

Aus dem Institut für Ernährungswirtschaft und Verbrauchslehre  
der Christian-Albrechts-Universität zu Kiel

# **The Impact of Macroeconomic Policies and Trade on Food and Nutrition Security and Child Health: Cross-Country Analyses**

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## Summary

During the 1960s and 1970s, it has been typical for governments of developing countries to isolate domestic markets from world markets through specific mechanisms such as direct tax and subsidies or quantitative restrictions. The main aim was to protect domestic sectors that would not have been able to compete successfully in world markets from foreign competition. These policy measures were found to inhibit agricultural trade, lead to distorted farmer incentives with respect to investment in agricultural production, marketing and storage, as well as resource misallocation, and became fiscally unsustainable during the 1970s in most developing countries (FAO, 2003). As a response, many developing countries initiated policy reforms under Structural Adjustment Programs of the World Bank and the International Monetary Fund during the 1980s and 1990s, which included trade liberalization reforms. These were expected to have a favorable effect on economic growth and poverty reduction.

Although trade liberalization may not be the most powerful or direct mechanism for addressing poverty, it is one of the easiest to implement. Trade reform involving tariff reductions and the abolition of non-tariff barriers may be one of the most effective anti-poverty policies available to governments (Winters et al., 2004). However, whether trade openness promotes economic growth and improves overall social welfare remains a controversial issue. Apart from its effect on GDP per capita growth, which has been extensively studied (see Baldwin, 2003, and Rodríguez, 2007 for a survey), a case in point that deserves further attention is the impact of trade on food and nutrition security and health.

Food insecurity, malnutrition, and ill health have direct consequences for human development and, in turn, for learning, individual productivity and the overall economic development of nations (World Bank, 2006). Therefore, continued research is needed to strengthen the knowledge of the causes and consequences of these outcomes. The focus of the study is justified, as the impact of specific national-level developments and policies is still not well understood. This is remarkable in light of the fact that countries across the globe,

including many developing countries, are increasingly integrated with the world economy, making the consequences of globalization across countries an important focus. The various channels through which trade impacts on food security, nutritional status and health are explained in some detail in each part of the thesis. In the empirical analysis, we take a number of steps to ensure that the relationship between the considered determinants and the specific outcomes is of causal nature.

The thesis is divided into five main parts. The first part of the thesis gives a general introduction to the topic of the study. It briefly outlines the general concept of food and nutrition security (FNS) and how this concept evolved over the last two decades. The outlining of the FNS concept is followed by a presentation of the motivation and significance of the study, in which the current state of the world's food insecurity, undernutrition and child mortality is displayed and the knowledge gap is identified. The last two points of the General Introduction shortly state the objectives of the study and give an overview over the structure of the thesis.

The second part of the thesis assesses the impact of trade policy on child malnutrition, based on a large cross-country panel data set covering 113 developing countries for the time period 1985-2007. Globally, interest in nutrition has increased significantly and investing in nutrition is seen as a key development priority to benefit global welfare (UNICEF, 2013). Although it is generally acknowledged that "non-nutrition" factors such as macroeconomic structural developments and policies can have profound effects on nutrition security, empirical evidence on this issue is scarce. The empirical analysis is based on the widely accepted UNICEF (1990) conceptual framework for the causes of child malnutrition. The study employs two-step feasible efficient GMM (Generalized Method of Moments) estimation of the fixed-effects (FE) panel data model that is robust to unobserved heterogeneity, correlated individual effects and endogeneity, to identify key determinants of child malnutrition as well as the impact of trade openness. The results reveal that trade openness works to reduce both child stunting and underweight significantly. The results are robust to the methodology and openness indicator employed as well as to changes in the sample composition. Taking a closer look at household food security, one of the most important underlying determinants of child's nutritional status, we find that, besides

national food availability, food access as well as dietary diversity and diet-quality related aspects of food security play a role for child's nutritional status.

Noting that food security is one important determinant of malnutrition, the third part of the thesis identifies the key determinants of food security, including the agricultural and economic development, as well as the impact of trade. The study employs a system GMM approach that is robust to unobserved heterogeneity and endogeneity to a cross-section of 151 countries for the period 1980-2007. Most of the data used in this study come from FAOSTAT and the World Bank World Development Indicators. The results reveal, *inter alia*, that trade openness and economic growth exert positive and significant impacts on dietary energy consumption. The results are robust to the employment of alternative food security and openness indicators as well as to the inclusion of additional variables capturing specific agro-climatic constraints (e.g. weather-related) and regional/country characteristics and to the sample composition. Most geographical regions are found to have significantly higher food security levels compared to Sub-Saharan Africa. Additional results indicate that besides calorie consumption trade openness also improves dietary diversity and diet quality-related aspects of food security. Results further point to the importance of complementary policies and reforms through which the beneficial effects of openness may be significantly improved.

The fourth part of the thesis focuses on child health, which is an important determinant of child's nutritional status. The international development and health-community is in urgent need to find adequate mechanisms to improve child health and reduce child mortality. Reducing the under-five mortality rate by two-thirds until 2015 has also been included as one of the United Nations Millennium Development Goals (MDGs). While much is known about the positive effects of specific behaviors such as care taking and breastfeeding and direct interventions such as vaccination campaigns, much less is known about the indirect effects of specific national-level policies on child health and empirical evidence on the issue is scarce. This study assesses the impact of trade on child health, based on a cross-country panel data set covering 66 countries for the period 1960-2013. To account for the time-series properties of the data and potential cross-country heterogeneity in the impact of trade, the study employs heterogeneous panel cointegration techniques that are robust to omitted variables and endogeneity, to identify the long-run cointegrating relationship

between trade and child health. The results reveal that trade and child health are cointegrated and that trade works to reduce the under-five mortality rate significantly in the long-run. The results are robust to the methodology and openness indicator employed as well as to the presence of cross-sectional dependence and changes in the sample composition. Additional analyses suggest that the trade-child health relationship tends to be stronger in countries with a favorable policy and institutional environment.

The fifth part of the thesis gives a general conclusion and summarizes the main findings and policy implications of the study.

## **Zusammenfassung**

In den 1960er und 70er Jahren war es typisch für die Regierungen vieler Entwicklungsländer ihre heimischen Märkten von den Weltmärkten durch Handelsbeschränkungen und spezifische Steuern abzuschotten. Das übergeordnete Ziel war es, heimische Produzenten, die nicht in der Lage gewesen wären auf den Weltmärkten zu konkurrieren, vor ausländischen Konkurrenten zu schützen. Diese Maßnahmen hemmten jedoch den Agrarhandel, führten zu verzerrten Anreizen auf Seiten der Agrarproduzenten und zu einer Fehlallokation der Ressourcen, und wurden steuerlich untragbar in vielen Entwicklungsländern Ende der 1970er Jahre (FAO, 2003). In Folge dessen wurden während der 1980er und 1990er Jahre auf der Basis von Strukturanpassungsprogrammen der Weltbank und des Internationalen Währungsfonds politische Reformen initiiert, darunter Handelsliberalisierungsmaßnahmen. Als Begründung für die Liberalisierung des Handels wurden erwartete günstige Wirkungen auf das Wirtschaftswachstum, insbesondere durch induzierte Effizienzgewinne bei der Allokation von Ressourcen, angeführt.

Obwohl die Liberalisierung des Handels vielleicht nicht der stärkste oder direkteste Mechanismus für die Bekämpfung der Armut ist, stellen Handelsreformen für Regierungen eine sehr einfach und schnell zu implementierende Maßnahme dar. Handelsreformen unter der Einbeziehung von Zolllenkungen und der Abschaffung nicht-tarifärer Handelshemmnisse könnten so eine der wirksamsten Maßnahmen zur Armutsbekämpfung für Regierungen darstellen (Winters et al., 2004). Ob die Öffnung des Handels das Wirtschaftswachstum fördert und die allgemeine soziale Wohlfahrt verbessert, bleibt jedoch ein kontrovers diskutiertes Thema. Neben den Effekten des Handels auf das Wirtschaftswachstum, welches bereits der Fokus zahlreicher empirischer Studien war (siehe Baldwin, 2003, und Rodríguez, 2007, für einen Überblick), wurde der Einfluss des Handels auf die Ernährungssicherung und die Gesundheit bisher kaum untersucht.

Ernährungsunsicherheit, Fehl – und Unterernährung sowie mangelnde Gesundheit haben direkte Folgen für die menschliche Entwicklung und dadurch wiederum auf die Lernfähigkeit, individuelle Produktivität und schlussendlich die gesamte wirtschaftliche Entwicklung ganzer

Nationen (World Bank, 2006). Daher ist weitere Forschung notwendig, um die Kenntnisse über die Ursachen und Folgen dieser wichtigen Ergebnisvariablen zu verbessern. Der Fokus dieser Studie ist auch dadurch gerechtfertigt, dass der Einfluss spezifischer Entwicklungen und Politiken auf nationaler Ebene immer noch nicht ausreichend verstanden wird. Dies ist bemerkenswert angesichts der Tatsache, dass ein Großteil der Länder weltweit, darunter viele Entwicklungsländer, zunehmend in die Weltwirtschaft integriert ist, was die Auswirkungen der Globalisierung zu einem wichtigen Betrachtungspunkt macht. Die vielfältigen Übertragungswege über welche sich die Globalisierung und der internationale Handel auf die Ernährungssicherheit, die Fehl – und Unterernährung sowie die Gesundheit auswirken, werden in den einzelnen Kapiteln der Studie näher erläutert. Im Rahmen der empirischen Analyse werden einige Schritte unternommen, um sicherzustellen, dass die Beziehung zwischen den untersuchten Faktoren und der spezifischen Ergebnisse kausaler Natur ist.

Die Arbeit ist in fünf Hauptteile unterteilt. Der erste Teil gibt eine generelle Einleitung zum thematischen Schwerpunkt der Studie. Zuerst wird das Konzept der Ernährungssicherheit und Unterernährung dargestellt und wie sich dieses Konzept über die letzten zwei Jahrzehnte weiterentwickelt hat. Dieser Darstellung folgt eine Erläuterung der Motivation und Bedeutsamkeit der Arbeit, in welcher auch auf den aktuellen Stand der weltweiten Ernährungsunsicherheit und Unterernährung sowie der Kindermortalität eingegangen und die Wissenslücke diesbezüglich identifiziert wird. Die letzten beiden Unterpunkte des ersten Kapitels präsentieren kurz die Ziele der Studie und geben zudem einen Überblick über den Aufbau der Arbeit.

Der zweite Teil untersucht den Einfluss von Handelspolitiken auf die Kinderunterernährung, auf Basis eines großen länderübergreifenden Paneldatensatzes für 113 Entwicklungsländer über den Zeitraum 1985-2007. Weltweit hat das Interesse an der Ernährung deutlich zugenommen und Investitionen in eine gute Ernährung werden als wichtiger Schwerpunkt zur Förderung der globalen Wohlfahrt angesehen (UNICEF, 2013). Obwohl es allgemein anerkannt wird, dass nicht direkt mit der Ernährung zusammenhängende Faktoren, beispielsweise makroökonomische Entwicklungen und nationale Politiken tiefgreifende Auswirkungen auf die Ernährungssicherheit der Bevölkerung haben können, sind empirische



Studien zu diesem Thema rar. Die empirische Analyse basiert auf dem weithin akzeptierten UNICEF (1990) – Modell zur Untersuchung der Ursachen der Unterernährung von Kindern. Die Studie verwendet einen zweistufigen effizienten Schätzer unter Einbeziehung fixer Effekte, basierend auf der verallgemeinerten Momentenmethode (Generalized Method of Moments - GMM), welcher für unbeobachtbare Heterogenität, korrelierte individuelle Effekte und potentielle Endogenität kontrolliert, um die Determinanten der Kinderunterernährung und den Einfluss des Handels zu identifizieren. Die empirischen Ergebnisse zeigen, dass die Handelsoffenheit insgesamt zu einer Verringerung der Unterernährung beigetragen hat. Die Ergebnisse sind robust in Bezug auf die Verwendung alternativer Methoden und Indikatoren sowie in Bezug auf Variationen des Ländersamples. Eine genauere Untersuchung der Ernährungssicherheit, eines der wichtigsten Determinanten der Kinderunterernährung, ergab, dass neben der Verfügbarkeit von Nahrungsmitteln vor allem der Zugang zu Nahrungsmitteln sowie die Qualität und Diversität der Nahrung eine wichtige Rolle für den Ernährungszustand von Kindern spielen.

In Anbetracht des Ergebnisses, dass die Ernährungssicherheit eine wichtige Determinante der Unterernährung darstellt, betrachtet der dritte Teil der Studie diesen Aspekt genauer und untersucht die Einflussfaktoren auf die nationale Ernährungssicherheit, unter anderem die landwirtschaftliche und generelle ökonomische Entwicklung eines Landes, sowie den Einfluss des Handels. Zu diesem Zweck verwendet die Studie einen Systemschätzer auf Basis der generalisierten Momentenmethode, der für unbeobachtete Heterogenität und potenzielle Endogenität kontrolliert, und wendet diesen auf ein repräsentatives Sample von 151 Ländern und die Periode 1980-2007 an. Der Großteil der Daten stammt aus der statistischen Datenbasis der Food and Agriculture Organization (FAOSTAT) und den World Development Indicators (WDI) der Weltbank. Die Ergebnisse zeigen unter anderem, dass sich die Handelsoffenheit und das Wirtschaftswachstum signifikant positiv auf die Ernährungssicherheit auswirken. Die Ergebnisse sind robust gegenüber der Verwendung alternativer Indikatoren, der Einbeziehung zusätzlicher Variablen zur Messung spezifischer Ländercharakteristika sowie der Zusammensetzung des Ländersamples. Die Ergebnisse zeigen zudem, dass die meisten Regionen eine höhere Ernährungssicherheit im Vergleich zu den Ländern Sub-Sahara Afrikas aufweisen. Zusätzliche Ergebnisse zeigen darüber hinaus, dass der internationale Handel auch zu einer höheren Diversität der Nahrung und einer

besseren Qualität der verfügbaren Nahrung beiträgt. Weiterhin sprechen die Ergebnisse für die Wichtigkeit komplementärer Politiken, durch welche die positiven Effekte der zunehmenden Handelsoffenheit verstärkt werden können.

Der vierte Teil dieser Arbeit betrachtet den Gesundheitszustand von Kindern, welcher wiederum ein wichtiger Einflussfaktor für den Ernährungszustand ist. Die internationale Gemeinschaft ist auf der dringenden Suche nach adäquaten Mechanismen zur Verbesserung der Gesundheit von Kindern und zur Reduktion der Kindermortalität. Eine Reduktion der Sterblichkeitsrate von Kindern unter fünf Jahren um Zweidrittel bis 2015 wurde zudem als eines der Millenniumsentwicklungsziele der Vereinten Nationen festgelegt. Während bereits einige Erkenntnisse über die positiven Effekte spezieller Verhaltensweisen in Bezug auf die Fürsorge und das Stillen sowie direkter Maßnahmen wie beispielsweise Impfkampagnen gewonnen werden konnten, ist wenig bekannt über die indirekten Effekte spezifischer nationaler Politiken auf die Gesundheit und empirische Befunde sind rar. Diese Studie untersucht, auf Basis eines länderübergreifenden Paneldatensatzes für 66 Länder über die Periode 1960-2013, die Auswirkungen des internationalen Handels auf den Gesundheitszustand von Kindern. Die verwendete Methodik berücksichtigt dabei die Zeitreiheneigenschaften der Daten und potenzielle Heterogenität hinsichtlich des Einflusses des Handels und verwendet heterogene Panelkointegrationsmethoden, die robust sind gegenüber ausgelassenen Variablen und Endogenität, um den langfristigen Effekt des Handels auf die Gesundheit zu identifizieren. Die Ergebnisse zeigen, dass die Handelsoffenheit und der Gesundheitszustand kointegriert sind und sich der länderübergreifende Handel mit Gütern und Dienstleistungen langfristig positiv auf den Gesundheitszustand von Kindern, gemessen anhand von Reduktionen der Mortalitätsrate, auswirkt. Die gefundenen Ergebnisse sind dabei robust sowohl hinsichtlich der verwendeten Methodik und der Verwendung alternativer Indikatoren als auch in Hinblick auf das Vorhandensein länderübergreifender Abhängigkeiten und Veränderungen des Ländersamples. Weitere Ergebnisse zeigen, dass die positive Assoziation zwischen dem Handel und der Gesundheit stärker in denjenigen Ländern ist, in denen vorteilhafte politische und institutionelle Rahmenbedingungen vorliegen.

Der fünfte Teil der Arbeit präsentiert eine Zusammenfassung der wichtigsten Ergebnisse und Politikimplikationen der Studie.

## I. GENERAL INTRODUCTION

The first chapter provides a general introduction to the thesis and describes the motivation and significance of the study, the concept of food and nutrition security, the main objectives, and presents a short outline of the thesis.

### (a) The concept of Food and Nutrition Security (FNS)

Before we present the motivation and significance of the study, we shortly outline the concepts of food and nutrition security (FNS) and document the problems associated with its measurement. The concept of FNS has undergone continuous changes during the last decades, moving from a food supply-focused concept to a multidimensional approach that tries to capture different aspects of FNS (see Pieters et al., 2012). At the same time, the evolution of a diverse set of indicators that capture different dimensions of FNS has taken place.

The first general definition of food security was elaborated during the World Food Conference of 1974 at a time of sharply rising world food prices, explaining its focus on an adequate and stable food supply:

*'Availability at all times of adequate world food supplies of basic foodstuffs [...] to sustain a steady expansion of food consumption. [...] and to offset fluctuations in production and prices' (United Nations, 1975)*

Taking into account the findings of an influential study by Sen (1981), which pointed to the importance of individual's and household's access to food, and recognizing the importance of the nutrition aspect of food security, this definition was reformulated at the World Food Summit in 1996:

*'Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life' (FAO, 1998)*

This definition is the most widely accepted definition of food security today (Pieters et al., 2012). This definition captures three key dimensions of food security – availability, access and stability – while already pointing to nutritional aspect of food security. During the last decade, more emphasis was put on the aspect of food utilization that reflects the ability to use food efficiently, leading to the embodiment of nutritional security in the concept of food security:

*‘Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. The four pillars of food security are availability, access, utilization and stability. The nutritional dimension is integral to the concept of food security’ (FAO, 2009)*

This comprehensive definition of food security reflects the view that the improved availability, stability and access to food at aggregate levels has to lead to improved energy and nutrient intake at individual levels, if the aim is to improve food and nutrition security.

From a conceptual perspective, the UNICEF (1990) conceptual framework for the causes of child malnutrition laid the foundations for later frameworks on food security, nutrition security and food and nutrition security (see Pieters et al., 2013). This framework emphasizes that there are both food and non-food determinants of nutrition, as well as different steps in the causal chain of the nutrition security determinants. The UNICEF conceptual framework reveals that nutrition security is inter-disciplinary in nature as it combines the aspects of food security, care and health.

Presumably due to the inter-disciplinary nature of FNS, making it an interesting topic for researchers from different fields, there is currently no consensus about the use of the combined term ‘food and nutrition security’, and food security, nutrition security, food security and nutrition, and food and nutrition security are used side by side (Committee on World Food Security (CFS), 2012). In this study, we follow the FAO and distinguish between food security and nutrition security in the way that “Nutrition security differs from food security in that it also considers the aspects of adequate caring practices, health and hygiene

in addition to dietary adequacy” (FAO, 2013). This differentiation recognizes the traditional emphasis on the food availability, access and stability dimensions of food security, and at the same time acknowledges the nutrition-relevant aspects of adequate care and feeding practices, health and hygiene (see CFS, 2012).

The multidimensional nature of food and nutrition security makes it difficult to find suitable indicators for its measurement, which led the FAO (2013) to conclude that one has to accept the inability of any one indicator to fully capture the complexity and multidimensionality of food security and improvements in one dimension may mask deteriorations in other. Moreover, the 2014 Global Nutrition Report complains about substantial data gaps in the areas of FNS, which makes changes in food security and nutrition very difficult to monitor.

The measurement of food security has mainly focused on availability of and access to food at the global, regional and national level. Commonly used food security indicators include dietary energy supply, average dietary energy supply adequacy, which have been used as proxies for food availability and national food security and are, according to the FAO (2013), one of the core indicators of food security closely linked to food consumption. Available indicators to measure the access dimension of food security include the prevalence of undernourishment and the prevalence of food inadequacy (see FAO, 2013).

Nutrition security is commonly measured by a variety of anthropometric measures such as the prevalence of stunting and underweight, which are based on height and weight distributions. These are considered informative indicators of nutritional status and have the advantage that they directly measure the point of policy interest as they reflect undernutrition (Strauss & Thomas, 1998; de Haen et al. 2011). The specific food security and nutrition security indicators employed in the present study are explained in more detail in the respective chapters.

#### (b) Motivation and significance of the study

During the 1960s and 1970s, it has been typical for governments of developing countries to isolate domestic markets from world markets through specific mechanisms such as direct tax and subsidies or quantitative restrictions. The main aim was to protect domestic sectors that

would not have been able to compete successfully in world markets from foreign competition. These policy measures were found to inhibit agricultural trade, lead to distorted farmer incentives with respect to investment in agricultural production, marketing and storage, as well as resource misallocation, and became fiscally unsustainable during the 1970s in most developing countries (FAO, 2003). As a response, many developing countries initiated policy reforms under Structural Adjustment Programs of the World Bank and the International Monetary Fund during the 1980s and 1990s, which included trade liberalization reforms. These were expected to have a favorable effect on economic growth and poverty reduction.

