897
Fax: 02 – 644 – 8194
E-Mail: martinberger@web.de

Bangkok, 12.9.2003

Dear Sir,

Interview Survey on Innovation Networks in Thailand's Automotive Industry

For companies as well as our country as a whole, innovation is critical for future competitiveness. To develop new products and processes, manufacturing firms increasingly rely on collaborations with external partners, such as customers, suppliers, research institutions, technical and business service providers, or even competitors.

Despite this recognition, very little is still known about how such networks work, and how their development could be fostered.

The National Science and Technology Development Agency (NSTDA) is cooperating with Prof. Revilla Diez from the Chair of Economic Geography at the University of Kiel, Germany, on an interview survey on innovation networks within Thailand's automotive industry. Following up on our recently completed R&D/Innovation Survey 2002, the aim of this survey is to illustrate and enhance some of the findings through selected case studies. These studies will be a basis for NSTDA's future policy recommendations.

Among the questions to be answered in this survey are:

1. What are the major challenges your company is facing today?
2. Do you try to improve your products or your production process? How?
3. Do you cooperate with external partners like customers, suppliers or universities on the improvement of your products, your process technology or your human resources? If yes, what kind of activities do you pursue with your partners?
4. Are you satisfied with the number and quality of local partners?
5. What problems do your company encounter in co-operations? Is more collaboration desirable, and if so, how can government support these activities?

We are writing to request a factory visit and an interview with you, or one of your colleagues, to discuss these matters. The survey will take place in early October. The interview should take about 60 minutes and will be conducted in a semi-structured way to give you ample opportunity to express your views. Your response to the questions will be treated in the strictest confidence. You are assured that the information you provide will not be published in a form which would identify you or your business without your consent.

We hope that you will agree to participate in this survey, because it is very important that we obtain an accurate picture for Thailand's automotive industry.

In anticipation of your co-operation, our interviewer, Mr Martin Berger, shall telephone you in the next few days to arrange a time when he can visit you.

As a small acknowledgement for your cooperation, we will happily provide you with the key findings of our survey.

Yours sincerely,

Dr. Chatri Sripaipan
Vice President of NSTDA

Dipl. Geogr. Martin Berger
Research Fellow, Kiel University

A8: List of independent variables included into the CHAID analysis for embedded foreign firms (exemplary for 2002; same variables with different labels were used in 2000)

Variable	Scale	Description
BKK	Nominal	Firm located in the BKK-region ³⁹ ? (yes/no)
SEC	Nominal	Sector affiliation (2 digit)
YEAR	Metric	Year of establishment
OWNER	Ordinal	Ownership (100%, 50-99%, 30-409% foreign owned)
NATION	Nominal	Nationality of largest foreign owner
EMPLOY	Metric	Number of employees at the end of 1999/2001
TRAIN	Metric	Share of training expenditure as % of sales
ASSET	Metric	Total fixed assets in million Bhat
SALE	Metric	Total annual sales
DOMES	Metric	Percentage of domestic sales
EXPORT	Metric	Percentage of export sales
P2Q10A	Metric	% of sales to parent/ associate company overseas
P2Q10B	Metric	% of OEM sales
P2Q10C	Metric	% of ODM sales
P2Q10D	Metric	% of OBM sales
TECHAC1	Nominal	Tech. activity: Acquisition of external technology (yes/no)
TECHAC2	Nominal	Tech. activity: Adaptation of external technology (yes/no)
TECHAC3	Nominal	Tech. activity: Reverse Engineering (yes/no)
TECHAC4	Nominal	Tech. activity: Basic design (yes/no)
TECHAC5	Nominal	Tech. activity: Detailed design (yes/no)
TECHAC6	Nominal	Tech. activity: Testing (yes/no)
TECHAC7	Nominal	Tech. activity: Quality control (yes/ no)
EMPSTART	Nominal	Did former employees found a start-up
P8Q7A	Metric	% of R&D expenditure on Product-oriented R&D
P8Q7B	Metric	% of R&D expenditure on Process-orient R&D
P7Q4A	Nominal	Carried out R&D in-house?
P7Q4B	Nominal	Acquisition of R&D services contracted out to other units
P7Q4B1	Nominal	- in thailand
P7Q4B2	Nominal	- from public institutes
P7Q4B3	Nominal	- from university
P7Q4B4	Nominal	- from abroad
P8Q6A	Metric	% of R&D expenditure on experimental development
P8Q6B	Metric	% of R&D expenditure on applied research
P8Q6C	Metric	% of R&D expenditure on basic research
RDSOURA	Nominal	Own funds for R&D activities?
RDSOURB	Nominal	External funds for R&D?
RDSOURB1	Nominal	- Funds from other companies, locally based?
RDSOURB2	Nominal	- Funds from other companies, foreign based?
RDSOURB3	Nominal	- Funds from government?
RDSOURB4	Nominal	- other funds
RDOUTPUP	Ordinal	Percent of total annual sales from R&D related products/process
RDELSE	Nominal	Carry out R&D elsewhere in the world?
INNOA00	Nominal	Acquisition of machinery, equip, software linked to innovation in 2000
INNOB00	Nominal	Acquisition of external technology in 2000
INNOC00	Nominal	Industrial design and engineering linked to innovation in 2000
INNOD00	Nominal	Training linked to innovation in 2000
INNOA01	Nominal	Acquisition of machinery, equip, software linked to innovation in 2001
INNOB01	Nominal	Acquisition of external technology in 2001