Although trade liberalization may not be the most powerful or direct mechanism for addressing poverty, it is one of the easiest to implement. Trade reform involving tariff reductions and the abolition of non-tariff barriers may be one of the most effective anti-poverty policies available to governments (Winters et al., 2004). However, whether trade openness promotes economic growth and improves overall social welfare remains a controversial issue. Apart from its effect on GDP per capita growth, which has been extensively studied (see Baldwin, 2003, and Rodríguez, 2007 for a survey), a case in point that deserves further attention is the impact of trade on food and nutrition security and health.

A considerable body of empirical research has focused on the impact of globalization and trade liberalization on certain dimensions of economic development, for example economic growth and poverty, however, with so far inconclusive results.<sup>1</sup> Recognizing that poverty is a very broad indicator of the well-being of a country's population and thinking more in terms of basic needs, the issue of food insecurity has attracted a large and growing volume of literature over the past decade and there has been continuous controversy over the impact of trade reforms on food security (Traub & Jayne, 2008). There is, however, still surprisingly little empirical evidence on this issue. More generally, food security- in terms of research- receives less attention than poverty and only very few studies explicitly explore the impact of trade liberalization on food security (Guha-Khasnobis, Acharya & Davis, 2007). Indeed,

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<sup>1</sup> For a survey of the openness-growth nexus, see Baldwin, 2003, and Rodríguez, 2007, and for a review of the evidence regarding trade liberalization impacts on poverty, see Winters et al., 2004.

also in terms of policy, it has been recognized that only few countries have well-developed food and nutrition policies. Although being aware that direct nutrition-specific interventions will impact on nutrition, governments are often unaware of the nutrition impact of national-level policies in other sectors, for example trade and agriculture, and these become unintentional but *de facto* food and nutrition policies (World Bank, 2006).

Globally, interest in nutrition has increased significantly and investing in nutrition is seen as a key development priority to benefit global welfare (UNICEF, 2013). Despite significant progress in world agriculture and economic development during the last decades, food insecurity and undernutrition persist in many countries, especially developing ones. Globally, one quarter of under-five children or an estimated 162 million preschool children are stunted in 2012, meaning their height given their age is below minus two standard deviations from median height for age of the reference population. Moreover, around fifteen per cent or an estimated 101 million children under-five years of age are estimated to be underweight, meaning their “weight-for-age” is below minus two standard deviations from the median weight for age of the reference population (UNICEF, 2013). Black et al. (2013) estimate that undernutrition was the underlying cause of 45 per cent of all deaths among children under-five years of age, around 3.1 million children worldwide in 2011. There has been some progress in reducing child undernutrition globally. According to UNICEF (2013), the global prevalence of stunting has declined by about 36 per cent over the last two decades, while the underweight prevalence has declined by approximately 37 per cent, however, still remaining at unacceptably high levels. In line with this, the World Bank (2012) concludes that a great part of developing countries is far away from achieving the MDGs closely linked to food and nutrition security.

Noting the importance of improving food and nutrition security, the goals of achieving reductions in hunger and undernutrition have explicitly been included in the MDGs. The eight MDGs were established in September 2000, following the Millennium Summit of the United Nations and the resulting United Nations Millennium Declaration. The international community committed to help achieve the MDGs by 2015, which have since then been used to track progress in various areas of development. The MDGs closely linked to food and nutrition security are MDG 1 “Eradicate extreme poverty and hunger” and MDG 4 “Reduce



child mortality". The overall progress towards the MDGs that has been made since 1990 has been the subject of the Millennium Development Goals Report 2015 of the United Nations.<sup>2</sup>

As regards the goal of eradicating hunger, the report reveals that the proportion of undernourished people in the developing regions has fallen from 23.3 per cent in the 1990–1992 period to 12.9 per cent in 2015, which is very close to the MDG hunger target of halving the proportion of people who suffer from hunger during this period. Today, about 795 million people globally are still undernourished, the vast majority of them (780 million people) living in the developing regions (UN, 2015). The prevalence of underweight children under age 5, which is a second indicator to measure progress towards MDG 1, has also shown significant reductions, going down from one in four children in 1990 to one in seven children, corresponding to over 90 million children, worldwide in 2015. Noting that according to UNICEF (2013), nearly half of all deaths in children under five are attributable to undernutrition, the great achievements with respect to MDG 4 are not surprising. Accordingly, the global under-five mortality rate dropped from 90 to 43 deaths per 1,000 live births between 1990 and 2015, corresponding to a drop of under-five deaths from 12.7 million per year in 1990 to 5.9 million in 2015 (UN, 2015).

Despite these significant improvements, progress has been uneven across regions and countries and about 800 million people still suffer from hunger and over 160 million children under the age of 5 are underweight, meaning they have inadequate height for their age due to insufficient food. While the Caucasus and Central Asia, Eastern Asia, Latin America and South-Eastern Asia have reached the hunger target, the pace of reduction in the Caribbean, Oceania, Southern Asia and Sub-Saharan Africa has been too slow to achieve the MDG 1 hunger target. As regards underweight, while Eastern Asia and Latin America and the Caribbean have clearly met the target, Southern Asia and Sub-Saharan Africa still account for nearly 90 per cent of all underweight children in 2015, despite significant reductions in the underweight prevalence in particular in Southern Asia (UN, 2015).

As the era of the MDGs is going to expire at the end of 2015, the Sustainable Development Goals (SDGs) are to replace them. These have been elaborated by the UN General

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<sup>2</sup> The report is available online at <http://www.undp.org/content/undp/en/home/librarypage.html>.

Assembly's Open Working Group on Sustainable Development Goals (OWG), which was established following the 2012 United Nations Conference on Sustainable Development, commonly known as Rio+20. Within the new SDGs, achieving the internationally agreed targets on stunting in children under 5 years of age is included as part of Goal 2 to “End hunger, achieve food security and improved nutrition, and promote sustainable agriculture”, confirming the previous focus on food and nutrition security (see OWG, 2015).

Further improvements and food and nutrition security in the coming decades are important, as food insecurity and malnutrition<sup>3</sup> have direct consequences for health and human development and, in turn, for learning, individual productivity and the overall economic development of nations (World Bank, 2006; Strauss & Thomas, 1998). The World Bank (2006) Report *‘Repositioning Nutrition as Central to Development: A Strategy for Large-Scale Action’* points out that macroeconomic policies can have significant impacts on child undernutrition and that there is a need for more studies on this important topic. Also the UNICEF (2013) report on *‘Improving child nutrition: The achievable imperative for global progress’* concludes that continued research is needed to strengthen the knowledge of the causes and consequences of child malnutrition. Early childhood undernutrition causes irreversible damage and has significant long-term consequences. Early childhood growth failure leads to a greater propensity for developing chronic diseases, has adverse effects for school attendance and performance as well as for cognitive capacity and future earnings (Deaton & Arora, 2009; Hoddinott et al., 2011). Because of these interrelationships, it has become apparent that reductions in undernutrition in pre-school children provide substantive economic benefits. Besides that, good nutrition is a fundamental driver of a wide range of developmental goals and a failure to eliminate hunger will undermine efforts to reach the other MDGs, for example those related to education, child mortality, maternal health, and disease (Guha-Khasnobis et al., 2007; Behrman et al., 2004; World Bank, 2013). As a response, numerous international initiatives have now placed high priority on food and

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<sup>3</sup> The terms “undernutrition” and “malnutrition” have been used interchangeably in the earlier development literature, although the latter generally also includes problems of over-nutrition and obesity, which have received some attention during the last decade (see e.g. Popkin, 2001, and Hawkes, 2006). We do not focus on over-nutrition and obesity, therefore the term malnutrition only refers to the problem of undernutrition throughout the study. This is consistent with the terminology of international organizations, for example the World Bank, which refer to the “malnutrition” prevalence, although, strictly speaking, it should be termed “undernutrition” prevalence (see e.g. the terminology used within the World Development Indicators database).

nutrition security issues, for example the UN-led Scaling Up Nutrition (SUN) and the USAID's Feed the Future initiative. Also in case of research, the recent landmark series of papers on *maternal and child undernutrition* published in the Lancet (2013) reveals that food and nutrition security are back on top of the international research agenda. The Lancet (2013, p. 12) concludes that the "national and international momentum to address human nutrition and related food security and health needs has never been higher".

The importance of trade policies for food and nutrition security was recognized by the World Food Summit in 1996, speaking in favor of a fair and market oriented world trade system. At the global level, international trade can link production and consumption of food and may thus play an important role in securing enhanced food security, as it permits global production to take place in those regions most suited to it and enables food to flow from countries with abundant food supplies to ones with insufficient supplies (Runge et al., 2003). A country's openness to trade may then lead to an increase in the total amount of goods (including food) available to the national population and make available a greater variety of goods, which affects the food choices available to consumers and may contribute to better nutrition. However, trade liberalization may also involve short-term adjustment costs, for example, unemployment costs in import-competing sectors, in turn worsening access to food and nutritional status (see FAO, 2003). Moreover, there are additional transmission channels through which trade policies impact on nutritional status, which will be described in more detail throughout the thesis. Therefore, whether trade openness ultimately improves food and nutrition security is theoretically ambiguous, which strongly calls for empirical analysis to assess whether the net effects are positive or negative. There is, however, still surprisingly little empirical evidence on this issue, especially in light of the increased demand for answers to the question on how child malnutrition can be reduced.

Therefore, continued research is needed to strengthen the knowledge of the causes and consequences of these outcomes. The focus of the study is justified, as the impact of specific national-level developments and policies is still not well understood. This is remarkable in light of the fact that countries across the globe, including many developing countries, are increasingly integrated with the world economy, making the consequences of globalization across countries an important focus. Although it is generally acknowledged that "non-

nutrition” factors such as macroeconomic structural developments and policies can have profound effects on nutrition security, empirical evidence on this issue is scarce.

Besides food security and nutrition, another topic that requires attention is the identification of measures leading to long-term improvements in health. The international development and health-community is in urgent need to find adequate mechanisms to improve child health and reduce child mortality. Reducing the under-five mortality rate by two-thirds until 2015 has also been included as one of the United Nations Millennium Development Goals (MDGs). While much is known about the positive effects of specific behaviors such as care taking and breastfeeding and direct interventions such as vaccination campaigns, much less is known about the indirect effects of specific national-level policies on child health and empirical evidence on the issue is scarce.

Globally, substantial progress has been made in improving child health during the last decades, with large but uneven reductions in child mortality in different regions. The global under-five mortality rate has dropped by 49 percent between 1990 and 2013—from 90 deaths per 1,000 live births in 1990 to 46 deaths per 1,000 live births in 2013. This corresponds to an absolute reduction in the number of under-five deaths worldwide from 12.7 million in 1990 to 6.3 million in 2013 (UNICEF et al., 2014). Despite these significant improvements in child health during the last decades, high child mortality rates persist in many countries, particularly in Sub-Saharan Africa, Central and Southern Asia. According to UNICEF, progress has been insufficient to meet the MDG 4 target at the global level and still about 17,000 children under the age of five die every day in 2013. High prevalence of disease and resulting early childhood undernutrition causes irreversible damage and has significant long-term consequences because of its adverse effects for school attendance and performance as well as for cognitive capacity and future earnings (Deaton & Arora, 2009; Currie, 2009; Hoddinott et al., 2011). Because of these interrelationships, it has become apparent that improvements in child health in pre-school children provide substantive economic benefits. As a response, numerous international organizations and initiatives have now placed high priority on improving child health, for example the United Nations Children’s Fund (UNICEF), the World Health Organization (WHO) and other UN organizations

who are joining public, private and civil society partners to accelerate progress in improving child health (UNICEF et al., 2014).

Several direct causes of child deaths have been identified in the past. For example, Black et al. (2013) estimated that undernutrition was the underlying cause of 45 per cent of all deaths among children under-five years of age, around 3.1 million children worldwide in 2011. Therefore, much of the reduction in child mortality can be attributed to the progress that has occurred in reducing child undernutrition globally during the last decades. According to UNICEF (2013), the global prevalence of stunting has declined by about 36 per cent over the last two decades, while the underweight prevalence has declined by approximately 37 per cent. The leading direct causes of death among children under age five further include preterm birth complications, pneumonia, intrapartum-related complications, diarrhea and malaria. Accordingly, direct health-specific interventions such as immunization, insecticide-treated mosquito nets, rehydration treatment for diarrhea, and nutrition supplements can be used to tackle these preventable direct causes of ill health (UNICEF et al., 2014). These direct measures tend to be the focus of health professionals, such that the health sector has traditionally avoided to focus on trade-health issues and to get involved in trade debates (MacDonald & Horton, 2009).

However, as countries are increasingly integrated with the world, health is also affected increasingly by factors beyond the health system, including trade (see Smith, Lee, & Drager, 2009). As a response to this, a recent *Lancet* (2009) series on trade and health provided an overview on this topic and aimed for strengthening the evidence of trade and health links (see MacDonald & Horton (2009) for an introductory comment on the series). According to UNICEF et al. (2014), a great part of child's deaths occurs due to preventable causes and treatable diseases, even though the knowledge, technologies, and medicines are available elsewhere. In case a more open trade regime leads to improvements in the availability and accessibility of these factors, international trade should lead to long-run improvements in child health. On the other hand, health may deteriorate if economic integration facilitates the transfer of infectious disease or unhealthy consumer goods and practices across borders (see Owen & Wu, 2007). In addition, there may be several other channels through which trade affects child health, which will be described in more detail throughout the thesis.

Therefore, whether trade openness ultimately improves child health is theoretically ambiguous, which strongly calls for empirical analysis to assess whether the net effects are positive or negative. Despite recent calls of the international health community aimed at strengthening the evidence on the trade-health nexus, there is still surprisingly little empirical evidence on this issue.

### (c) Objectives of the study

The main aim of the thesis is to throw more light on the impact of macroeconomic policies and trade and other macro-level drivers on food and nutrition security and child health. The study is intended to contribute to the existing literature on the linkages between globalization, trade openness and economic growth and between trade and poverty, but which does not explicitly explore the implications for food and nutrition security, and previous cross-country studies that examined cross-country variation in malnutrition rates (of children), however, without considering policy effects.

The second chapter identifies the key determinants of child's nutritional status for a large sample of countries and gains insight into the impact of trade on malnutrition, measured as underweight and stunting rates. The empirical analysis is based on the widely accepted UNICEF (1990) conceptual framework for the causes of child's malnutrition. This framework emphasizes that there are both food and non-food determinants of nutrition, as well as different steps in the causal chain of the nutrition security determinants. Our main focus is on the basic or root causes of child malnutrition (as opposed to the immediate and underlying causes which have been the focus of most previous studies in the area), as reflected by the prevalence of underweight and stunting. While past studies predominantly focused solely on child underweight, the focus on stunting is justified, as an international consensus is emerging favoring stunting among underfives over underweight as the indicator of choice to monitor child's nutritional status. We extend previous work on the determinants of child malnutrition in various directions. We consider trade policy effects and the impact of the domestic macroeconomic policy environment, both potentially affecting people's incentives and the allocation and utilization of resources in the economy. Besides that, we employ GMM estimation techniques, allowing us to control for the potential endogeneity of some of the determinants of nutritional status as well as accounting for unobserved

heterogeneity. Furthermore, we show that, besides national availability of food, other aspects of food security, for example food access as well as dietary diversity and diet-quality related aspects of food security, which have largely been neglected in previous studies, play a role in child's nutritional status.

The third chapter takes a broader perspective and focuses on the overall level of food security of the population as indicated by average dietary energy consumption, which is also one of the main determinants of child's nutritional status (Smith & Haddad, 2000, 2001). One immediate advantage over child malnutrition studies is the greater availability of national food security data, which is not limited by the availability of household survey data and leads to a significantly greater sample size and the possibility to employ more advanced econometric methods dealing with the potential complexity of the dynamic relationships. These circumstances enable a more convincing assessment of the key determinants of food security and of whether food security is responsive to trade policy. Our objective is to identify the key determinants of food security at the national level for a large sample of countries and gain insight into the issue of whether or not trade openness generally promotes food security, based on (dynamic) cross-country regression. This study extends previous research of trade openness impacts and the determinants of food security in various directions. Importantly, we adopt a dynamic modeling approach, which allows us to control for potential endogeneity arising from simultaneity or reverse causality between variables, which is difficult to control for in a static pooled regression model. For these reasons and because most economic processes are dynamic the majority of cross-country empirical analyses have moved away from static models to dynamic regression techniques (Headey, 2013), which may be especially important in the analysis of policy reforms, which have long-term effects that persist into the future. Our objective is to provide a systematic quantitative assessment of the impact of these important macroeconomic structural factors and policies on overall food security levels and to assess the combined effects of various factors on the food economy and the overall state of food security while putting special emphasis on the impact of trade openness.

The fourth chapter of the thesis aims to contribute to the empirical evidence base needed to identify the causes of child mortality and assess the impact of trade on child health, based

on a cross-country panel data set of 66 countries for the period 1960-2013. Taking note of the fact that “trade aspects need to be considered in the context of improving diet, nutrition and the prevention of chronic diseases (WHO, 2003, p. 28)” we provide a systematic quantitative analysis of the impact of trade on child health and mortality. We account for the fact that trade may not be strictly exogenous, as trade can be both a cause and a consequence of increased population health, as better health is generally associated with higher productivity and thus potentially more trade. Secondly, the effect of trade on life expectancy may vary across countries that have different structural country characteristics and policy environments, potentially affecting the functionality of markets and the ability of market participants to respond to induced changes in prices and incentives. In order to consistently and efficiently estimate the long-run-effect of trade on child health, we employ heterogeneous panel cointegration techniques that are robust to a variety of estimation problems such as cross-country heterogeneity, non-stationarity of the data, omitted variables and endogeneity.

#### (d) Outline of the study

The thesis is structured as follows. The first chapter provided a general introduction and presented the FNS concept and the motivation, significance and objectives of the study. The second chapter of the thesis assesses the impact of trade policy on child malnutrition, based on a large cross-country panel data set covering 113 developing countries for the time period 1985-2007. The empirical analysis is based on the widely accepted UNICEF (1990) conceptual framework for the causes of child malnutrition. The study employs two-step feasible efficient GMM (Generalized Method of Moments) estimation of the fixed-effects (FE) panel data model to identify the key determinants of child malnutrition as well as the impact of trade openness.

Noting that food security is one important determinant of malnutrition, the third chapter of the thesis identifies the key determinants of food security, including the agricultural and economic development, as well as the impact of trade. The study employs a system GMM approach that is robust to unobserved heterogeneity and endogeneity to a cross-section of 151 countries for the period 1980-2007 to identify the impact of trade openness on various measures capturing the different dimensions of food security.



The fourth chapter of the thesis focuses on child health, which is an important determinant of child's nutritional status. This study assesses the impact of trade on child health, based on a cross-country panel data set covering 66 countries for the period 1960-2013. To account for the time-series properties of the data and potential cross-country heterogeneity in the impact of trade, the study employs heterogeneous panel cointegration techniques that are robust to omitted variables and endogeneity, to identify the long-run cointegrating relationship between trade and child health.

The fifth chapter of the thesis gives a general conclusion and summarizes the main findings and policy implications of the study.

## II. The Impact of Trade Policy on Child Malnutrition in Developing Countries

### **Abstract**

Globally, interest in nutrition has increased significantly. Although it is generally acknowledged that “non-nutrition” factors such as macroeconomic structural developments and policies can have profound effects on nutrition security, empirical evidence on this issue is scarce. In the first part of the thesis, we assess the impact of trade policy on child malnutrition, based on a large cross-country panel data set covering 113 developing countries for the time period 1985-2007. The empirical analysis is based on the widely accepted UNICEF (1990) conceptual framework for the causes of child malnutrition. The study employs two-step feasible efficient GMM (Generalized Method of Moments) estimation of the fixed-effects (FE) panel data model that is robust to unobserved heterogeneity, correlated individual effects and endogeneity, to identify key determinants of child malnutrition as well as the impact of trade openness. The results reveal that trade openness works to reduce both child stunting and underweight significantly. The results are robust to the methodology and openness indicator employed as well as to changes in the sample composition. Taking a closer look at household food security, one of the most important underlying determinants of child’s nutritional status, we find that, besides national food availability, access to enough food as well as dietary diversity and diet-quality related aspects of food security play a role for child’s nutritional status.

## 1. INTRODUCTION

Globally, interest in nutrition has increased significantly and investing in nutrition is seen as a key development priority to benefit global welfare (UNICEF, 2013). Despite significant progress in world agriculture and economic development during the last decades, food insecurity and undernutrition persist in many countries, especially developing ones. Globally, one quarter of under-five children or an estimated 162 million preschool children are stunted in 2012, meaning their height given their age is below minus two standard deviations from median height for age of the reference population. Moreover, around fifteen per cent or an estimated 101 million children under-five years of age are estimated to be underweight, meaning their “weight-for-age” is below minus two standard deviations from the median weight for age of the reference population (UNICEF, 2013). Black et al. (2013) estimate that undernutrition was the underlying cause of 45 per cent of all deaths among children under-five years of age, around 3.1 million children worldwide in 2011. There has been some progress in reducing child undernutrition globally. According to UNICEF (2013), the global prevalence of stunting has declined by about 36 per cent over the last two decades, while the underweight prevalence has declined by approximately 37 per cent, however, still remaining an unacceptably high levels. In line with this, the World Bank (2012) concludes that a great part of developing countries is far away from achieving the MDGs closely linked to food and nutrition security.

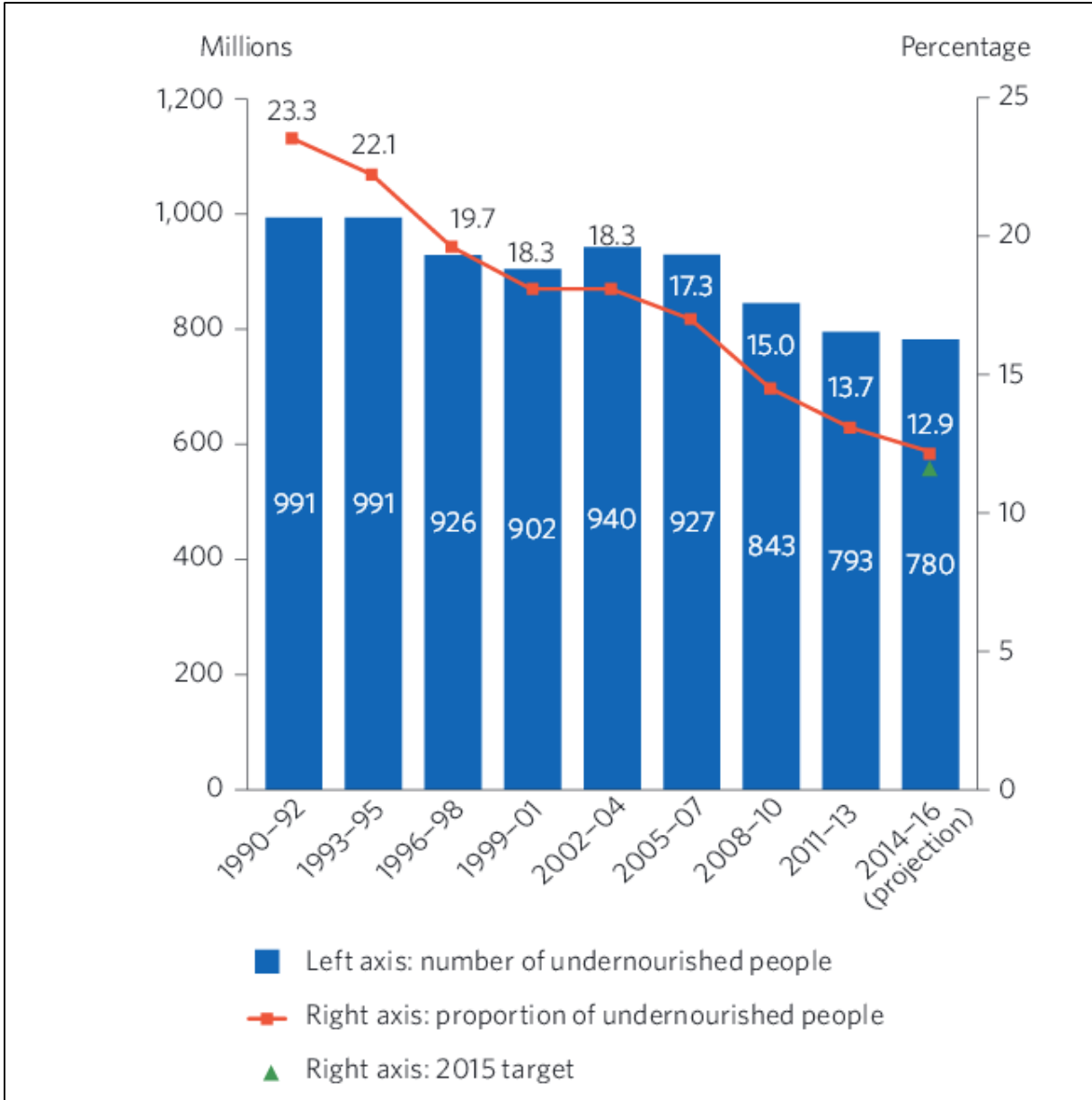
Noting the importance of improving food and nutrition security, the goals of achieving reductions in hunger and undernutrition have explicitly been included in the MDGs. The eight MDGs were established in September 2000, following the Millennium Summit of the United Nations and the resulting United Nations Millennium Declaration. The international community committed to help achieve the MDGs by 2015, which have since then been used to track progress in various areas of development. The MDGs closely linked to food and nutrition security are MDG 1 “Eradicate extreme poverty and hunger” and MDG 4 “Reduce child mortality”. The overall progress towards the MDGs that has been made since 1990 has been the subject of the Millennium Development Goals Report 2015 of the United Nations.<sup>4</sup>

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<sup>4</sup> The report is available online at <http://www.undp.org/content/undp/en/home/librarypage.html>.

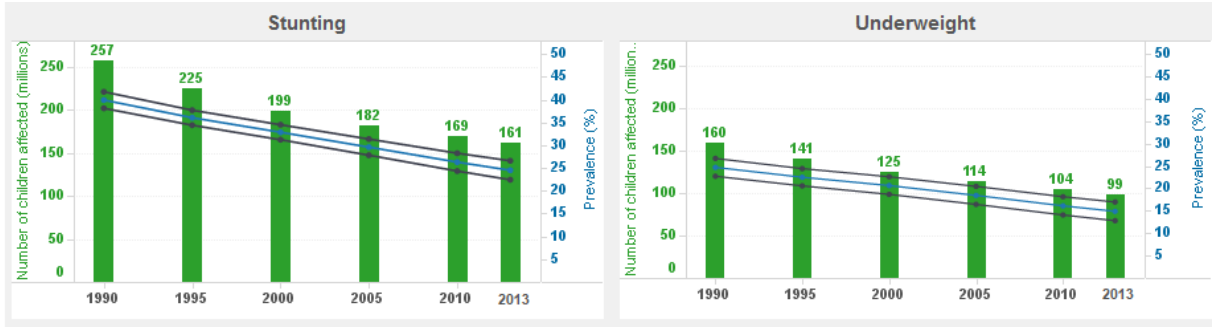
As regards the goal of eradicating hunger, the report reveals that the proportion of undernourished people in the developing regions has fallen from 23.3 per cent in the 1990–1992 period to 12.9 per cent in 2015, which is very close to the MDG hunger target of halving the proportion of people who suffer from hunger during this period (see Figure 1). Today, about 795 million people globally are still undernourished, the vast majority of them (780 million people) living in the developing regions (UN, 2015). The prevalence of underweight children under age 5, which is a second indicator to measure progress towards MDG 1, has also shown significant reductions, going down from one in four children in 1990 to one in seven children, corresponding to over 90 million children, worldwide in 2015. A graphical representation of the global child malnutrition trends, based on the latest UNICEF-WHO-The World Bank Joint child malnutrition estimates 2013, is depicted in Figure 2. Noting that according to UNICEF (2013), nearly half of all deaths in children under five are attributable to undernutrition, the great achievements with respect to MDG 4 are not surprising. Accordingly, the global under-five mortality rate dropped from 90 to 43 deaths per 1,000 live births between 1990 and 2015, corresponding to a drop of under-five deaths from 12.7 million per year in 1990 to 5.9 million in 2015 (UN, 2015).

**Figure 1:** Number and proportion of undernourished people in developing regions



Source: UN, 2015

**Figure 2:** Global child malnutrition trends (1990 – 2013)



Source: UNICEF-WHO-The World Bank Joint child malnutrition estimates 2013

Despite these significant improvements, progress has been uneven across regions and countries and about 800 million people still suffer from hunger and over 160 million children under the age of 5 are underweight, meaning they have inadequate height for their age due to insufficient food. While the Caucasus and Central Asia, Eastern Asia, Latin America and South-Eastern Asia have reached the hunger target, the pace of reduction in the Caribbean, Oceania, Southern Asia and Sub-Saharan Africa has been too slow to achieve the MDG 1 hunger target. As regards underweight, while Eastern Asia and Latin America and the Caribbean have clearly met the target, Southern Asia and Sub-Saharan Africa still account for nearly 90 per cent of all underweight children in 2015, despite significant reductions in the underweight prevalence in particular in Southern Asia (UN, 2015).

As the era of the MDGs is going to expire at the end of 2015, the Sustainable Development Goals (SDGs) are to replace them. These have been elaborated by the UN General Assembly's Open Working Group on Sustainable Development Goals (OWG), which was established following the 2012 United Nations Conference on Sustainable Development, commonly known as Rio+20. Within the new SDGs, achieving the internationally agreed targets on stunting in children under 5 years of age is included as part of Goal 2 to “End hunger, achieve food security and improved nutrition, and promote sustainable agriculture”, confirming the previous focus on food and nutrition security (see OWG, 2015).

Further improvements and food and nutrition security in the coming decades are important, as food insecurity and malnutrition<sup>5</sup> have direct consequences for health and human development and, in turn, for learning, individual productivity and the overall economic development of nations (World Bank, 2006; Strauss & Thomas, 1998). The World Bank (2006) Report *‘Repositioning Nutrition as Central to Development: A Strategy for Large-Scale Action’* points out that macroeconomic policies can have significant impacts on child

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<sup>5</sup> The terms “undernutrition” and “malnutrition” have been used interchangeably in the earlier development literature, although the latter generally also includes problems of over-nutrition and obesity, which have received some attention during the last decade (see e.g. Popkin, 2001, and Hawkes, 2006). We do not focus on over-nutrition and obesity, therefore the term malnutrition only refers to the problem of undernutrition throughout the study. This is consistent with the terminology of international organizations, for example the World Bank, which refer to the “malnutrition” prevalence, although, strictly speaking, it should be termed “undernutrition” prevalence (see e.g. the terminology used within the World Development Indicators database).

undernutrition and that there is a need for more studies on this important topic. Also the UNICEF (2013) report on *'Improving child nutrition: The achievable imperative for global progress'* concludes that continued research is needed to strengthen the knowledge of the causes and consequences of child malnutrition. Early childhood undernutrition causes irreversible damage and has significant long-term consequences. Early childhood growth failure leads to a greater propensity for developing chronic diseases, has adverse effects for school attendance and performance as well as for cognitive capacity and future earnings (Deaton & Arora, 2009; Hoddinott et al., 2011). Because of these interrelationships, it has become apparent that reductions in undernutrition in pre-school children provide substantive economic benefits. Besides that, good nutrition is a fundamental driver of a wide range of developmental goals and a failure to eliminate hunger will undermine efforts to reach the other MDGs, for example those related to education, child mortality, maternal health, and disease (Guha-Khasnobis et al., 2007; Behrman et al., 2004; World Bank, 2013). As a response, numerous international initiatives have now placed high priority on food and nutrition security issues, for example the UN-led Scaling Up Nutrition (SUN) and the USAID's Feed the Future initiative. Also in case of research, the recent landmark series of papers on *maternal and child undernutrition* published in the Lancet (2013) reveals that food and nutrition security are back on top of the international research agenda. The Lancet (2013, p. 12) concludes that the "national and international momentum to address human nutrition and related food security and health needs has never been higher".

The importance of trade policies for food and nutrition security was recognized by the World Food Summit in 1996, speaking in favor of a fair and market oriented world trade system. At the global level, international trade can link production and consumption of food and may thus play an important role in securing enhanced food security, as it permits global production to take place in those regions most suited to it and enables food to flow from countries with abundant food supplies to ones with insufficient supplies (Runge et al., 2003). A country's openness to trade may then lead to an increase in the total amount of goods (including food) available to the national population and make available a greater variety of goods, which affects the food choices available to consumers and may contribute to better nutrition. However, trade liberalization may also involve short-term adjustment costs, for example, unemployment costs in import-competing sectors, in turn worsening access to

food and nutritional status. Moreover, there are additional transmission channels through which trade policies impact on nutritional status, which are explained in more detail in Section 2. Therefore, whether trade openness ultimately improves food and nutrition security is theoretically ambiguous, which strongly calls for empirical analysis to assess whether the net effects are positive or negative. There is, however, still surprisingly little empirical evidence on this issue, especially in light of the increased demand for answers to the question on how child malnutrition can be reduced.

In this study, we aim to contribute to the empirical evidence base needed to identify the causes of child malnutrition and assess the impact of trade policy on child malnutrition, based on a large representative cross-country panel data set of 113 developing countries for the time period 1985-2007. We focus on developing countries because of a lack of data for most developed countries as regards the malnutrition indicators employed in the present study. An additional advantage comes from the greater comparability with related studies in the issue, which equally focused on developing countries (see e.g. Smith & Haddad, 2000; Haddad et al., 2003). In the empirical analysis, we take a number of steps to ensure that the relationship between the considered determinants and child malnutrition is of causal nature. First, we apply a well-established conceptual framework, which divides the determinants of child malnutrition into three levels of causality. This allows us to distinguish between groups of determinants lying at different levels of causality. Second, we utilize panel data techniques and employ an instrumental variables approach to account for unobserved heterogeneity and potential endogeneity of the explanatory variables. Additionally, we investigate the channels through which trade policy affects child's nutritional status.

The focus of the study is justified, as the impact of specific national-level developments and policies is still not well understood (see World Bank, 2006). This is remarkable in light of the fact that developing countries are increasingly economically integrated with the world, making the consequences of globalization in these countries an important focus (Bourguignon et al., 2002). However, only very few studies explicitly explore the impact of trade liberalization on food and nutrition security (Guha-Khasnobis et al., 2007). Indeed, also in terms of policy, the World Bank (2006) report on *“Repositioning Nutrition as Central to Development: A Strategy for Large-Scale Action”* recognized that only few developing



countries have well-developed nutrition policies. Although being aware that direct nutrition-specific interventions will impact on nutrition, governments are often unaware of the nutrition impact of national-level policies in other sectors, for example trade and agriculture, and these become unintentional but de facto nutrition policies (World Bank, 2006). Besides that, it has recently been argued that interventions outside the nutrition sector could conceivably be more cost-effective compared to direct nutrition-specific interventions over the medium to longer term, and thus may play an important role for food and nutrition security (Deolalikar, 2008). Nutrition-specific interventions that directly address the immediate causes of child malnutrition, for example supplementation programs, should therefore be complemented by broader approaches lying on the basic determinant level that have an indirect impact on nutritional status (UNICEF, 2013).<sup>6</sup> In the same vein, Gillespie et al. (2013) state that "Beyond nutrition-sensitive programs and interventions (...), other macro-level drivers exist that lie at the end of long causal pathways (p. 553)". Trade may be considered as one of these macro-level drivers, which can be expected to affect food and nutrition security. In line with this reasoning, the WHO (2003, p. 28) emphasizes that "trade aspects need to be considered in the context of improving diet, nutrition and the prevention of chronic diseases", and consequently that "trade has an important role to play in improving food and nutrition security". Thus, although it is generally acknowledged that more fundamental causes of malnutrition lying outside the field of nutrition can have profound effects on food and nutrition security and that undernutrition is also linked to political factors such as trade policy, evidence on what factors are important and which policies are beneficial for nutrition security is still limited (UNICEF, 2013). We try to fill this gap, as there exists, to the best of our knowledge, no systematic quantitative analysis of the impact of macroeconomic structural factors and policies, including trade policy, on food and nutrition security.

Our aim is to identify the key determinants of child's nutritional status for a large sample of countries and gain insight into the impact of trade on malnutrition, based on cross-country regressions. The study is intended to contribute to the existing literature on the linkages

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<sup>6</sup> Section 2 explains in more detail the differentiation between different causality levels (immediate, underlying, and basic) of the determinants of child's nutrition status according to the well-known UNICEF (1990) conceptual framework.

between globalization, trade openness and economic growth<sup>7</sup> and between trade and poverty<sup>8</sup>, but which does not explicitly explore the implications for food and nutrition security, and previous cross-country studies that examined cross-country variation in malnutrition rates (of children), however, without considering policy effects<sup>9</sup>.

The empirical analysis is based on the widely accepted UNICEF (1990) conceptual framework for the causes of child's malnutrition, which will be described in more detail in Section 2. This framework emphasizes that there are both food and non-food determinants of nutrition, as well as different steps in the causal chain of the nutrition security determinants. Our main focus is on the basic or root causes of child malnutrition (as opposed to the immediate and underlying causes which have been the focus of most previous studies in the area), as reflected by the prevalence of underweight and stunting. While past studies predominantly focused solely on child underweight, the focus on stunting is justified, as an international consensus is emerging favoring stunting among underfives over underweight as the indicator of choice to monitor child's nutritional status. The reason behind this shift of focus is that stunting generally remains a problem of greater magnitude than underweight (or wasting), and it more accurately reflects nutritional deficiencies and illness that occur during early life (UNICEF, 2009). We extend previous work on the determinants of child malnutrition in various directions. First, we use a more comprehensive dataset on child's nutritional status for a representative sample of developing countries over the period 1985-2007. During this period, significant trade policy changes have taken place in many developing countries. The data on child's nutritional status comes from the UNICEF-WHO-The World Bank joint child malnutrition estimates. Second, we consider trade policy effects and the impact of the domestic macroeconomic policy environment, both potentially affecting people's incentives and the allocation and utilization of resources in the economy. Third, we employ GMM estimation techniques, allowing us to control for the potential endogeneity of some of the determinants of nutritional status as well as accounting for unobserved heterogeneity.

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<sup>7</sup> Among others, see: Dollar, 1992, Sachs & Warner, 1995; Edwards, 1998; Frankel & Romer, 1999; Rodriguez & Rodrik, 2000; Greenaway et al., 2002; Baldwin, 2003; Dollar & Kraay, 2004; DeJong & Ripoll, 2006; Chang et al., 2009.

<sup>8</sup> Among others, see: Dollar & Kraay, 2004; Agénor, 2004; Winters et al., 2004; Dollar, 2005; Bardhan, 2006, Nissanke & Thorbecke, 2006; Ravallion, 2006; Goldberg & Pavcnik, 2007; Fosu & Mold, 2008.

<sup>9</sup> Among others, see: Smith & Haddad, 2000, 2001, 2002; Haddad et al., 2003; Alderman et al., 2005; Apodaca, 2008; Gabriele & Schettino, 2008; Webb & Block, 2010; Headey, 2013.

Fourth, we show that, besides national availability of food, other aspects of food security, for example food access as well as dietary diversity and diet-quality related aspects of food security, which have largely been neglected in previous studies, play a role in child's nutritional status.

The rest of the chapter is structured as follows. Section 2 describes the links between trade policy and malnutrition. Section 3 describes the data and explains the empirical specification and estimation methodology employed in the analysis. Section 4 presents the empirical results for the underlying and basic determinants models of child malnutrition as well as for the transmission channel analysis. Finally, Section 5 offers some concluding remarks and policy recommendations.

## **2. THE LINKS BETWEEN TRADE POLICY AND MALNUTRITION**

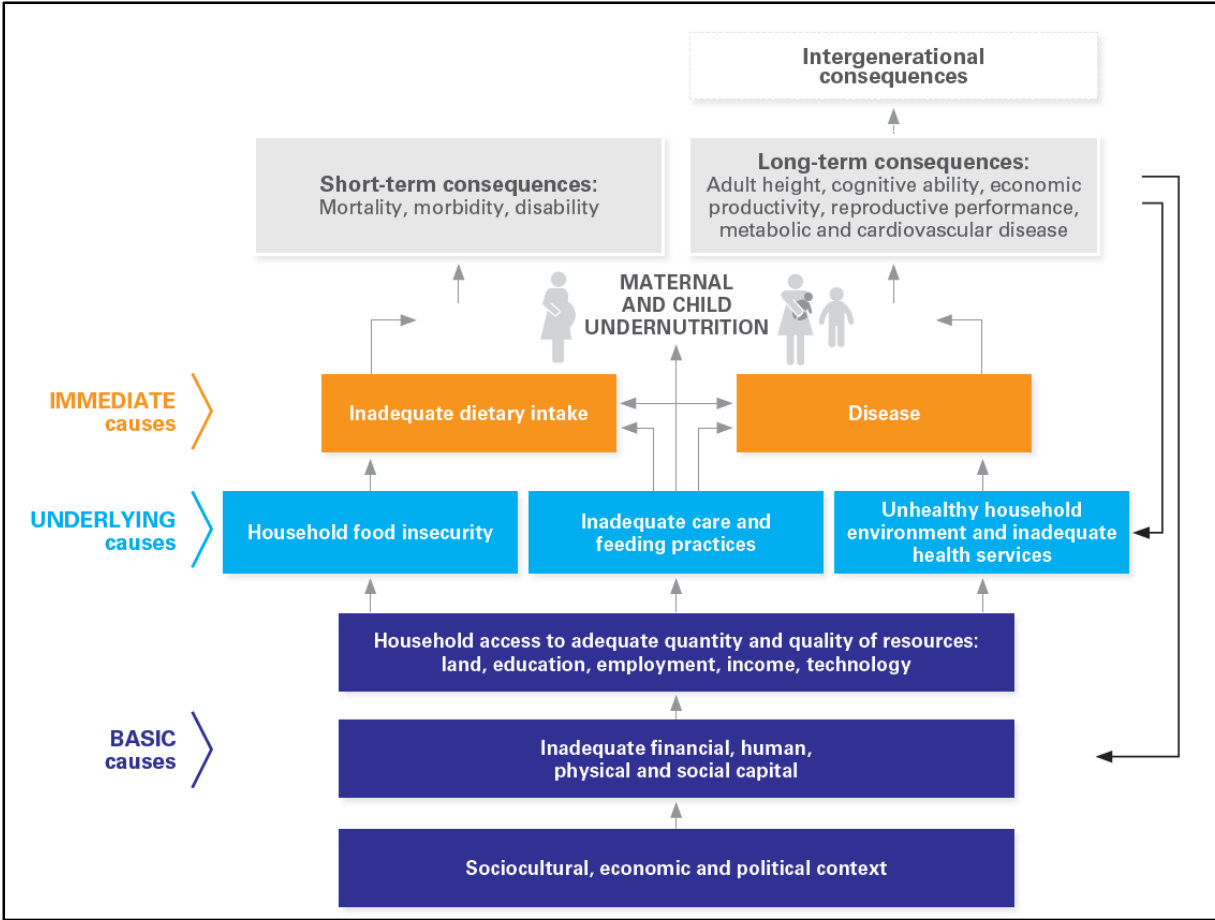
We take the UNICEF (1990) conceptual model on the causes of child malnutrition, as basis for our empirical model specification (see Figure 3). This model divides the determinants of child malnutrition into three levels of causality: immediate, underlying, and basic. The *immediate determinants* manifest themselves at the individual level and are child's dietary intake and health status (or the presence of disease), which are themselves interdependent. The health status partly determines child malnutrition, because it affects both appetite as well as the absorption of nutrients (UNICEF, 2013).