³⁹ Consisting of the following provinces: Bangkok, Nonthaburi, Pathum Thani, Nakhon Pathom, Samut Sakhon, Samut Prakan, Ayutthaya, Chachoengsao, Chon Buri and Rayong

INNOC01	Nominal	Industrial design and engineering linked to innovation in 2001
INNOD01	Nominal	Training linked to innovation in 2001
PRODIN	Nominal	Introduce into the market any product innovation developed in Thailand?
PRODINP	Ordinal	% of total annual sales of new/improved products
PROCIN	Nominal	Adopt any process innovation developed in Thailand?
PROCINP	Ordinal	% of production volume using of new/improved process
COLLA1	Ordinal	Importance for R&D and innovation: Sources within the enterprise
COLLA2	Ordinal	Importance for R&D and innovation: Parent/ associate companies
COLLA3	Ordinal	Importance for R&D and innovation: Clients
COLLA4	Ordinal	Importance for R&D and innovation: Locally-owned suppliers
COLLA5	Ordinal	Importance for R&D and innovation: Foreign-owned suppliers
COLLA6	Ordinal	Importance for R&D and innovation: Universities or other higher education institutes
COLLA7	Ordinal	Importance for R&D and innovation: Government or private non-profit research institutes
COLLA8	Ordinal	Importance for R&D and innovation: Business Services Providers
COLLA9	Ordinal	Importance for R&D and innovation: Technical services providers
COLLA10	Ordinal	Importance for R&D and innovation: Competitors
COLLA11	Ordinal	Importance for R&D and innovation: Patent disclosures
COLLA12	Ordinal	Importance for R&D and innovation: Fairs and exhibitions
COLLA13	Ordinal	Importance for R&D and innovation: Professional conferences & meetings
COLLA14	Ordinal	Importance for R&D and innovation: Specialist literature
COLLA15	Ordinal	Importance for R&D and innovation: Internet
EMPLOYAP	Metric	% of university graduates of total employment
EMPLOYBP	Metric	% of vocational school graduates of total employment
EMPLOYCP	Metric	% of secondary school graduates of total employment
EMPLOYDP	Metric	% of primary school graduates of total employment
KNOWEXP0	Metric	knowledge expenditure (R&D+ Innovation exp.) as % of sales 2000
KNOWEXP1	Metric	knowledge expenditure (R&D+ Innovation exp.) as % of sales 2001
INOVATIV	Nominal	Innovative firms (process and product innovation)?
PATENT	Nominal	Patenting firms (at least one patent applied or granted)
SALEMP00	Metric	Sales per employee 2000
SALEMP01	Metric	Sales per employee 2001
INRDIVE	Nominal	Innovative firm (product, process innovation or R&D related product/process)

Erklärung

Hiermit erkläre ich, dass die Abhandlung – abgesehen von der Beratung durch den Betreuer – nach Inhalt und Form meine eigene Arbeit ist.

Sie ist weder ganz noch zum Teil einer anderen Stelle im Rahmen eines Prüfungsverfahrens vorgelegt oder veröffentlicht worden, noch ist sie zur Veröffentlichung eingereicht.

Kiel, 17. März 2005

Martin Berger

Martin Berger
Zieglergasse 18/18
A-1070 Wien
Austria

Curriculum Vitae

Born 6.12. 1974, Gehrden, Germany
Citizenship: German

Professional Experience

- | | |
|------------------|--|
| Since 4/2005 | Researcher at the Institute of Technology and Regional Policy, Joanneum Research Forschungsgesellschaft mbH, Wien, Austria |
| 10/2002 – 3/2005 | Research Fellow at the Chair of Economic Geography, Institute of Geography, Kiel University, Kiel, Germany |
| 7/2004 – 10/2004 | Visiting Researcher at the National Science and Technology Development Agency (NSTDA), Bangkok, Thailand |

Academic Education

- | | |
|------------------|---|
| 10/2002 – 3/2005 | PhD Studies in Human Geography (Economic Geography) at Kiel University, Germany (5 semesters) |
| 10/1996 – 5/2002 | Studies of Geography at the University of Hannover (10 semesters)
Degree: Diplom Geograph (Economic Geography)
Minor subjects: Economics, Urban and Regional Planning
Diploma Thesis: Methods for evaluating the damage potential of flood prone coastal areas at a meso-scale |
| 9/1998 – 7/1999 | Studies of Geography at the University of Salford, UK (2 semesters) |
| Summer term 1996 | Studies of Philosophy and History at the University of Hannover; Germany |

Internships

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| 2/2001 – 3/2001 | Department of Economics/ Regional Economics at Norddeutsche Landesbank (Nord/LB), Hannover, Germany |
| 7/2000 – 10/2000 | Department Regions and Market Dynamics, the Fraunhofer Institute for Systems and Innovation Research, Karlsruhe, Germany |

Civil Service

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| 10/1994 – 12/1995 | Centre for Environmental Protection (Umweltschutzzentrum) of the Bürgerinitiative Umweltschutz e.V., Hannover, Germany |
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