The immediate determinants are influenced by three *underlying determinants* manifesting themselves at the household level: food security, care for mothers and children, and health environment quality, including access to healthcare services. Household food security indicates how much food resources are available for allocation between the household members and thus directly determines child's dietary intake. However, also caring behaviors and feeding practices of women in particular (who are commonly the primary caretakers) partly determine child's dietary intake as well as its health status. Child feeding practices, cognitive stimulation, and general health-seeking behaviors belong to these child caring behaviors. In addition, care for mothers, for example during pregnancy, affects child's nutritional well-being. The health environment and services as third underlying determinant includes access to safe water and sanitation as well as the availability and access to

healthcare services, for example vaccinations, and therefore partly determines the incidence of disease or child's health status (see Smith & Haddad, 2000).

These underlying determinants are influenced, in turn, by *basic determinants* at the societal or national level that affect child malnutrition through their impact on the underlying determinants. These basic or structural causes include the potential resources available to a country and the political and economic structure as well as the sociocultural environment, which affect people's incentives, the utilization of potential country resources and how they are translated into resources for food security, care, and the health environment quality (Smith & Haddad, 2000). The black arrows in Figure 3 show that the consequences of undernutrition can feed back to the underlying and basic determinants (see UNICEF, 2013). We put special emphasis on the basic (or root) causes of malnutrition and introduce trade policy as part of the political context, potentially affecting nutritional status through the underlying determinants, as will be described in more detail below. A similar conceptual framework provides the analytical basis for recent studies of the Copenhagen Consensus, which conceptualize trade policy as part of the 'economic setting', which create both opportunities and constraints and eventually affect outcomes as food security and nutrition (see Hodinott et al., 2012).

**Figure 3:** Conceptual framework of the determinants of child undernutrition



Source: UNICEF, 2013

Smith & Haddad (2000, p. 7-8) show that this conceptual framework can be usefully placed in the context of a multimember household economic model, which can ultimately be used to identify important national-level determinants of child’s nutritional status. The household maximizes household welfare  $W$ , which consists of the utility functions of the household members ( $U^i$ ), indexed  $i=1, \dots, n$ . The household members consist of a main caregiver who is assumed to be the mother (indexed  $i=M$ ),  $D$  other adults (indexed  $i=1, \dots, D$ ) and  $J$  children (indexed  $i=1, \dots, J$ ). Accordingly, the household welfare function can be stated as:

$$W(U_M, U_{ad}^1, \dots, U_{ad}^D, U_{ch}^1, \dots, U_{ch}^J; \beta) \text{ and } \beta = (\beta^M, \beta_{ad}^1, \dots, \beta_{ad}^D), \tag{1}$$

where the  $\beta$ s represent each adult household member’s “status” within the household. Such status affects the relative weight placed on the member’s preferences in the overall household decision making process. The status of the mother as the main caregiver affects the control of her time and over household resources, potentially dedicated to her children (Smith et al., 2003). The utility functions of household member  $i$  can be specified as:

$$U^i = U(N, F, X_0, T_L) \text{ for } i = 1, \dots, n = 1+D+J, \quad (2)$$

where  $N$  represents nutritional status,  $F$  food consumption,  $X_0$  non-food consumption, and  $T_L$  leisure time of each household member.

The nutritional status is viewed as a household provisioning process with inputs of food, non-food commodities and services, and care. The nutritional status of each child can be stated as follows:

$$N_{ch}^i = N(F^i, C^i, X_N^i; \xi^i, \Omega_{HEnv}, \Omega_{Food}, \Omega_{NEnv}) \text{ for } i = 1, \dots, J, \quad (3)$$

where  $F^i$  is food consumption of child  $i$ ,  $C^i$  is the care received by the child  $i$ , and  $X_N^i$  represents non-food commodities and services purchased for caregiving purposes, such as medicines and health services. The variable  $\xi^i$  denotes the physiological endowment of child  $i$ , representing his or her innate healthiness. Finally, the  $\Omega$  are community-level determinants such as the health environment,  $\Omega_{HEnv}$ , the availability of food,  $\Omega_{Food}$ , and the characteristics of the natural environment,  $\Omega_{NEnv}$ .

The care received by child  $i$  is itself dependent on a number of factors, specified as follows:

$$C^i = C(T_c^i, N^M; E^M, \Omega_C) \text{ for } i = 1, \dots, J, \quad (4)$$

where  $T_c^i$  is the time input of the mother,  $E^M$  is the mother's educational level affecting her knowledge and beliefs,  $\Omega_C$  represents cultural factors affecting caring practices, and  $N^M$  is the mother's own nutritional status, which is a function of the following factors:

$$N^M = N(F^M, C^M, X_N^M; \xi^M, \Omega_{HEnv}, \Omega_{Food}, \Omega_{NEnv}, \beta), \quad (5)$$

where the nutritional status of the mother is similarly determined as in case of the child, but is additionally influenced by her status relative to the other adult members ( $\beta$ ), reflecting the relative value placed on the mother's well-being.

The maximization of (1) subject to (2), (3), (4), and (5) along with the household members' time and income constraints leads to the following (quasi) reduced-form equation for the nutritional status of child  $i$  in any given year:

$$N_{ch}^{i*} = f(\beta, \xi^i, \dots, \xi^J, \xi^M, \Omega_{HEnv}, \Omega_{Food}, \Omega_{NEnv}, \Omega_C, E^M, P, I) \text{ for } i = 1, \dots, J, \quad (6)$$

where  $P$  is a vector of prices of food and non-food commodities and services, and  $I$  is the household's total (exogenous) income.<sup>10</sup>

Equation (6) can then be used to identify variables at the national level being important determinants of child's nutritional status, lying at different levels of causality. At the underlying determinants level, these are women's relative status ( $\beta$ ), the health environment quality ( $\Omega_{HEnv}$ ), the availability of food ( $\Omega_{Food}$ ), characteristics of a countries' natural environments ( $\Omega_{NEnv}$ ), cultural factors ( $\Omega_C$ ), and women's education ( $E^M$ ). These underlying determinants are influenced by *basic determinants* that affect child malnutrition through their impact on the underlying determinants, as described above. The effect of a factor in this context may mainly flow through two channels, through induced changes of the level, accessibility or relative prices of factors in the production function for nutritional status, or through induced changes in the parents' decisions impacting on child's nutritional status.

We recognize that macroeconomic policies can have significant impacts on child undernutrition working through the underlying determinants and conceptualize trade policy as part of the basic determinants of child's nutritional status. Generally, trade creates both opportunities and constraints and affects the allocation and utilization of resources in the economy. It also affects the incentives and choices regarding productive activities undertaken by households and the parents' decisions impacting on the health of their children, for example through its effect on income, education, and time dedicated to care. Lastly, it changes the level, accessibility or relative prices of factors in the production function for nutritional status, i.e. food security, care, and the health environment and services. This may have a significant impact in many developing countries that generally start from a low level with respect to most health inputs, such that the size of the response in child health to changes in the inputs can be expected to be large (Currie, 2000). From this general reasoning outlined above, we expect that trade policy eventually affects outcomes such as food security and nutritional status. In the following, the potential linkages between

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<sup>10</sup> Note that equation (6) is only a reduced form equation of the model if we consider income as exogenous. Strictly speaking, income is itself determined by the labor allocation decision of the household in the solution to the utility maximizing problem, i.e. nutritional status and income are simultaneously determined (see e.g. Currie, 2000).

trade and nutritional status working through the underlying determinants will be described in more detail.

(a) Trade – food security linkages

An important link between child malnutrition and trade policy works through the *food security* transmission channel. To understand how trade policy may affect child' nutritional status through the food security link, some important linkages between trade and food security will be discussed in the following.<sup>11</sup> To understand the potential effects of trade, we refer to the different dimensions of food security. Food security is defined by the FAO as a situation in which all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life (FAO, 1998). It entails three dimensions of food security: availability, stability, and access. Adequate food availability means that, on average, sufficient food supplies should be available to meet consumption needs. Stability refers to the issue of ensuring adequate food supplies in years of severe food shortages, e.g. during drought years. Food security in the access dimension is about ensuring that all people at all times have *economic* access to the basic food they need (FAO, 2003).

Trade may affect all of the different dimensions of food security. International trade can link production and consumption of food and allows food to flow from countries with abundant food supplies to ones with insufficient supplies. Trade may therefore serve to smooth out excess demand or excess supply situations in domestic markets, thereby stabilizing national food supplies and reducing price fluctuations. This constitutes an important mechanism for many developing countries, especially those that have to deal with frequent production shortfalls or whose output is constrained by agro-climatic and other factors (Runge et al., 2003; Hoddinott et al., 2012). Conversely, if this mechanism is disrupted by trade barriers, it may have negative consequences for food security. Moreover, participation in the export market may induce spillovers for domestic food production, related for example to a general improvement of input and service delivery to agriculture and infrastructure development (FAO, 2000). Related to this, trade opens up opportunities for specialization in production as

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<sup>11</sup> Note that our discussion of potential links is only exemplarily and is not meant to be comprehensive. For a complete conceptualization and discussion of the potential linkages between trade reform and food security, see FAO (2000, 2003).



well as the realization of dynamic efficiency gains from factors such as economies of scale, technology transfers and knowledge spillover effects, positively affecting agricultural productivity and development.<sup>12</sup>

International trade also impacts on the access dimension of food security via its effect on prices, economic growth, infrastructure investment, household incomes and employment. For example, potential employment and income increases created by trade participation can be used to buy more or more diverse foods on local markets or, seen on a country level, revenues can be used to buy more food on international markets. New employment opportunities partly arise in the off-farm sector, leading to increased off-farm income, which has been found to improve food security and nutrition (see e.g. Babatunde & Qaim, 2010). Besides that, increased trade spurs investments in a country's infrastructure, thereby improving market integration and access to food (see e.g. Hochman et al., 2013). These factors should contribute to a more efficient domestic agriculture and food production. Consumers should additionally benefit from lower food prices following a reduction in trade barriers. Trade may then lead to a higher and more stable domestic food supply, make available a greater variety of foods, and increase food access, which will contribute to better nutrition.

The economic choice of importing a commodity generally implies that it can be procured from abroad more cheaply than it can be produced domestically and as such is no *a priori* reason for concern (FAO, 2000). However, high dependence on just a few export commodities to generate the foreign exchange necessary to finance food imports may leave some countries vulnerable to changing market conditions. Besides that, opening up the economy for trade may involve short-term adjustment costs, for example, unemployment costs in import-competing sectors, and the availability of cheap imports can make it unprofitable for some of the less efficient domestic producers to keep on producing food for local markets (FAO, 2003). Furthermore, if trade liberalization involves tariff reductions, this may adversely affect the ability of the government in providing transfers to the poor, including food transfers. Trade may then lead to a decrease in domestic food supply, food supply stability, and access to food, which would adversely affect nutrition security.

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<sup>12</sup> See, for example, cross-country studies by Coe et al. (1997), Edwards (1998), and Wacziarg & Welch (2008).

## (b) Trade – care for mothers and children linkages

Trade policy affects child malnutrition not only through the food security link, but may more generally influence the choices regarding productive activities undertaken by households and affect the utilization of potential resources and how these are translated into resources for care and the health environment and services (see Hoddinott et al., 2012). In general, as has been described above, the parents' decisions impacting on the health of their children as well as the accessibility or relative prices of factors in the production function for nutritional status (including for care) are affected by trade policy. Deaton (2004) emphasizes that closer integration with the world facilitates the transmission of health-related knowledge. Furthermore, trade openness can bring about new employment opportunities as well as increases in wages and returns to education, thereby strengthening education incentives (Oostendorp & Doan, 2013). Confirming this, Schultz (2006) finds that opening up the economy for trade is associated with improvements in women's employment opportunities and consequently leads to a greater accumulation of human capital and to increased gender equality. Related to this, though not uncontroversial (see e.g. Rodríguez & Rodrik, 2000; Yanikkaya, 2003), trade openness accelerates the accumulation of human and physical capital and raises economic growth, thereby increasing national income (Frankel & Romer, 1999; Wacziarg & Welch, 2008).

In summary, increased incomes and better education combined with a better status of women in the society and accompanied by greater control over the allocation of resources within the household should then positively affect the quality of care that mothers dedicate to themselves and their children. On the other hand, if increased employment of women (in case they are mothers), leads to less time dedicated to care, it may adversely affect child's nutritional status. For example, Paolisso et al. (2002) find that cash crop adoption in rural Nepal partly detracted parents, who spent more time in cultivation activities, from sufficient child care provision. Whether the positive effects outweigh the negative effects remains an empirical question.

### (c) Trade – health environment quality linkages

Finally yet importantly, trade may affect nutritional status through its effect on the health environment and the availability of healthcare services. Higher incomes generally promote better health, such that economic integration and trade-induced poverty reductions, amongst others leading to increased access to improved water and sanitation, can be a powerful force for improvements in population health (see Pritchett & Summers, 1996; Dollar, 2001). Besides that, trade facilitates the international transmission of health-related ideas and practices, new knowledge and technologies, leading to an accumulation of health-relevant knowledge, for example knowledge about appropriate treatments for disease and good health practices, as well as better access to new medical technologies (see e.g. Deaton, 2004). Related to that, opening up the economy, for example by reducing tariffs, can be accompanied by increased trade and transfers of medical supplies and drugs, for example vaccines, medical treatments, pharmaceuticals, as well as better sanitation and water facilities, which are important for child health (Owen & Wu, 2007). In line with this, Papageorgiou et al. (2007) show that technology diffusion through medical exports is an important contributor to health outcomes. Accordingly, Cutler et al. (2006) argue that a great part of the decline in mortality in developing countries after World War II happened because health-improving measures developed in richer countries, such as improvements in water supply, the use of antibiotics and the widespread immunization of children, were transmitted to the rest of the world very quickly (see also Deaton, 2005).

Lastly, openness to trade can be associated with sound economic policies and impact positively on the quality of institutions (see e.g. Rodrik et al., 2004, and Acemoglu & Robinson, 2006) that themselves may create a policy environment that is conducive to improved health, for example the development of healthcare systems and better access to health services for the poor. Cornia (2001) argues that the positive health effects associated with globalization may be dependent on domestic conditions in terms of human development and physical infrastructure as well as on complementary policies, for example, the creation of democratic institutions that ensure that markets are non-exclusionary and safety nets in place.

On the negative side, health and nutritional status may deteriorate if increased trade is associated with a deterioration of environmental quality that contributes to ill-health (see e.g. Grossman & Krueger, 1991). For example, the pollution haven hypothesis (PHH) states that increased openness to trade will lead to a relocation of polluting industries from countries with stringent environmental regulations to countries with less stringent regulations (see e.g. Copeland & Taylor, 2004).<sup>13</sup> Similarly, health may decrease as a result of trade openness if general working conditions deteriorate or if economic integration facilitates the transfer of infectious disease or unhealthy consumer goods and practices across borders (Owen & Wu, 2007; Deaton, 2004). Besides that, if tariff reductions lead to decreasing government revenues, this may adversely affect public expenditure on health. Lastly, not specifically related to trade but to a general opening up of a country, openness may lead to a “brain-drain” where educated workers migrate to and work where wages are higher, which in case of doctors and nurses may pose a threat to the health sector and may ultimately adversely affect nutrition security (see e.g. Mills et al., 2011).<sup>14</sup>

As has become apparent from the above discussion, trade and trade policy exert substantial impacts on the underlying determinants of nutritional status, whereas the direction of impact cannot be stated *a priori*, which strongly calls for empirical analysis to assess whether the *net* effects are positive or negative.

### **3. DATA AND ESTIMATION STRATEGY**

#### **(a) Data**

To perform the estimations, we compiled a pooled cross-country panel data set consisting of a maximum of 113 developing countries over the period 1985-2007, selected on the basis of data availability. The representative developing country sample includes countries from the following regions: East Asia & Pacific, Developing Europe & Central Asia, Latin America & the Caribbean, Middle East & North Africa, South Asia, and Sub-Saharan Africa. Using the most

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<sup>13</sup> Note, however, that there is mixed empirical evidence on the PHH, with some authors even concluding that freer trade is good for the environment (e.g. Antweiler et al., 2001). This can be explained by the easier transmission of environmentally friendly technologies following a reduction in trade barriers.

<sup>14</sup> Note, however, that, while the migration of educated workers is a source of “brain-drain”, their remittances potentially paid to other household members may contribute to better health outcomes.

recent UNICEF-WHO-The World Bank joint child malnutrition estimates, we are able to include about 90 per cent of the countries classified as “developing” (in our starting period) by the World Bank in our empirical analysis (see Table A.1 in the appendix for a list of these countries).<sup>15</sup> During the considered period, substantial trade reforms have taken place in many of these countries. The choice of variables, described in this chapter, is guided by the conceptual framework as described in Section 2, experience gleaned from past studies, and data availability. Next, we will therefore describe the child malnutrition indicators and the basic and underlying determinants of child malnutrition accounted for in the baseline model.<sup>16</sup>

Child malnutrition is commonly measured as prevalence rates of underweight and stunting. These are considered informative indicators of nutritional status and long-term health status (Strauss & Thomas, 1998). A child is considered stunted if its “height-for-age” is below minus two standard deviations from the median height for age of the reference population, while a child is considered as underweight if its “weight-for-age” is below minus two standard deviations from the median weight for age of the reference population. According to Smith & Haddad (2000, p. 22) the underweight indicator thus “represents a synthesis of height-for-age (identifying long-term growth faltering or stunting) and weight-for-height (identifying acute growth disturbances or wasting)”. While past studies predominantly focused solely on child underweight, a Millennium Development Goal (MDG) indicator, the focus on stunting is justified, as an international consensus is emerging favoring stunting among underfives over underweight as the indicator of choice to monitor child’s nutritional status.<sup>17</sup> This can be explained by the fact that stunting generally remains a problem of greater magnitude than

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<sup>15</sup> The World Bank Country and Lending Groups classification as of 2011 as well as a historical classifications list can be found at <http://data.worldbank.org/about/country-classifications/country-and-lending-groups>.

<sup>16</sup> Note that due to severe data constraints not all potential determinants could be captured in the empirical model. For example, poverty is excluded from the analysis due to scarcity of data, as data for more than one point in time are not always available. We follow common practice and employ per capita national income instead of a direct poverty measure (see Smith & Haddad, 2000, 2002). Indeed, several studies have confirmed the existence of a strong (negative) relationship between national incomes and poverty (see, for example, Ravallion & Chen, 1997).

<sup>17</sup> Note that also in the case of the Sustainable Development Goals (SDGs), which are to replace the MGDs by the end of 2015, achieving the internationally agreed targets on stunting in children under 5 years of age is still included as part of Goal 2 to “End hunger, achieve food security and improved nutrition, and promote sustainable agriculture”. More information on the SDGs can be found in the A/68/970 - Report of the Open Working Group on SGDs (available online at <https://sustainabledevelopment.un.org/focussdgs.html>).

underweight (or wasting), and it more accurately reflects nutritional deficiencies and illness that occur during early life (UNICEF, 2009).

According to UNICEF (2013), the focus has shifted toward stunting as the indicator of choice for measuring progress towards reducing undernutrition. Stunting is a measure of chronic, long-term undernutrition and seems to be particularly well suited for our longer-term empirical investigations. Although underweight and stunting prevalences show a similar pattern of change over time and both should give a good indication of the general nutrition condition in a country, factors associated with different measures of child's nutritional status may differ at the national level (see Frongillo et al., 1997). Therefore, we also assess if there are any difference in the determinant factors of underweight and stunting. The data on child's nutritional status is provided by the WHO Global Database on Child Growth and Malnutrition, which covers national child malnutrition prevalence estimates for children under-five years of age for many developing countries using available survey data since 1985.<sup>18</sup> The panel is unbalanced and the number of years for which data is available differs by country.

### 1. Underlying determinants model

In accordance with the conceptual model, three underlying determinants are considered in the baseline model: food security, care for mothers and children, and the health environment quality. Food security is represented by dietary energy supply (*DES*), which measures one dimension of food security, namely "*food availability*", and is our preferred food security measure that refers to the amount of food, expressed in kilocalories (kcal) per day, available for each individual in the total population.<sup>19</sup> It is calculated based on food balance sheets and caloric content is derived by applying the appropriate food composition factors to the quantities of the commodities consumed. Per person supplies are then derived from the total amount of food available for human consumption by dividing total calories by

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<sup>18</sup> The latest UNICEF-WHO-The World Bank joint child malnutrition estimates are available online at <http://www.who.int/nutgrowthdb/estimates/en/>.

<sup>19</sup> One also has to accept the inability of any one indicator to fully capture the complexity and multidimensionality of food security (FAO, 2013). For the sake of comparability with related studies on the issue (e.g. Smith & Haddad, 2000), which use *DES* as a proxy for food security in the baseline model, while we capture additional dimensions of food security in the sensitivity analysis section. For a complete list of variables used, and sources, see Table A.2 in the appendix.

total population actually partaking of the food supplies during the reference period (FAOSTAT). While subject to error (see Svedberg, 1999)<sup>20</sup>, this measure has been used in previous studies as a proxy for food availability and national food security and is, according to the FAO, one of the core indicators of food security closely linked to food consumption.<sup>21</sup> To account for the declining marginal effect of per capita dietary energy supply on child's nutritional status (see Smith & Haddad, 2000), we use the logarithm of DES in the empirical analysis.<sup>22</sup> The mean log per capita dietary energy supply is 7.79 (or 2443 kcal) for the sample of countries included in the underlying determinants model for stunting, ranging from 7.32 (or 1508.54 kcal for Eritrea in 2002) to 8.18 (or 3577.01 kcal for Turkey in 1993).<sup>23</sup> Since food security and nutritional status are potentially interlinked (as for example households where malnourishment is prevalent may be less productive food producers) or may simultaneously be caused by some third variable (e.g. a government policy targeting food security programs to areas with high malnutrition), we treat it as endogenous in the empirical analysis.

As comparable “*care for mothers and children*” measures are not available, we use female education (*FemaleEduc*) and women's status relative to men's (*Women'sStatus*) as proxies for this underlying determinant. These factors partly determine child and mothers' care, as described in equations (4) and (5). The education of women, which are mostly responsible for child care in developing countries, is expected to have several potentially positive effects for care and feeding practices for both mothers and children. Women that are more educated tend to be better able to acquire relevant nutrition knowledge, process the relevant child health – specific information and to adopt positive caring behaviors (Smith & Haddad, 2000; Ruel & Alderman, 2013).

We use gross female secondary school enrollment rates to measure women's education. This measure corresponds to the total female enrollment in secondary education, regardless

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<sup>20</sup> One also has to accept the inability of any one indicator to fully capture the complexity and multidimensionality of food security (FAO, 2013). For the sake of comparability with related studies on the issue (e.g. Smith & Haddad, 2000), which use *DES* as a proxy for food security in the baseline model, while we capture additional dimensions of food security in the sensitivity analysis section.

<sup>21</sup> See, for example, Frongillo et al., 1997; Smith & Haddad, 2000, 2001; FAO, 2005; Dawson & Sanjuán, 2011.

<sup>22</sup> Indeed, when including the squared value of *DES* in the regression, its coefficient is positive and significant.

<sup>23</sup> See Table A.3 in the appendix for the summary statistics of the variables included in the underlying determinants model.

of age, expressed as a percentage of the female population of official secondary education age (WDI). We prefer this measure to primary education, which is less variable across countries and presumably less directly related to mother and child care. The mean female secondary school enrollment rate is 51.34 per cent for the sample of countries included in the underlying determinants model for stunting, with a lowest rate of 2.74 for Burundi in 1987 and a highest rate of 117 in Uruguay in 2003.

Women's status relative to men's affects mothers' physical and mental health, their autonomy and confidence, as well as their control of their time and over household resources (Smith et al., 2003; Bhagowalia et al., 2012). As such, low women's status may restrict their ability to take care of themselves as well as to allocate resources to their children. Unfortunately, women's relative status comprises various aspects and is difficult to measure and good indicators are not readily available. We follow related studies on the issue (e.g. Smith & Haddad, 2000, 2001; Masters, 2013) and employ the female-to-male life expectancy ratio (based on WDI life expectancy data) as proxy for women's status relative to men's, where discrimination against women are expected to be reflected in lower life expectancy ratios.<sup>24</sup> The mean female-to-male life expectancy ratio is 1.06 for the sample of countries included in the underlying determinants model for stunting as well as for underweight.

The last underlying determinant of child's nutritional status, the "*health environment quality*", is captured by including access to improved water sources (% of population) (*WaterAccess*). Access to safe water reduces the incidence of waterborne illnesses, e.g. intestinal infections caused by parasites, and prevents the spread of illness, e.g. diarrhea, and is therefore expected to positively affect child's health and in turn nutritional status (Hoddinott, 1997). This variable is also highly correlated with other measures of the health environment quality, for example access to sanitation facilities, and should therefore

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<sup>24</sup> Although a very crude measure of gender status differences in a society, comparisons of mortality or life expectancies should "throw light on some of the coarsest aspects of gender-related inequality" (Sen, 1998, p. 10). Nevertheless, in the robustness section of this chapter, we assess the sensitivity of results with respect to alternative proxies for women's relative status.



constitute a reasonably good proxy for the overall health environment.<sup>25</sup> The mean population share with access to improved water sources is 76.25 for the whole sample, ranging from 15 to 100. Only slowly changing country difference in the health environment quality will partly be accounted for by including country fixed effects. Access to safe water may not be strictly exogenous, as unobserved factors (e.g. specific health related policies) may simultaneously affect access to safe water and child malnutrition. We account for this in the empirical analysis.

From the conceptual framework, we can summarize for the underlying determinants model:

$$\textit{Child Malnutrition} = f(\textit{Food availability}, \\ \textit{Care for mothers and children}, \textit{Health environment quality})$$

Moreover, from the above elaborations, we can summarize for the empirical specification of the underlying determinants model:<sup>26</sup>

$$\textit{Child Malnutrition} = f(\textit{Dietary energy supply}, \textit{Female education}, \\ \textit{Women's relative status}, \textit{Access to safe water}, \textit{Country fixed effects})$$

Mathematically, the underlying determinants model can be represented as follows:

$$CM_{i,t} = f(DES_{it}, FemaleEduc_{it}, Women'sStatus_{it}, WaterAccess_{it}, \mu_i) \quad (7)$$

Overall, the empirical analysis of the underlying determinants model makes use of 492 country-year observations for the prevalence of underweight and 473 country-year observations for the prevalence of stunting as child malnutrition indicator. The mean prevalence rates of underweight and stunting for the country sample of the underlying determinants model are 17.65 and 31.96, respectively.

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<sup>25</sup> Because of the greater data availability, we decided to choose this measure. Nevertheless, in the robustness section of the chapter, we show that the results are not sensitive to the choice of the health environment measure employed.

<sup>26</sup> For comparability and because our focus is on the basic determinants of child malnutrition, we use the same baseline model specification for the underlying determinants as in Smith & Haddad (2000). However, in the robustness section of the chapter, we show how the model can be extended to capture additional potentially relevant underlying determinants of child's nutritional status.

## 2. Basic determinants model

While we also assess the underlying determinants of child malnutrition in a rigorous empirical framework accounting for potential endogeneity, our focus is on the basic determinants of child's nutritional status and the impact of trade. With respect to the basic determinants of child malnutrition, which should directly affect or are expected to play a facilitating role in all of the underlying determinants, we employ per capita national income, measured as logged per capita real (chain-weighted) *GDP* (Penn World Table (PWT) 7.0), to broadly capture the *economic resource availabilities* of countries. Higher income is strongly associated with a reduction in poverty. It should improve the resources available for purchasing food and thus the ability to afford food security. Besides that, higher national income facilitates the public provision of clean water and sanitation and can be expected to positively affect the amount of resources dedicated to the improvement of a countries' health environment and services and education facilities (OECD, 2006; Cutler et al., 2006). The mean log per capita GDP is 8.13 for the sample of countries included in the basic determinants model for stunting, corresponding to \$3,395.<sup>27</sup> Because of a potential reverse causality problem, as malnutrition may adversely affect individual productivity and income earning possibilities and thus national income, we treat GDP per capita as endogenous in our empirical model specification.

The *political context* is (partly) accounted for by including the political regime as basic determinant of child's nutritional status. Democratic governments are more likely to care for the protection and effective realization of human rights – including the right to food (Haddad & Oshaug, 1998). Democracies may also be more willing to promote equal rights and status of men and women as well as access to education. Democratic nations have also been found to spend more on health care (see Gregorio & Gregorio, 2013). As a proxy for the strength of democratic institutions, we employ the Democracy-Dictatorship (DD) measure introduced by Alvarez et al. (1996) and extended by Cheibub et al. (2010). The DD variable (*DEMOC*) is dichotomous where a one indicates a democracy and a zero a non-democracy. A country is classified as a democracy if it satisfies four criteria: the chief executive is selected by a popular election or by a body which itself is chosen by a popular election, the legislature is

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<sup>27</sup> See Table A.3 in the appendix for the summary statistics of the variables included in the basic determinants model.

popularly elected, elections have more than one competing party, and an alternation of power has taken place under the same electoral rules that brought the incumbent to power (Cheibub et al., 2010). *Sociocultural factors* that may affect child malnutrition but which change only slowly over time can partly be accounted for by our employed econometric technique that accounts for unobserved heterogeneity.

These basic determinants of child's nutritional status have been accounted for in previous studies on the issue (see e.g. Smith & Haddad, 2000).<sup>28</sup> However, while the included democracy index broadly accounts for a country's political regime, it is only a part of the *policy environment* and does not capture other political factors, more directly affecting the underlying determinants and child's nutritional status. We therefore extend the basic determinants model in various directions. First, a country's trade policy has significant effects on the economy as a whole and, more specifically, on nutrition security. Trade openness may affect all of the underlying determinants of child malnutrition in various ways, as has been described in some detail in Section 2. Besides accounting for a country's political regime, we therefore also account for trade policy effects. As trade policy measure, we employ a trade openness indicator, which is proxied by the volume of trade (exports plus imports) over GDP (PWT 7.0) (*TradeOpen*). This revealed openness measure is the measure usually employed in impact studies of trade liberalization and is arguably better than de jure measures (e.g. tariffs) to the extent that the latter are difficult to summarize in a single indicator.<sup>29</sup> The mean trade-to-GDP ratio is 74.61 for the sample of countries included in the basic determinants model for stunting. We treat the trade openness measure as endogenous because of a potential reverse causality problem, as countries may adopt protectionist policies in response to past shocks to the nutritional status of the population.

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<sup>28</sup> The focus of these previous studies was largely on the underlying determinants of child's nutritional status, which may explain the fragmentary model specification in the case of the basic determinants model to some extent. Smith & Haddad (2000) note that omitted variables may be a problem in their basic determinants model, as a performed Ramsey RESET test for omitted variables bias rejects the absence of omitted variables.

<sup>29</sup> Among others, see Dollar, 1992; Dollar & Kraay, 2004; Chang et al., 2009; Loayza et al., 2012, who employed this indicator in cross-country analyses on the trade – poverty and trade – growth nexus. Moreover, this indicator is also used in the trade-environment literature (see e.g. Antweiler et al., 2001). Nevertheless, in the robustness section of the chapter, we assess the sensitivity of the results with regard to alternative trade policy measures.

Second, we account for the quality of governance to some extent by including a measure of political instability or, more precisely, political violence (*PoliticalViolence*). The existence of violent conflicts can be seen as a factor of vulnerability and may dramatically slow a country's development process (Collier et al., 2003). Already back in 1996, the World Food Summit recognized the establishment of a peaceful stable political, social and economic environment as a precondition for the achievement of food and nutrition security (Thomson & Metz, 1999). Recently, a number of studies pointed to the potential importance of governance for health and nutrition (see e.g. Halleröd et al., 2013; Haddad, 2012). We employ data on political violence provided by the Major Episodes of Political Violence (MEPV) database of the Center for Systemic Peace. Major episodes of political violence are defined by the systematic and sustained use of lethal violence by organized groups that result in at least 500 directly-related deaths over the course of the episode. We employ an intensity measure of political violence, which is the total sum of all societal and interstate political violence episodes, comprising international violence and warfare as well as civil and ethnic violence and warfare, where the magnitude of societal-systemic impact is measured on an eleven-point scale, from 0-10. The magnitude scores are considered consistent and comparable across categories and cases, that is, approximating a ratio scale.<sup>30</sup>

Political instability or the presence of violent conflicts may negatively affect all of the underlying determinants of child malnutrition, i.e. food security, mothers' and child care, and the health environment quality and access to healthcare services. First, conflicts are a major cause of structural food insecurity due to its adverse impacts on food supply from domestic production and on access to food by causing income losses and disrupting transport, trade and markets and thus domestic food chains (World Bank, 1986). Second, schools are destroyed and populations displaced from their homes or killed, leading to potential household dissolution and a separation of children from their caretakers and causing considerable psychological distress, all of which may adversely affect caring capacity (Engle et al., 1999; Wiesmann, 2006). Third, the health environment quality may be adversely affected, if health-care facilities are destroyed and access to medical supplies is impaired due to conflicts (see Green, 1994). The absence of violence, in contrast, should

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<sup>30</sup> The database as well as a detailed description of the construction of the violence measured is available online at <http://www.systemicpeace.org/inscrdata.html>.

create an enabling environment for the functioning of markets delivering important inputs for nutritional status. However, malnutrition may also lead to or exacerbate conflict, which is why it may not be strictly exogenous (see e.g. Pinstrup-Andersen & Shimokawa, 2008).

Third, we also account for the domestic macroeconomic policy quality, potentially affecting people's incentives and the allocation and utilization of resources in the economy. In line with the empirical literature (see e.g. Agénor, 2004, Roodman, 2007, and Loayza et al., 2012), we employ the consumer price index (CPI) inflation rate (WDI) as a proxy for macroeconomic instability (*MacroeconomicInstability*) (also related to monetary policy), with high inflation being associated with bad macroeconomic policy.<sup>31</sup> Previous studies have indicated that domestic (price) stabilization policies creating an economically stable environment are beneficial for growth, investment, and productivity and thus have welfare enhancing effects, whereas macroeconomic instability has been found to increase poverty, thereby potentially negatively affecting food and nutrition security.<sup>32</sup> Macroeconomic instability hurts the poor, as for example high inflation rates erode real wages and the assets of the poor (Ames et al. 2001). Easterly & Fischer (2001) indicate that the poor tend to mention inflation as a top national concern and find a significant association between lower inflation and improved well-being of the poor. It can therefore be expected that the domestic macroeconomic policy quality impacts on all of the underlying determinants of child's nutritional status and that macroeconomic instability potentially negatively affects the accessibility of factors in the production function for nutritional status.<sup>33</sup>

Fourth, we include the ratio of domestic credit provided by the banking sector to GDP (WDI) as a proxy for financial depth or, more generally, the financial development of a country (*FinancialDevelop*). This measure has *inter alia* been used in cross-country growth

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<sup>31</sup> As customary in the literature, the inflation rate enters the regressions as  $\log [1 + \text{inflation}]$ . Although macroeconomic instability generally involves more than inflation, the average inflation rate is commonly used to account for macroeconomic instability in empirical analyses as more comprehensive measures are not available for a large number of countries and years.

<sup>32</sup> See for example Agénor (2004) for the case of poverty and Ames et al. (2001) for general human development, or the food security case studies of Feleke et al. (2005) and Rena (2005), which identified a lack of purchasing power resulting from high inflation rates as one of the main causes of food insecurity in Ethiopia and Eritrea.

<sup>33</sup> Note that, although we use the inflation rate as a proxy for macroeconomic (price) stability, consumer price inflation may also directly affect the underlying determinants as it lowers purchasing power and may thus decrease access to important child nutrition inputs.

regressions to capture the role of structural policies and institutions and to study the impact of the degree of monetization in the economy (Loayza et al., 2012). The mean domestic credit provided by the banking sector to GDP ratio is 39.63.<sup>34</sup> Leite et al. (2002) consider financial development as part of a set of “super pro-poor” policies that directly affect the income of the poor after accounting for the effect of economic growth. It benefits the poor by facilitating access to credit and improving risk-sharing possibilities, allowing for consumption smoothing and investments in riskier but more productive technologies. Therefore, if the financial development of a country is positively associated with economic growth and better availability of credit, it may positively affect household expenditure levels on and access to adequate quantities and qualities of resources important for child’s nutritional status, e.g. food, education, and healthcare. For example, in the case of food security, the availability of (rural) credit allows for agricultural investments and potentially affects the supply response of producers to market signals and the potential of adopting new and more productive agricultural technologies. Financial development policies increasing the availability of financial services can therefore be expected to benefit agricultural production (World Bank, 2007). Besides that, case studies on the household level point to statistically significant impacts of access to credit (providing additional resources for the household) to measures of the healthiness of children (see e.g. Pitt et al., 2003).

From the conceptual framework, we can summarize for the basic determinants model:

$$\text{Child Malnutrition} = f(\text{Potential resources, Sociocultural factors, Economic context, Political environment})$$

Moreover, from the above elaborations, we can summarize for the empirical specification of the basic determinants model:

$$\text{Child Malnutrition} = f(\text{GDP, Democracy, Trade openness, Political violence, Macroeconomic instability, Financial Development, Country fixed effects})$$

Mathematically, the basic determinants model can be represented as follows:

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<sup>34</sup> Note that the *Financial Develop* variable can take on negative values as claims on the central government are a net item (claims on the central government minus central government deposits) (WDI).

$$CM_{it} = f(GDP_{it}, Democracy_{it}, TradeOpen_{it}, PoliticalViolence_{it}, MacroInstability_{it}, FinancialDevelop_{it}, \mu_i) \quad (8)$$

Overall, the empirical analysis of the basic determinants model makes use of 592 country-year observations for the prevalence of underweight and 473 country-year observations for the prevalence of stunting as child malnutrition indicator. The mean prevalence rates of underweight and stunting for the country sample of the basic determinants model are 17.17 and 31.47, respectively.

### 3. Transmission channels

According to the conceptual framework presented in Section 2, we hypothesize that the basic determinants affect malnutrition mainly through their impact on the underlying determinants. The specific linkages between trade and the underlying determinants have been described in detail in Section 2. The other basic determinants are expected to work through the same transmission channels. For example, GDP may reduce child malnutrition by increasing food security and by facilitating access to safe water and education, and potentially, by improving women's social status. To give an indication of the pathways of impact, we run separate fixed effects regressions for each of the underlying determinants with the basic determinants as explanatory variables, while also taking into account the potential endogeneity of some of the determinants. While not including other controls for the specific underlying determinants, the results should give an indication of the direction of impact of the basic on the underlying determinants.

Mathematically, the transmission channel equations can be represented as follows:

$$DES_{i,t} = f(GDP_{it}, Democracy_{it}, TradeOpen_{it}, PoliticalViolence_{it}, MacroInstability_{it}, FinancialDevelop_{it}, \mu_i) \quad (9)$$

$$FemaleEduc_{i,t} = f(GDP_{it}, Democracy_{it}, TradeOpen_{it}, PoliticalViolence_{it}, MacroInstability_{it}, FinancialDevelop_{it}, \mu_i) \quad (10)$$

$$Women'sStatus_{i,t} = f(GDP_{it}, Democracy_{it}, TradeOpen_{it}, PoliticalViolence_{it}, MacroInstability_{it}, FinancialDevelop_{it}, \mu_i) \quad (11)$$

$$WaterAccess_{i,t} = f(GDP_{it}, Democracy_{it}, TradeOpen_{it}, PoliticalViolence_{it}, MacroInstability_{it}, FinancialDevelop_{it}, \mu_i) \quad (12)$$

In the following, we present the estimation strategy for estimating the underlying and basic determinants models as outlined above.

(b) Empirical specification and estimation strategy

We employ two-step feasible efficient GMM estimation of the fixed-effects (FE) panel data model to a representative sample of 113 developing countries and the period 1985-2007 to study the underlying and basic determinants of child's nutritional status as well as the most important transmission channels through which the basic determinants affect child malnutrition. The advantage of this FE model specification is that any unobserved (country-specific) time-invariant factors, e.g. climate, geographic factors (e.g. characteristics of a countries' physical environment) or deeply rooted social or cultural factors, can be controlled for in order to eliminate any possibly spurious correlation between child malnutrition and the included explanatory variables (Smith & Haddad, 2002).<sup>35</sup> To account for potential endogeneity, we estimate the fixed effects model via GMM, taking advantage of the panel nature of the data and instrumenting for possibly endogenous regressors using lagged values of these regressors ("GMM-style instruments") in order to get consistent and efficient estimates of the effects. In the first step, the residuals of the (consistent but inefficient) one-step estimation are obtained, while in the second step GMM estimation is rerun with the moments weighted by the optimal weight matrix, which is constructed using the residuals from the first step estimation. In line with the conceptual framework outlined in Section 2, we model child malnutrition (*CM*) as a function of *K* explanatory variables, denoted *X*, separately for the underlying and basic determinant factors as described above. This ensures that variables lying at different levels of causality and determining each other

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<sup>35</sup> We employed a Hausman specification test, which tests for correlation between the country-specific effects and the covariates, to choose between the FE and random effects (RE) estimator. The test resulted in a rejection of the appropriateness of the RE estimator. Therefore, we use the consistent FE estimator in our empirical analysis.



are not included in the same regression equation.<sup>36</sup> Hence, in line with the theoretical considerations, the core specification takes the form:

$$CM_{i,t} = \alpha + \sum_{k=1}^K \beta_k X_{k,it} + \mu_i + \varepsilon_{i,t} \quad (13)$$

with  $i = 1, \dots, n; t = 1, \dots, T$  and  $\varepsilon_{i,t} \sim N(0, \sigma^2)$ ,

where the subscripts  $i$  and  $t$  represent country and time periods, respectively;  $CM$  denotes child malnutrition and is represented by the prevalence of stunting (among children under 5), which is our preferred measure of child's nutritional status, based on the discussion above. A child is considered stunted if its "height-for-age" is below minus two standard deviations from the median height for age of the reference population. For comparison, and to see if the determinants of the prevalence of stunting and underweight differ, we also report the results when the prevalence of underweight is used as child malnutrition indicator.  $X$  contains the set of potential determinants of child malnutrition, separately for the underlying and basic determinants model, as has been described above. Finally,  $\mu_i$  denotes unobserved country-specific effects, while  $\varepsilon_{i,t}$  is the stochastic error term.<sup>37</sup> The FE specification implies that the following equation is estimated, where original variables are transformed into deviations from country-specific means:

$$CM_{i,t} - \overline{CM}_i = \sum_{k=1}^K \beta_k (X_{k,it} - \overline{X}_{k,i}) + (\varepsilon_{i,t} - \overline{\varepsilon}_i) \quad (14)$$

, where the time-invariant country-specific effects drop out of the model. This model can consistently be estimated via Ordinary Least Squares (OLS), if the explanatory variables are uncorrelated with the error term. However, in case of endogenous explanatory variables this assumption will be violated. Therefore, we use instrumental variables techniques to estimate equation (14) consistently, as will be described in more detail below. The average time span between the first and last observations for our undernutrition measures is about

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<sup>36</sup> Smith & Haddad (2000) explain in more detail why it is important to distinguish between the different levels of causality in case of the determinants of child malnutrition to avoid underestimation of the impact of determinants lying at a broader level of causality, which may partly be picked up by the variables they determine.

<sup>37</sup> Note that due to the unbalanced nature of our panel, we do not include period dummies in our model specification. These are not appropriate, because any particular year or even group of years (e.g. a decade) is not available for all countries in our sample, such that their inclusion would misrepresent the time-specific effects for the sample (see Smith & Haddad, 2000).

12 years, such that results of the FE model for the underlying and basic determinants can be interpreted as a medium to long-run impact.

Although we account for unobserved heterogeneity by using a FE specification, potential endogeneity may render the estimation results inconsistent. Endogeneity may arise from various sources, for example the presence of reverse causality, the omission of important explanatory variables (if they are correlated with the included variables), the simultaneous determination of the dependent and independent variables by some third unobserved variable, or measurement error in variables (see Baltagi, 2008). As has been described above, based on economic reasoning, endogeneity may indeed be a problem for some of the underlying and basic determinants of child malnutrition. We take this into account by estimating the above equations using IV/GMM estimation techniques, where we use sufficiently lagged observations of the potentially endogenous variables as instruments to ensure that the direction of causality runs from the explanatory variables to child malnutrition (and not vice versa). In the first stage, each endogenous variable is regressed on all of the exogenous variables in the model (including the excluded instruments). In the second stage, the original equation is estimated using the predicted values for each endogenous variable from the first stage regression. In efficient GMM estimation, an optimal weighting matrix for the moment conditions (instruments) is used. It weighs the moment conditions by a consistent estimate of their covariance matrix, or more specifically, weighs the moments in inverse proportion to their variances and covariances, such that highly correlated instruments get less weight in the estimation process. The optimal weight matrix thus attaches more weight to the moments that contain more unique identifying information, improving efficiency of the estimates (see Roodman, 2009).

The employed instruments should be both *valid*, i.e. orthogonal to the errors, and *relevant*, i.e. sufficiently correlated with the endogenous regressors. To ensure that the model does not suffer from serious misspecification, we perform several specification tests, which are described in the following.

First, we have to note that for the regression equation to be estimable, it must be identified. This implies that the rank condition must be satisfied, i.e. the matrix of regressors including

the instruments is of full column rank. Put simply, the rank condition requires that the canonical correlations between the groups of endogenous regressors and excluded instruments is nonzero. This implies that we need to test the rank of a matrix (Baum et al., 2007). We employ the Kleibergen-Paap rk Lagrange multiplier (LM) test to test for underidentification. The Kleibergen-Paap rk LM statistic can be seen as a generalization of the Anderson's (1951) canonical correlations test (testing the null that the smallest canonical correlation is zero) to the case of non-i.i.d. errors (see Kleibergen and Paap, 2006). Rejection of the null hypothesis that the equation is underidentified implies that the matrix is full column rank, i.e. the model is identified (Baum et al., 2007).

Second, the endogenous regressors should be relevant determinants of the variable of interest, in our case child malnutrition. To test for the significance of the endogenous regressors in the structural equation being estimated, we report the p-value of the Anderson-Rubin (1949) F-test of the first-stage regression, which provides weak-instrument robust inference for testing the joint significance of the endogenous regressors in the structural equation being estimated (Baum et al., 2007). Rejection of the null hypothesis that the coefficients of the endogenous regressors in the main equation are jointly equal to zero indicates that the endogenous regressors are relevant determinants of child malnutrition.

Third, we note that even in the case that underidentification can be rejected, weak instruments may still be a problem. To test for instrument relevance, we employ a weak identification test suited for IV regressions. Weak identification arises when the excluded instruments are correlated with the endogenous regressors, but only weakly. The consequence of the employment of instruments that are only weakly correlated with the endogenous variables is increased bias in the estimated coefficients (Stock & Wright, 2000).<sup>38</sup> Correlation of the instruments with the endogenous regressors can be assessed by an examination of the significance of the excluded instruments in the first-stage IV regression, which are reduced form regressions of the endogenous variables on the full set of instruments (Baum et al., 2007). Specifically, to test for weak identification, we report the Kleibergen-Paap rk Wald F statistic and compare it to the critical values compiled by Stock &

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<sup>38</sup> For a more detailed discussion of the weak-instruments problem in GMM estimation, see Stock et al. (2002) and Baltagi (2008).

Yogo (2005).<sup>39</sup> We test the null hypothesis that the maximal bias in the coefficient estimates for the potentially endogenous regressors is greater than 5 (or 10) per cent relative to OLS, in which case the estimator may be only weakly identified. Rejection of the null indicates the absence of a weak-instruments problem.<sup>40</sup>

Fourth, to test for validity of the orthogonality conditions, we employ Hansen's (1982) J-test of overidentifying restrictions. If the equation is overidentified (i.e. the number of excluded instruments exceeds the number of included endogenous regressors), the "Hansen test" tests the null of joint validity of the moment conditions (full set of instruments), which amounts to testing the exogeneity of the covariates. Specifically, it tests whether the vector of empirical moments is randomly distributed around zero. The Hansen J-test for over identification of all instruments is robust to heteroskedasticity and within-group correlation. The joint null hypothesis that the instruments are valid instruments, i.e. uncorrelated with the error term, and that the excluded instruments are correctly excluded from the estimated equation, should not be rejected (Baum et al., 2007).

#### **4. EMPIRICAL RESULTS**

In this section, we present the empirical results for the two-step feasible efficient GMM estimation of the underlying and basic determinants models as well as for the transmission channels.

##### **(a) Baseline model estimation results**

First, we present the estimation results of the underlying determinants model, second, the estimation results of the basic determinants model, and finally the results for the transmission channels.

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<sup>39</sup> This procedure is recommended by Baum et al. (2007) to test for weak instruments in the case of non-i.i.d. errors. Alternatively, one could refer to the "rule of thumb" of Stock & Yogo (1997), which states that the F statistic should be at least 10 for weak identification not to be considered a problem (Baum et al., 2007).

<sup>40</sup> Note that we also tested subsets of instruments for redundancy using an LM version of the Kleibergen Paap rk statistic (see Breusch et al., 1999). Excluded instruments can be considered redundant if the asymptotic efficiency of the estimation is not improved by including them. "Too many" instruments can cause the estimator to have poor finite-sample performance. Thus, dropping redundant instruments should lead to a more reliable estimation (Roodman, 2009). We ended up with, on average, two instruments per endogenous variable.

## 1. Underlying determinants model estimation results

Table 1 shows the estimation results of the core underlying determinants regression model for stunting using the full sample and our preferred specification, which is the two-step feasible efficient GMM (EGMM) estimator robust to the presence of arbitrary heteroskedasticity.<sup>41</sup> To test the sensitivity of the regression results, in Column 2 and 3 we present alternative consistent estimators, both addressing the econometric problems induced by unobserved country-specific effects and endogeneity resulting from reverse causation, spurious correlation, or measurement error. Below, we explain in more detail how the model specifications differ. For comparison, we also present results for the fixed effects (FE) estimator, which is inconsistent in the presence of endogeneity.

The estimation results for the baseline underlying determinants model and the prevalence of *stunting* as dependent variable are presented in Column 1. All performed specification tests support the model specification. The Kleibergen-Paap rk Wald F-statistic indicates a rejection of the null that the maximal bias in the coefficient estimates for the potentially endogenous regressors exceeds 5 per cent, indicating the absence of weak identification. The underidentification LM test clearly rejects the null that the equation is underidentified, indicating that the matrix is full column rank, i.e., the model is identified. The Anderson-Rubin (1949) test also rejects the null hypothesis that the coefficients of the endogenous regressors in the structural equation are jointly equal to zero, indicating the significance of the endogenous regressors in the structural equation. Lastly, the Hansen J test of overidentifying restrictions cannot reject the null hypothesis is that the instruments are valid instruments, i.e., uncorrelated with the error term, and that the excluded instruments are correctly excluded from the estimated equation (see Baum et al., 2007). Thus, the whole instrument set can be considered valid.<sup>42</sup>

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<sup>41</sup> To test for heteroskedasticity, we employed Pagan and Hall's (1983) test of heteroskedasticity for IV estimation, which clearly rejected the null hypothesis of homoscedasticity.

<sup>42</sup> Additionally, we performed a Ramsey/Pesaran-Taylor regression error specification test (RESET) for omitted variables after IV regression (see Schaffer, 2005), which could not reject the null hypothesis that there are no "omitted variables" or, more specifically, no neglected nonlinearities in the choice of the functional form, lending further support to the model specification.

The direction of impact of the underlying determinants on *stunting* are as expected. Dietary energy supply (in logs), proxying for food security, works to reduce the prevalence of stunting significantly. A one percent increase in *DES* reduces the prevalence of stunting by 0.21 (=21.32/100) percentage points. This corresponds to an elasticity at the sample mean of -0.667. A quite low 0.047 increase in log *DES* is needed to reduce stunting by one percentage point, only 5.44 percent of its developing country range, corresponding to about 112 kcal. Female education also helps to reduce stunting significantly. The coefficient of -0.2089 corresponds to an elasticity at the developing country sample mean of -0.336. An increase of the female secondary school enrolment rate of 4.79 would *ceteris paribus* reduce the prevalence of stunting by one percentage point, only 4.19 percent of the variables' range. An improvement in gender equality as represented by an increase in women's relative status also reduces stunting significantly. The coefficient of the female-to-male life expectancy ratio corresponds to an elasticity of -2.318. An increase of this ratio by 0.0144 reduces stunting by one percentage point, about 5.96 percent of its range. Finally, the last underlying determinants, access to safe water, also significantly negatively affects the prevalence of stunting, with an elasticity of around -0.376. A 6.34-point increase of the percentage of the population having access to an improved drinking water source reduces stunting by one percentage point, about 7.46 percent of its range. In line with the hypothesized relationships outlined in the conceptual framework, the results presented in Column 1 therefore speak in favor of a favorable impact of the underlying determinants on child malnutrition as represented by stunting.

Table 1: *The effect of the underlying determinants on child stunting*

Depvar: Prevalence of stunting	(1)	(2)	(3)	(4)
	FE-EGMM (baseline)	FE-EGMM with HAC standard errors	GMM-CUE	FE
DES (log)	-21.3167*** (7.6591)	-21.2773*** (7.9875)	-21.3460*** (7.6817)	-12.42 (8.257)
FemaleEduc	-0.2089*** (0.0379)	-0.2082*** (0.0421)	-0.2088*** (0.0380)	-0.228*** (0.0530)
Women'sStatus	-69.5700*** (23.9516)	-69.4034*** (25.6138)	-69.8126*** (24.1083)	-57.94** (28.58)
WaterAccess	-0.1577*** (0.0509)	-0.1582*** (0.0536)	-0.1577*** (0.0509)	-0.192*** (0.0675)
Observations	473	473	473	486
Number of countries	111	111	111	117
Prob > F	0.000	0.000	0.000	0.000
R-squared	0.3570	0.3570	0.3569	0.3650
Kleibergen-Paap rk Wald F-stat	91.25 <sup>++</sup>	85.49 <sup>++</sup>	91.25 <sup>++</sup>	
<i>Tests (p-values)</i>				
Underidentification test	0.000	0.000	0.000	
Anderson-Rubin F-test	0.000	0.000	0.000	
Hansen J statistic	0.723	0.719	0.726	

Notes: <sup>++(+)</sup> of the Kleibergen-Paap rk Wald F-statistic indicates a rejection of the null that the maximal bias in the coefficient estimates for the potentially endogenous regressors exceeds 5 (10) per cent. Rejection of the null supports our model specification for the Underidentification and Anderson-Rubin F-test, whereas the null should not be rejected in case of the Hansen test. HAC stands for heteroskedastic and autocorrelation-consistent. GMM-CUE refers to the continuously updated GMM estimator (CUE) of Hansen, Heaton, and Yaron (1996). See text for details. Numbers in parentheses are robust standard errors.

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

The results of the alternative consistent estimators presented in Columns 2-4 support the above findings. In Column 2, we show the results for the underlying determinants model employing the two-step EGMM estimator additionally correcting for possibly autocorrelated errors, i.e. using HAC (heteroskedasticity- and autocorrelation-consistent) standard errors. For this purpose, we use the asymptotically optimal QS (quadratic spectral) kernel (see Andrews, 1991) to estimate the covariance matrix of orthogonality conditions.<sup>43</sup> The results only very marginally change, which gives further support for the baseline model results. In line with this finding, a performed Cumby-Huizinga (1992) test for autocorrelation did not reject the null hypothesis of no autocorrelation.<sup>44</sup> Note that when we re-estimate the model with HAC standard errors, the Hansen J-test of overidentifying restrictions is “robustified” as well, lending greater credence to the appropriateness of our instrument set (Baum et al., 2007).

In Column 3, we present the results for the underlying determinants model employing the "continuously-updated" GMM estimator (CUE) of Hansen, Heaton & Yaron (1996). In this case, the second-step minimization does not treat the weighting matrix of orthogonality conditions as a constant matrix but as a function of estimated coefficients, such that estimation of the covariance matrix of orthogonality conditions and estimation of the GMM estimator is done simultaneously. The CUE estimator provides no asymptotic efficiency gains over two-step GMM and has the disadvantage that it requires numerical optimization (Baum et al., 2007). However, recent research suggests that their finite-sample performance may be superior in the presence of weak instruments (Hahn et al., 2004). The results of the GMM-CUE estimator are very similar to the FE-EGMM model results, showing the robustness of the estimation results as regards the estimation methodology. This gives us greater confidence that the baseline model results are not affected by weak identification.

Additionally to these alternative consistent estimators, in Column 4, we present the estimation results using a conventional FE estimator that is inconsistent in the presence of

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<sup>43</sup> We set the bandwidth, which specifies the number of lags of the autocovariances included in the estimation, equal to  $T^{1/3}$  (here:  $22^{1/3}$ , roughly equal to 3), a common choice of bandwidth according to Greene (2008). Note that variation of the bandwidth (e.g. using  $T^{1/4}$ , here: roughly equal to 2 or  $T^{1/2}$ , here: roughly equal to 5, also common choices of the bandwidth) did not change the results.

<sup>44</sup> As the finite sample properties of the HAC estimator may be inferior in some circumstances as revealed by Cushing & McGarvey (1999), we stick to the baseline model specification throughout the study.



endogeneity. As can be seen, the magnitude and significance of the underlying determinants differs when using this inconsistent estimator, even rendering the effect of food availability on child stunting insignificant. We attribute this outcome to the fact that food availability cannot be considered exogenous in the underlying determinants model of child malnutrition, because food availability and nutritional status are almost certainly interlinked. For example, households where malnourishment is prevalent may be less productive food producers, leading to reverse causality. Similarly, food availability and malnutrition may simultaneously be caused by some third variable, e.g. a government policy targeting food security programs to areas with high malnutrition. In line with this reasoning, a performed endogeneity test for *DES*, defined as the difference of two Hansen statistics, clearly rejects the null hypothesis that *DES* (specified as endogenous) can actually be treated as exogenous. This result reveals the inherent danger in not taking this endogeneity into account and employing inconsistent estimation techniques.

The estimation results for the baseline underlying determinants model and the prevalence of *underweight* as dependent variable are presented in Column 1 of Table 2. The results are similar to the case of stunting, but the magnitude of impact of the underlying determinants is somewhat smaller, being partly related to the fact that underweight has a substantially lower sample mean compared to stunting. Dietary energy supply works to reduce the prevalence of underweight significantly. A one percent increase in *DES* reduces the prevalence of stunting by 0.162 percentage points. An increase of 0.062 in log *DES* is needed to reduce stunting by one percentage point, about 7.15 percent of its range, corresponding to about 147 kcal. Female education also helps to reduce underweight significantly. The coefficient of -0.145 corresponds to an elasticity at the developing country sample mean of -0.42. An increase of the female secondary school enrolment rate of 6.89 would *ceteris paribus* reduce the prevalence of underweight by one percentage point, about 6.04 percent of the variables' range. An improvement in the empowerment of women also reduces underweight significantly. The coefficient of the female-to-male life expectancy ratio corresponds to an elasticity of -2.32. An increase of this ratio by 0.026 reduces underweight by one percentage point, about 10.77 percent of its range. Finally, the last underlying determinant, access to safe water, also significantly negatively affects the prevalence of underweight, with an elasticity at the developing country sample mean of around -0.507. An

8.54-point increase of the percentage of the population having access to safe water reduces underweight by one percentage point, about 10.05 percent of its range.

The magnitudes of the effects are comparable to those of Smith & Haddad (2000) for a considerably smaller sample of 63 countries and the period 1970 to 1996. Therefore, taking the prevalence of underweight as measure of child undernutrition does not change the conclusion of a favorable impact of the underlying determinants on child's nutritional status. Interestingly, the effects of all of the underlying determinants is stronger for child stunting compared to underweight. In light of the fact that stunting generally remains a problem of greater magnitude than underweight, the relatively strong impact of food availability, child and mothers' care as well as the health environment quality lets us conclude that governments of developing countries should pay high attention to the improvement of these factors to improve the nutrition security of their population.

As in the case of stunting as dependent variables, the results of the alternative consistent estimators presented in Columns 2 and 3 support the above findings for the prevalence of underweight and speak in favor of the robustness of our results with respect to the employment of alternative consistent estimators. Again, in addition to these alternative consistent estimators, in Column 4, we present the estimation results using the FE estimator, which we should not give much credence, as it is inconsistent in the presence of endogeneity. In line with the hypothesized relationships outlined in the conceptual framework, the results presented in Tables 1 and 2 therefore speak in favor of a favorable impact of all of the underlying determinants on child's nutritional status. In following, we present the estimation results of the basic determinants model.

Table 2: <i>The effect of the underlying determinants on child underweight</i>				
Depvar: Prevalence of underweight	(1)	(2)	(3)	(4)
	FE-EGMM (baseline)	FE-EGMM with HAC standard errors	GMM-CUE	FE
DES (log)	-16.19*** (4.795)	-16.1529*** (5.2990)	-16.1873*** (4.7959)	-0.00384* (0.00225)
FemaleEduc	-0.145*** (0.0281)	-0.1446*** (0.0346)	-0.1448*** (0.0281)	-0.161*** (0.0555)
Women'sStatus	-38.53** (16.40)	-38.4103** (17.7781)	-38.5360** (16.4096)	-33.55 (24.77)
WaterAccess	-0.117*** (0.0382)	-0.1177*** (0.0427)	-0.1175*** (0.0382)	-0.133*** (0.0461)
Observations	492	492	492	505
Number of countries	111	111	111	117
Prob > F	0.000	0.000	0.000	0.000
R-squared	0.3624	0.3625	0.3624	0.3661
Kleibergen-Paap rk	88.38 <sup>++</sup>	84.96 <sup>++</sup>	88.38 <sup>++</sup>	
Wald F-stat				
<i>Tests (p-values)</i>				
Underidentification test	0.000	0.000	0.000	
Anderson-Rubin F-test	0.000	0.000	0.000	
Hansen J statistic	0.943	0.944	0.943	

Notes: <sup>++</sup>(<sup>+</sup>) of the Kleibergen-Paap rk Wald F-statistic indicates a rejection of the null that the maximal bias in the coefficient estimates for the potentially endogenous regressors exceeds 5 (10) per cent. Rejection of the null supports our model specification for the Underidentification and Anderson-Rubin F-test, whereas the null should not be rejected in case of the Hansen test. HAC stands for heteroskedastic and autocorrelation-consistent. GMM-CUE refers to the continuously updated GMM estimator (CUE) of Hansen, Heaton, and Yaron (1996). See text for details. Numbers in parentheses are robust standard errors.

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

## 2. Basic determinants model estimation results

Table 3 shows the estimation results of the core basic determinants regression model for stunting and the full sample, employing the two-step feasible efficient GMM (EGMM) estimator. In Columns 2 and 3, we present the alternative consistent estimators of the model and in Column 4 the results of the fixed effects (FE) estimator, which is inconsistent in the presence of endogeneity.

The estimation results for the baseline basic determinants model and the prevalence of *stunting* as dependent variable are presented in Column 1. All performed specification tests support the model specification. The Kleibergen-Paap rk Wald F-statistic indicates the absence of a weak identification and the Hansen J test of overidentifying restrictions confirms the validity of the whole instrument set. We also performed a Ramsey's regression error specification test (RESET) for omitted variables, which could not reject the null hypothesis that there are no "omitted variables" or, more specifically, no neglected nonlinearities, lending further support to the model specification.<sup>45</sup> The explanatory power of the basic determinants model is comparable to the case of the underlying determinants.

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<sup>45</sup> As the RESET test is not available after FE-GMM estimation, we had to run the test on the model without fixed effects but with clustering by country, using the `ivreg2` command in Stata (see Baum et al., 2007). The RESET test returned a p-value of 0.8526, clearly not rejecting the null of no neglected non-linearities.

Table 3: *The effect of the basic determinants on child stunting*

Depvar: Prevalence of stunting	(1)	(2)	(3)	(4)
	FE-EGMM (baseline)	FE-EGMM with HAC standard errors	GMM-CUE	FE
GDP (log)	-9.6333*** (1.7118)	-9.5795*** (1.7869)	-10.0115*** (1.7420)	-9.524*** (1.940)
Democracy	-1.5639 (1.5096)	-1.5537 (1.5010)	-1.5828 (1.5148)	-1.104 (1.238)
TradeOpen	-0.0914*** (0.0230)	-0.0909*** (0.0243)	-0.0880*** (0.0231)	-0.0891*** (0.0259)
MacroInstability	5.2590*** (0.8499)	5.2032*** (0.8655)	5.2289*** (0.8477)	5.440*** (0.907)
PoliticalViolence	0.7831** (0.3646)	0.8313** (0.3839)	0.8272** (0.3672)	0.428* (0.245)
FinancialDevelop	-0.0605*** (0.0200)	-0.0608*** (0.0215)	-0.0599*** (0.0201)	-0.0588*** (0.0218)
Observations	473	473	473	480
Number of countries	113	113	113	117
Prob > F	0.000	0.000	0.000	0.000
R-squared	0.3557	0.3548	0.3542	0.3610
Kleibergen-Paap rk Wald F-stat	14.84 <sup>++</sup>	14.51 <sup>++</sup>	14.84 <sup>++</sup>	
<i>Tests (p-values)</i>				
Underidentification test	0.000	0.000	0.000	
Anderson-Rubin F-test	0.000	0.000	0.000	
Hansen J statistic	0.180	0.183	0.195	

Notes: <sup>++(+)</sup> of the Kleibergen-Paap rk Wald F-statistic indicates a rejection of the null that the maximal bias in the coefficient estimates for the potentially endogenous regressors exceeds 5 (10) per cent. Rejection of the null supports our model specification for the Underidentification and Anderson-Rubin F-test, whereas the null should not be rejected in case of the Hansen test. HAC stands for heteroskedastic and autocorrelation-consistent. GMM-CUE refers to the continuously updated GMM estimator (CUE) of Hansen, Heaton, and Yaron (1996). See text for details. Numbers in parentheses are robust standard errors.

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Overall, the direction and significance of the effect of the basic determinants on stunting are as expected, except for the case of the democracy indicator, which fails to be statistically significant when stunting is used as malnutrition indicator.<sup>46</sup> The FE-GMM results also point to a negative causal effect of national income on the prevalence of stunting. A ten per cent increase in GDP per capita leads, on average, to a 3.1 per cent reduction in the prevalence of stunting. This magnitude is somewhat smaller than the 4.5 per cent recently reported by the World Bank (2013), using FE regression but not accounting for the endogeneity of income and the other determinants we consider in our baseline model. This confirms previous findings pointing to the importance of income for the reduction of undernutrition, but at the same time suggests that the effect may be smaller than previously found, when the endogeneity of income and other potential determinants of stunting are accounted for. Our democracy index fails to be a significant determinant in the case of stunting, raising some doubts that the presence of democratic institutions helps to reduce child undernutrition, at least in the case of stunting.<sup>47</sup>

Coming to the focus variable of our study, trade openness, we find that an increase in a countries' openness does significantly reduce the prevalence of stunting. The coefficient of -0.0914 corresponds to an elasticity at the sample mean of -0.217. An increase of the trade-to-GDP ratio of 10.94 would *ceteris paribus* reduce the prevalence of stunting by one percentage point, only 5.38 percent of the variables' range. This effect is statistically and economically significant. For example, would Cameroon be as open to trade as Ghana, all else equal, it could reduce its prevalence of stunting by about 6 percentage points from currently 32.6 to 26.6 per cent. This could be achieved, for example, through a reduction in applied tariffs, which are currently at a high level of 18.9%<sup>48</sup>.

The results regarding the other explanatory variables also conform to our expectations. Macroeconomic instability, measured as the consumer price inflation, leads to an increase in

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<sup>46</sup> Note that this result does not seem to be caused by possibly high correlation between the democracy indicator and our political instability indicator, which are negatively correlated, albeit not highly (with a correlation coefficient of only - 0.13). This is confirmed by our empirical results for the prevalence of underweight, in which case democracy turns out to be a significant determinant.

<sup>47</sup> Note that also the employment of other democracy indicators, e.g. the well-known Freedom House indicators of political rights and civil liberties or the democracy measure drawn from the POLITY project, did not change the results.

<sup>48</sup> This value is the simple mean applied tariff rate for all traded products of Cameroon in 2012 (WDI).

stunting. The coefficient of 5.259 corresponds to an elasticity of 0.167. An increase of about two per cent in the price inflation rate leads to an increase of one percentage point in stunting. Besides that, political instability leads to an increase in the prevalence of stunting. The coefficient of 0.78 for the intensity of political violence corresponds to an elasticity of 0.162. The magnitude of societal-systemic impact is measured on an eleven-point scale, from 0-10. An increase of 1.28 points in this ratio scale leads to an increase of stunting by one percentage point. Finally, the last basic determinant, the level of financial development of the country as proxied by domestic credit provided by the banking sector (% of GDP), significantly negatively affects the prevalence of stunting. A 16.52-point increase of this ratio reduces stunting by one percentage point, about 5.4 percent of its range. This finding suggests that the development of the financial sector leading to better provision of financial services and increased access to credit may help to reduce undernutrition in developing countries. In summary, we find for the basic determinants of child stunting that an increase in national income, the openness and the financial development of a country have a favorable impact on child's nutritional status, whereas political and macroeconomic instability leads to increasing child undernutrition.

The employment of alternative consistent estimators presented in Columns 2 and 3 of Table 3 only marginally changes the results and leads to the same conclusions. Again, for comparison, we present the estimation results using the FE estimator, which is inconsistent in the presence of endogeneity, in Column 4. Unlike the case of the underlying determinants models, the FE results point in the same direction in case of the basic determinants, whereas the coefficient estimates are less precise. Overall, these additional results support the credibility of our baseline model results for the basic determinants of stunting.

Table 4: *The effect of the basic determinants on child underweight*

Depvar: Prevalence of underweight	(1)	(2)	(3)	(4)
	FE-EGMM (baseline)	FE-EGMM with HAC standard errors	GMM-CUE	FE
GDP (log)	-7.1043*** (1.2444)	-7.1625*** (1.2925)	-7.1072*** (1.2539)	-6.964*** (1.389)
Democracy	-2.5097** (1.1627)	-2.4741** (1.1882)	-2.5312** (1.1657)	-1.228 (0.836)
TradeOpen	-0.0605*** (0.0159)	-0.0599*** (0.0165)	-0.0616*** (0.0159)	-0.0520*** (0.0175)
MacroInstability	2.4222*** (0.6203)	2.3760*** (0.6296)	2.3920*** (0.6289)	2.538*** (0.663)
PoliticalViolence	0.5999*** (0.2075)	0.6030*** (0.2260)	0.5981*** (0.2078)	0.559*** (0.176)
FinancialDevelop	-0.0311** (0.0121)	-0.0307** (0.0132)	-0.0309** (0.0121)	-0.0320** (0.0158)
Observations	489	489	489	496
Number of countries	113	113	113	117
Prob > F	0.000	0.000	0.000	0.000
R-squared	0.3264	0.3268	0.3259	0.3350
Kleibergen-Paap rk Wald F-stat	26.72 <sup>++</sup>	25.49 <sup>++</sup>	26.72 <sup>++</sup>	
<i>Tests (p-values)</i>				
Underidentification test	0.000	0.000	0.000	
Anderson-Rubin F-test	0.000	0.000	0.000	
Hansen J statistic	0.638	0.611	0.646	

Notes: <sup>++(+)</sup> of the Kleibergen-Paap rk Wald F-statistic indicates a rejection of the null that the maximal bias in the coefficient estimates for the potentially endogenous regressors exceeds 5 (10) per cent. Rejection of the null supports our model specification for the Underidentification and Anderson-Rubin F-test, whereas the null should not be rejected in case of the Hansen test. HAC stands for heteroskedastic and autocorrelation-consistent. GMM-CUE refers to the continuously updated GMM estimator (CUE) of Hansen, Heaton, and Yaron (1996). See text for details. Numbers in parentheses are robust standard errors.

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1



The estimation results for the baseline basic determinants model and the prevalence of *underweight* as dependent variable are presented in Column 1 of Table 4. As can be seen in the lower part of the table, the model specification is supported by all available specification tests, such that specification error or poor instruments do not appear to be driving the results. The results are similar to the case of stunting, with the noticeable exception of the democracy indicator being a significant determinant in the case of underweight. The FE-GMM results also point to a negative causal effect of national income on the prevalence of underweight. A ten per cent increase in GDP per capita leads, on average, to a 4.3 per cent reduction in the prevalence of underweight. This confirms our above finding for stunting and again points to the importance of general economic development for the fight against malnutrition. Unlike in the case of stunting, democracy turns out to be a significant determinant of the prevalence of underweight. According to this result, democracies tend to have lower underweight prevalences. This confirms earlier findings of Smith & Haddad (2000) and may be explained by the fact that underweight captures both chronic and *acute* undernutrition and democracies can be expected to put more weight on ensuring the right to health and the right to food and to intervene in the presence of acute nutrition security shocks.

An increase in a country's openness to trade does significantly reduce the prevalence of underweight. The coefficient of -0.06 corresponds to an elasticity at the sample mean of -0.28. An increase of the trade-to-GDP ratio of 16.52 (5.68 percent of the variables' range) would, *ceteris paribus*, reduce the prevalence of underweight by one percentage point. This effect is statistically and economically significant, however, somewhat smaller compared to the case of stunting. Macroeconomic instability, again, leads to a deterioration of a country's nutrition security. The same is true for political instability, which also leads to an increase in the prevalence of underweight. The magnitudes of impact are somewhat smaller compared to the case of stunting. Lastly, a country's financial development significantly improves nutrition security as indicated by the underweight prevalence, confirming the above finding that the provision of financial services and increased access to credit helps to reduce undernutrition in developing countries. The results of the alternative consistent estimators presented in Table 4 confirm the above findings. In summary, national income, a country's openness and financial development have a favorable impact on child's nutritional

status, whereas political and macroeconomic instability leads to increasing child undernutrition, regardless if measured as stunting or underweight prevalence. The favorable effect of democratic institutions for child's nutritional status could be confirmed only for the case of underweight capturing chronic and *acute* undernutrition, possibly showing that democracies are more willing to intervene in the presence of acute instances of undernutrition. Despite being theoretically ambiguous, the hypothesis that trade openness positively affects nutrition security receives clear empirical support. This implies that trade liberalization policies, increasing the volume of trade, have the potential to improve the nutritional status of a country's population. Overall, the impact of the basic determinants is relatively strong for the prevalence of stunting, which is good news in light of the fact that stunting generally remains a problem of greater magnitude than underweight in most developing countries.

### 3. Transmission channel estimation results

According to the conceptual framework presented in Section 2, we hypothesize that the basic determinants affect malnutrition mainly through their impact on the underlying determinants. To give an indication of the pathways of impact, we run separate fixed effects regressions for each of the underlying determinants with the basic determinants as explanatory variables, while also taking into account the potential endogeneity of some of the determinants (see Eqs. (9) to (12)). While not including other controls for the specific underlying determinants, the results should give an indication of the direction of impact of the basic on the underlying determinants.

The results for the effects of the basic on the underlying determinants are displayed in Table 5. It shows the causal pathways through which each of the basic determinants affects child's nutritional status. Column 1 documents the effect of GDP, democracy, trade openness, macroeconomic and political instability, and financial development on food security, represented as dietary energy supply. To estimate the effects, we employ the two-step FE-GMM estimator, accounting for unobserved heterogeneity and potential endogeneity. For example, we treat the trade openness measure as endogenous because of a potential reverse causality problem, as countries may adopt protectionist policies in response to past food security shocks. The same is true for political violence, as food insecurity may also lead

to or exacerbate conflict, which is why it may not be strictly exogenous. We use sufficiently lagged observations of the potentially endogenous variables as instruments. As can be seen in the lower part of the table, all available specifications tests support the model specification, although it proved difficult to find suitable instruments in the case of women's relative status, as revealed by the Hansen J statistic, only marginally accepting the validity of the instrument set.

The estimation results reveal that national income, democratic institutions and trade openness significantly positively affect food security, whereas macroeconomic instability and political violence are detrimental for food security. The potential trade – food security linkages have been described in some detail in Section 2. The statistically significant positive impact of trade openness on food security leads us to conclude that the benefits of trade outweigh the costs when the objective is to attain national food security. It shows that an open trade policy leads to a significant increase in national food availability.<sup>49</sup>

All of the basic determinants also affect female education, measured as female secondary school enrollment. While GDP per capita, democracy, trade openness and a country's financial development have a favorable impact on female education, macroeconomic and political instability lead to a decrease in female secondary school enrollment rates. The positive effect of a country's openness on educational attainment supports the findings of Schultz (2006) and Oostendorp & Doan (2013) that opening up the economy for trade is associated with improvements in women's employment opportunities and consequently leads to a greater accumulation of human capital.

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<sup>49</sup> This confirms previous case study results on the impact of trade liberalization on national food security (see e.g. Dorosh, 2001; Dorosh et al., 2009)

Table 5: *The effect of the basic on the underlying determinants (transmission channels)*

Depvar:	DES (log)	FemaleEduc	Women'sStatus	WaterAccess
	(FE-EGMM)	(FE-EGMM)	(FE-EGMM)	(FE-EGMM)
GDP (log)	0.1244*** (0.0066)	21.2284*** (1.4846)	0.0082*** (0.0028)	10.4937*** (1.0905)
Democracy	0.0147*** (0.0047)	6.1220*** (0.8380)	0.0156*** (0.0044)	7.6548*** (0.7329)
TradeOpen	0.0005*** (0.0001)	0.1056*** (0.0156)	-0.0001 (0.0001)	0.0882*** (0.0114)
MacroInstability	-0.0160*** (0.0059)	-4.8755*** (1.0379)	0.0043 (0.0033)	-2.4982*** (0.8960)
PoliticalViolence	-0.0066*** (0.0012)	-0.5297** (0.2587)	0.0012 (0.0011)	-0.4412** (0.2200)
FinancialDevelop	-0.0001 (0.0001)	0.0587*** (0.0123)	0.0001** (0.00004)	0.0352*** (0.0097)
Observations	2,406	2,347	2,263	2,134
Number of countries	115	114	115	113
Prob > F	0.000	0.000	0.000	0.000
R-squared	0.2666	0.3035	0.1496	0.2655
Kleibergen-Paap rk	13.80 <sup>+</sup>	39.34 <sup>++</sup>	62.48 <sup>++</sup>	15.99 <sup>++</sup>
Wald F-stat				
<i>Tests (p-values)</i>				
Underidentification test	0.000	0.000	0.010	0.000
Anderson-Rubin F-test	0.000	0.000	0.000	0.000
Hansen J statistic	0.227	0.363	0.083*	0.543

Notes: <sup>++</sup>(<sup>+</sup>) of the Kleibergen-Paap rk Wald F-statistic indicates a rejection of the null that the maximal bias in the coefficient estimates for the potentially endogenous regressors exceeds 5 (10) per cent. Rejection of the null supports our model specification for the Underidentification and Anderson-Rubin F-test, whereas the null should not be rejected in case of the Hansen test. See text for details. Numbers in parentheses are robust standard errors.

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

As documented in Column 3, the explanatory power of the basic determinants for women's relative status, indicating the degree of gender equality, is relatively low. Only income, whether a country is a democracy, and financial depth seem to affect women's status significantly, while the other determinants exert no significant impacts. Other factors, for example unobserved social and cultural factors, may play a greater role for women's social status than the ones captured here, or the female-to-male life expectancy ratio is an imperfect proxy for women's relative status.

Focusing on the last underlying factor, the health environment quality and services, represented by access to safe drinking water, we find that national income, a country being a democracy, a country's openness and financial development has a positive impact, while macroeconomic instability and political conflicts negatively affect water access. The positive effect of democracy is in line with the findings of Smith & Haddad (2000) and Gregorio & Gregorio (2013), implying that democratic governments are more willing to direct budgets to improvements in the health environment quality. Furthermore, the results lend some support to the hypothesis that trade policy affects nutritional status also through its effect on the health environment and the availability of healthcare services. As has been described in Section 2, increased interaction with other countries can be associated with better health outcomes, if trade facilitates the accumulation of health-relevant knowledge, for example knowledge about appropriate treatments for disease and good health practices, as well as technology spillovers, for example access to new medical technologies. Besides that, openness to trade can be associated with sound economic policies and impact positively on the quality of institutions that themselves may create a policy environment that is conducive to improved health, for example the development of healthcare systems and better access to healthcare for the poor. Our results of a positive impact of a country's openness on the health environment quality support this view.

In summary, the findings for the pathways of influence are in line with the conceptual framework presented in Section 2, which hypothesized that the basic determinants affect malnutrition through their impact on the underlying determinants. The results of our transmission channel analysis confirm the presence of important pathways for all of the basic determinants. In the following, we perform some additional analyses to assess the

sensitivity of our basic determinants model results to the sample composition, alternative economic liberalization measures, and to the employment of additional variables potentially determining child malnutrition or modifying the trade openness – malnutrition relationship.

#### (b) Sensitivity analysis for basic determinants model

In this section, we perform some additional robustness checks for the basic determinants model and the impact of trade openness. The sensitivity with respect to the estimation methodology was part of the last section. In the following, we test the robustness of the results with respect to the sample composition, to the employment of alternative trade policy/openness indicators, to the inclusion of additional explanatory variables.

##### **1. Are the results sensitive to the country sample composition?**

In the following, we test the sensitivity of the baseline basic determinants model results with respect to the sample composition. First, we have to note, that although it would be interesting to assess the influence of specific structural country constraints or characteristics, it proves difficult to do so within our modeling framework as these characteristics are mainly time-invariant or change only very slowly over time. These characteristics may include geographic features or specific agro-climatic constraints (e.g. weather-related) of a country, which may affect the underlying determinants and accordingly child's nutritional status. As such, we have to assume that these effects are accounted for by the inclusion of country specific fixed effects.

Countries from the following regions are captured in the baseline model analysis, based on the country classification as suggested by the World Bank: East Asia & Pacific, Developing Europe & Central Asia, Latin America & the Caribbean, Middle East & North Africa, South Asia, and Sub-Saharan Africa. In order to test whether the results are driven by the presence of observations from a specific region in the sample, we perform a regional jackknife analysis, in which all countries from a particular region are dropped from the analysis one at a time. The results for child stunting are displayed in Table 6 and for child underweight in Table 7.

Table 6: *Regional jackknife analysis for the basic determinants model and stunting*

Sample without:	East Asia & Pacific	Europe & Central Asia	Latin America & Caribbean	Middle East & North Africa	South Asia	Sub Saharan Africa
Depvar: Prevalence of stunting	(FE-EGMM)	(FE-EGMM)	(FE-EGMM)	(FE-EGMM)	(FE-EGMM)	(FE-EGMM)
GDP (log)	-8.9218*** (1.9076)	-11.236*** (1.6691)	-9.1886*** (2.0832)	-8.7174*** (1.7520)	-7.6055*** (1.6699)	-12.5873*** (2.5012)
Democracy	-0.8017 (1.6101)	-0.9751 (1.5161)	-1.8285 (1.7047)	-1.5080 (1.4950)	-1.8794 (1.3294)	-2.2605 (2.6307)
TradeOpen	-0.0998*** (0.0294)	-0.1044*** (0.0224)	-0.0788*** (0.0254)	-0.1072*** (0.0227)	-0.0789*** (0.0229)	-0.0813** (0.0379)
MacroInstability	5.4489*** (0.8887)	5.5656*** (0.8195)	4.9394*** (1.0447)	5.3885*** (0.9108)	5.2806*** (0.8355)	4.2503*** (1.3066)
PoliticalViolence	0.7955** (0.4038)	0.6573* (0.3561)	0.9590** (0.4706)	0.5942*** (0.2172)	0.8019** (0.3572)	0.5962 (0.4368)
FinancialDevelop	-0.0613*** (0.0227)	-0.0594*** (0.0188)	-0.0861*** (0.0244)	-0.0718** (0.0282)	-0.0427** (0.0172)	-0.0505** (0.0198)
Observations	417	423	348	428	430	317
Number of countries	100	97	89	102	107	70
Prob > F	0.000	0.000	0.000	0.000	0.000	0.000
R-squared	0.2806	0.4177	0.3399	0.3670	0.3579	0.3937
Kleibergen-Paap rk Wald F-stat	19.89 <sup>++</sup>	18.70 <sup>++</sup>	22.39 <sup>++</sup>	12.73 <sup>++</sup>	23.21 <sup>++</sup>	13.26 <sup>++</sup>
<i>Tests (p-values)</i>						
Underidentification test	0.000	0.000	0.000	0.000	0.000	0.000
Anderson-Rubin F-test	0.000	0.000	0.000	0.000	0.000	0.000
Hansen J statistic	0.306	0.176	0.135	0.173	0.174	0.630

Notes: <sup>++(+)</sup> of the Kleibergen-Paap rk Wald F-statistic indicates a rejection of the null that the maximal bias in the coefficient estimates for the potentially endogenous regressors exceeds 5 (10) per cent. Rejection of the null supports our model specification for the Underidentification and Anderson-Rubin F-test, whereas the null should not be rejected in case of the Hansen test. See text for details. Numbers in parentheses are robust standard errors.

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

The results reveal that none of the regions substantially drives the results. The individual exclusion of each region leaves the coefficient of trade openness significant in all cases and similar in magnitude for most of the cases. Focusing first on stunting, the results show that the trade openness coefficient is significant at the 1% level in all cases, except in case of the exclusion of Sub-Saharan African countries, where it nevertheless remains significant at the 5% level. The magnitude of the impact of trade is greatest with the exclusion of Middle East and North African countries, which may be seen as evidence that the trade openness effect in these countries is somewhat smaller. Conversely, the magnitude of the trade effect is smallest with the exclusion of Latin America & the Caribbean and similarly with the exclusion of South Asia, which can be taken as evidence that the trade openness effect in these countries is somewhat larger compared to the other regions. Only in the case of the exclusion of Sub Saharan African countries, the largest category, political instability turns insignificant. It is difficult to say, however, if this is due to the substantially reduced sample size or if it indicates that political factors play a significantly greater role for nutrition security in these countries. The results look similar for the case of child underweight as the dependent variable, with the trade openness coefficient being a highly significant determinant in all of the cases. The democracy indicator turns insignificant in case of the exclusion of Sub Saharan African countries, which may, again, be caused by the strongly reduced sample size or indicate that the political regime plays a significantly greater role for nutrition security in these countries.

Overall, the results are not very sensitive to the choice of the sample composition, suggesting that our findings are not driven by regional differences in the sample countries. Next, we are going to assess the robustness of our basic determinants model results to the choice of the trade policy/openness indicator employed.



Table 7: *Regional jackknife analysis for the basic determinants model and underweight*

Sample without:	East Asia & Pacific	Europe & Central Asia	Latin America & Caribbean	Middle East & North Africa	South Asia	Sub Saharan Africa
Depvar: Prevalence of underweight	(FE-EGMM)	(FE-EGMM)	(FE-EGMM)	(FE-EGMM)	(FE-EGMM)	(FE-EGMM)
GDP (log)	-7.2735*** (1.5137)	-8.7419*** (1.3427)	-7.7853*** (1.4717)	-7.0610*** (1.3793)	-5.5537*** (1.1110)	-6.4033*** (1.7726)
Democracy	-2.4188* (1.3425)	-2.5630** (1.2165)	-3.2663** (1.2916)	-2.4209** (1.1526)	-2.3091*** (0.8677)	-0.9951 (1.6644)
TradeOpen	-0.0544*** (0.0199)	-0.0586*** (0.0161)	-0.0554*** (0.0189)	-0.0675*** (0.0146)	-0.0558*** (0.0139)	-0.0831*** (0.0213)
MacroInstability	2.4791*** (0.6410)	2.5641*** (0.6181)	2.8541*** (0.7258)	2.4804*** (0.6434)	2.5943*** (0.6752)	1.2676** (0.5850)
PoliticalViolence	0.7480** (0.3036)	0.4921** (0.2120)	0.5251** (0.2510)	0.6210*** (0.2202)	0.5615*** (0.1880)	0.6446** (0.2577)
FinancialDevelop	-0.0291** (0.0134)	-0.0274** (0.0118)	-0.0606*** (0.0175)	-0.0333** (0.0152)	-0.0170* (0.0090)	-0.0249** (0.0107)
Observations	417	443	355	445	443	336
Number of countries	100	97	89	102	107	70
Prob > F	0.000	0.000	0.000	0.000	0.000	0.000
R-squared	0.2576	0.3607	0.3524	0.3524	0.3786	0.3699
Kleibergen-Paap rk Wald F-stat	29.68 <sup>++</sup>	24.79 <sup>++</sup>	23.03 <sup>++</sup>	29.29 <sup>++</sup>	26.53 <sup>++</sup>	21.34 <sup>++</sup>
<i>Tests (p-values)</i>						
Underidentification test	0.000	0.000	0.000	0.000	0.000	0.000
Anderson-Rubin F-test	0.000	0.000	0.000	0.000	0.000	0.000
Hansen J statistic	0.854	0.301	0.810	0.445	0.940	0.224

Notes: <sup>++</sup>(<sup>+</sup>) of the Kleibergen-Paap rk Wald F-statistic indicates a rejection of the null that the maximal bias in the coefficient estimates for the potentially endogenous regressors exceeds 5 (10) per cent. Rejection of the null supports our model specification for the Underidentification and Anderson-Rubin F-test, whereas the null should not be rejected in case of the Hansen test. See text for details. Numbers in parentheses are robust standard errors.

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

## 2. Are the results sensitive to the trade policy/openness measure used?

In order to see whether the results only apply to the specific openness measure used, we re-estimate the basic determinants model with alternative trade policy indicators. For brevity and because the results for underweight showed no differences, we only report the results for stunting, depicted in Table 8. The volume of trade used as the basis of our trade openness measure is an outcome measure in principle related to trade policy, but not exclusively so. As a first alternative, we therefore employ a structure-adjusted trade openness measure that tries to strengthen the outcome-policy connection and captures the portion of trade volume not due to structural country characteristics such as population size, area, oil wealth, and access to the sea.<sup>50</sup> As shown in Column 1, this policy measure of openness is significantly negatively related with child stunting as well, providing further evidence that trade liberalization is on average beneficial for nutrition security.

The focus of the present study is on the economic component of globalization as the benefits of globalization are expected to flow mainly from trade (see FAO, 2003). Additionally, as globalization is not only an economic phenomenon and trade openness measures may not fully capture other aspects of globalization or openness of a country, for example people or ideas flows, a multivariate approach to measuring globalization is used. In Column 2 of Table 8, we report the results when the KOF index of globalization is used instead of our trade openness measure. It is a more comprehensive measure of globalization that measures three dimensions (economic, political and social) and combines them into one index (Dreher, 2006). Economic globalization includes information on actual flows such as trade and foreign direct investment (FDI), and data on restrictions such as import barriers and taxes on international trade. Political globalization includes information on membership in international organizations and international treaties. The social component of the globalization index includes data on personal contact, information flows and cultural proximity.<sup>51</sup> As the results show, this more comprehensive measure of openness has a

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<sup>50</sup> It is calculated as the residual of a regression of the trade to GDP ratio, on the logs of land area and population, and dummies for oil exporting and landlocked countries. For a more detailed description of the rationale behind the construction of this policy openness measure, see Chang et al. (2009), who applied this measure in the context of cross-country growth regressions.

<sup>51</sup> See Figure A.1 in the appendix for a representation of the different components included in the KOF globalization index. For a more detailed representation of the globalization index and its different components, see Dreher, 2006, updated in Dreher, Gaston & Martens, 2008.

negative impact on the prevalence of stunting as well, supporting the view that general openness and integration into the world economy is beneficial for a country's nutrition security. Note that the drop in the coefficient of GDP can be expected, as some of the components of the KOF index of globalization are highly correlated with national income. Globalization generally affects nutrition security through the same pathways as trade openness, while the effect of improved access to information may be better captured by the globalization index, which includes data on the social component of openness. This result is in line with findings of other related studies pointing to beneficial effects of globalization for economic growth (see e.g. Dreher, 2006), for absolute poverty (see Bergh & Nilsson, 2014) and health (see Bergh & Nilsson, 2010), and for gender equality (see Potrafke & Ursprung, 2012).

An alternative way, which has been considered in the previous empirical literature on trade liberalization impacts, is to classify countries as closed or open and to analyze if there are differences in outcome measures based on this classification. For this purpose, we use the Sachs-Warner policy openness measure, which classifies economies as closed (0) or open (1), based on the level of average tariff rates, non-tariff barriers, the black market exchange rate, and if a state monopoly on major exports or a socialist economic system exists.<sup>52</sup> The results in Column 3 show that, controlling for the level of economic development and the basic determinants, open economies based on this classification have significantly lower stunting prevalences compared to closed ones. In addition, we try to assess if it is both an open policy environment and trade-related aspects of openness that affect nutrition security simultaneously. To test this idea, we include the two measures of openness simultaneously—our volume based measure of openness and the Sachs-Warner policy openness measure. The results depicted in Column 4 show that both the trade and policy indicator of openness retain its positive favorable effect on nutritional status. We interpret the continued significance of the volume-based and the policy-based measure of openness as an indication that both direct trade related aspects of openness as well as an open policy environment simultaneously affect nutritional status.

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<sup>52</sup> We use the data provided by Wazciarg & Welch (2008), which extends the Sachs and Warner (1995) data to the 1990s, while accounting for some of the pitfalls of this openness indicator first identified by Rodríguez & Rodrik (2000).

Table 8: *Employing alternative trade policy/openness indicators*

Depvar: Prevalence of stunting	Policy openness	KOF Index of globalization	Sachs- Warner (SW) openness indicator	SW openness indicator & TradeOpen	Tariffs	Agricultural distortions
	(FE- EGMM)	(FE-EGMM)	(FE-EGMM)	(FE- EGMM)	(FE- EGMM)	(FE- EGMM)
GDP (log)	-9.4011*** (1.7010)	-6.6346*** (1.9611)	-10.6523*** (1.9238)	-9.2518*** (1.7549)	-10.449*** (3.4654)	-15.0800*** (2.8888)
Democracy	-1.4099 (1.5091)	-0.7538 (1.4768)	-2.1578 (1.5978)	-1.1393 (1.6042)	-1.0523 (2.6579)	-1.5775 (2.1433)
Policy openness	-0.0939*** (0.0222)				-0.0558*** (0.0139)	-0.0831*** (0.0213)
Globalization		-0.2787*** (0.0557)				
SW openness (+TradeOpen)			-2.7912*** (1.0276)	-2.2118** (1.0533)		
Tariffs					-0.0749*** (0.0263)	
Ag. distortions					0.1994*** (0.0366)	4.7524* (2.5835)
MacroInstability	5.2190*** (0.8492)	3.9964*** (0.9923)	4.7048*** (0.9934)	5.2143*** (0.9428)	3.7096** (1.8887)	8.2557** (3.4968)
PoliticalViolence	0.7730** (0.3629)	0.7526** (0.3676)	0.7284* (0.3754)	0.6096* (0.3523)	0.8919** (0.4515)	1.3787** (0.7009)
FinancialDevelop	-0.0612*** (0.0198)	-0.0530*** (0.7526**)	-0.0710** (0.0328)	-0.0713** (0.0285)	-0.0641** (0.0306)	-0.0217 (0.0253)
Observations	473	469	434	434	144	168
Number of countries	113	112	99	99	42	37
Prob > F	0.000	0.000	0.000	0.000	0.000	0.000
R-squared	0.3601	0.3797	0.3365	0.3755	0.5141	0.4289
Kleibergen-Paap rk Wald F-stat	15.03 <sup>++</sup>	14.65 <sup>++</sup>	16.86 <sup>++</sup>	19.06 <sup>++</sup>	6.766 <sup>+</sup>	5.282
<i>Tests (p-values)</i>						
Underidentification test	0.000	0.000	0.000	0.000	0.001	0.000
Anderson-Rubin F- test	0.000	0.000	0.000	0.000	0.000	0.000
Hansen J statistic	0.159	0.305	0.752	0.831	0.776	0.237

Notes: <sup>++(+)</sup> of the Kleibergen-Paap rk Wald F-statistic indicates a rejection of the null that the maximal bias in the coefficient estimates for the potentially endogenous regressors exceeds 5 (10) per cent. Rejection of the null supports our model specification for the Underidentification and Anderson-Rubin F-test, whereas the null should not be rejected in case of the Hansen test. See text for details. Numbers in parentheses are robust standard errors.

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Moreover, as a more direct policy indicator of trade openness, we employ a tariff measure and assess its impact on child stunting. Tariffs continue to be a significant source of trade restrictiveness in many developing countries (Hoekman & Nicita, 2011). We use the mean applied tariff rate as tariff measure, which is the average of effectively applied rates for all products subject to tariffs calculated for all traded goods (WDI).<sup>53</sup> As shown in Column 5, applied tariffs are associated with a significant increase in child stunting, with a 5-percentage point increase in tariffs leading to a one-percentage point increase in stunting. As it can be argued that a reduction of protectionist policies and trade barriers such as tariffs lead to freer trade and in a sense more open economies, this finding lends further support to the hypothesis that trade openness is beneficial for a country's nutrition security. One caveat that has to be issued for the results using applied tariffs is the substantially reduced sample size. Related to this, it proved difficult to find a strong instrument set as revealed by the Kleibergen-Paap rank Wald F-statistic, which indicates that the maximal bias of the instrumental variables estimates exceeds 5%. However, the bias is still not excessive, being at less than 10%.

The vast majority of the poorest and food-insecure households in developing countries are living in rural areas, with their earnings often depressed by pro-urban and anti-agricultural biases implemented by their government policies. Even today, many of these trade-reducing price distortions remain intersectorally as well as within the agricultural sector (Anderson & Valenzuela, 2008). It has also been found that distortions to agriculture in particular are detrimental for economic growth in many developing countries, especially in Sub Saharan Africa (see Anderson & Brückner, 2012). Despite our focus being on the general trade openness of a country, additionally we try to assess if distortions in the agricultural sector affect child undernutrition.<sup>54</sup> Therefore, in the last column of Table 8, we employ a comprehensive measure of a country's agricultural distortions, the Trade Bias Index (TBI), obtained from the World Bank database of Distortions to Agricultural Incentives. The TBI is

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<sup>53</sup> Note that, when the effectively applied rate is unavailable, the most favored nation rate is used instead. To the extent possible, specific rates have been converted by the World Bank to their ad valorem equivalent rates and have been included in the calculation of simple mean tariffs (WDI).

<sup>54</sup> Note that the net effect of trade policy changes that impact differently on the various sectors of the economy may be very different from what might be deducted by just looking at the changes directed to agriculture (see e.g. Valdés & Foster, 2002, and Anderson, 2002). This justifies our focus on the overall openness of a country to trade.

calculated on the basis of the average nominal rates of assistance for the import-competing and exportable parts of the agricultural sector. It takes the value of zero when the import-competing and export sub-sectors are equally assisted, and approaches the lower bound of -1 in the most extreme case of an anti-trade policy bias (Anderson & Valenzuela, 2008). Note that we use the inverse of this index, such that an increase in the index corresponds to an increase in agricultural distortions. Although the sample size is reduced substantially, we still find a marginally significant positive impact of agricultural distortions on child stunting. The same caveat as above applies here, as the maximal bias of the instrumental variables exceeds 10%, indicating somewhat weaker instruments. Nevertheless, the results point to detrimental effects of distorting agricultural trade policy measures, a result that should spur further investigations in future research.

We conclude from the additional results using alternative indicators of a country's trade policy/openness that, on average, economic openness is beneficial for child's nutritional status.

### 3. Incorporating additional explanatory variables

We tried to build a comprehensive model for the basic causes of child malnutrition, based on the conceptual framework outlined in Section 2, with our focus being on the macro-level policy drivers. However, there may be a number of additional factors determining child's nutritional status on the basic determinants level or potentially modifying the trade openness – malnutrition relationship. In this section, we assess the sensitivity of our results to the employment of additional control variables and additional political factors potentially affecting the results. Recalling that different measures of child undernutrition may have different determinants, we report both the results for stunting in Table 9 and for underweight in Table 10.

First, we additionally control for the degree of urbanization of a country as part of the economic structure. Urbanization has been one of most visible macroeconomic developments during the past decades. People living in urban areas may have better access to more and higher diversified food, schools as well as to improved water sources. Besides that, the poorest countries are typically predominantly rural and malnutrition is generally

more prevalent in rural areas (FAO, 2003). Because of its nonlinear effect, we include the logarithm of the urban population share, defined as the percent of people living in urban areas as defined by national statistical offices (WDI). The results are depicted in Column 1 of Table 9 and 10. They show that the urban population share has a negative impact on child malnutrition, indicating favorable effects of urbanization on child's nutritional status, presumably through better access to important inputs for nutritional status, for example food and health services. Therefore, although not being uncontroversial (see e.g. Ruel et al., 1999), the benefits of urbanization in that it provides better access to essential goods and services seem to outweigh potential detrimental effects associated with additional population pressure. Our urbanization measure, however, is very highly correlated with GDP, which is not surprising, as urbanization tends to go hand in hand with economic development. Accordingly, the coefficient of GDP loses some of its magnitude when the urban population share is included as additional control variable. The other results remain largely unchained.

Second, we add the annual population growth rate (in logs, WDI) as control variable to the basic determinants model. Annual population growth is intended to capture broadly one important facet of a country's demographic development, leading to growing food requirements and potentially being associated with time constraints in mother and child care, thereby potentially negatively affecting child's nutritional status. Besides that, population pressures have effects on development more generally, for example education rates and employment opportunities as well as various environmental consequences for e.g. cropland and water availability, with potential repercussions on food and nutrition security. The coefficient of the population growth rate is positive, but only marginally significant for both stunting and underweight, indicating small negative effects of high population growth for child's nutritional status.

Third, the level of infrastructure development in a country may affect the functioning of markets and access to food, education, and better health care services. We use the percentage of paved roads (WDI) as a proxy for infrastructure development. Moreover, infrastructure development can significantly reduce transaction costs, facilitate trade and promote market integration. Conversely, lack of an accurate physical and information

infrastructure may reduce efficiency and hamper a country's ability to participate in and benefit from trade-related activities (FAO, 2003). Therefore, inclusion of public infrastructure provision as an additional control may also modify the trade openness – malnutrition relationship. The number of observations, however, is reduced significantly when this variable is included as it is available only from 1990 onwards and for a smaller set of countries. It was therefore not included in the baseline model. Nevertheless, the results depicted in Column 3 of Tables 9 and 10 show that the infrastructure development has a significantly negative impact on child malnutrition, as it increases access to important inputs into child's nutritional status. One caveat that has to be mentioned for the reliability of these results is that the Kleibergen-Paap rk Wald F-statistic indicates that the maximal bias of the instrumental variables estimates exceeds 5%, pointing to somewhat weak instruments. However, the bias is still not excessive, being at less than 10%.

Fourth, a growing literature has recognized the existence of potential linkages between trade and foreign direct investment (FDI) for developing countries. FDI may be seen as an additional driving force of economic globalization, proxying for financial integration, and the amount of FDI targeted at developing countries is steadily increasing. Larger inflows of FDI can lead to higher volumes of trade as well as other benefits such as increased productivity and overall economic growth, and improvements in the quality of institutions (Aizenman & Noy, 2006; Alfaro et al., 2010; Bekaert et al., 2011). However, the effects of FDI on important dimensions of the quality of life such as health conditions have so far largely been neglected in the literature (Blonigen and O'Fallon, 2011). Nevertheless, FDI could have an effect on nutrition security, if it contributes to economic growth and leads to increased employment opportunities and higher wages, in turn increasing access to food and the demand for health services. Foreign direct investments can make more highly processed foods available to more people and have the potential to lower prices, open up new purchasing channels and increase sales (Hawkes, 2005). However, FDI may also be associated with potential negative effects, as the popular notion of "land grabs" suggests, in which case FDI may be detrimental for the food and nutrition security of the affected population (see e.g. Deininger et al., 2011). We test if FDI has an effect on malnutrition or modifies the openness – malnutrition relationship by adding per capita FDI, measured as net inflows of foreign direct investment divided by the total population (WDI), as additional basic determinant to the model. Despite



a reduced number of observations, the results depicted in Column 4 show a significantly negative effect of per capita FDI on malnutrition, which is only marginally significant in the case of stunting but highly significant for underweight. These findings suggest that the positive effects outweigh the potential negative effects of FDI when the goal is to improve child's nutritional status. The effect of trade openness is not affected by including FDI as additional basic determinant of child malnutrition.

In summary, we find that some other factor, which may be considered as part of the economic and political environment, potentially affect child malnutrition. These factors include the provision of public infrastructure and the availability of foreign direct investment, which have not been considered in previous studies on child's nutritional status. It thus seems to be that both trade and a beneficial policy and institutional environment play a role when it comes to the goal of achieving nutrition security. A bunch of studies found that a country's openness to trade exerts a positive impact on that country's institutional quality, in particular on institutions that focus on economic features such as corruption, the rule of law, and government effectiveness and that institutional quality in turn positively affects trade (see Islam & Montenegro, 2002; Rodrik et al., 2004; Acemoglu & Robinson, 2006). Considering this, the positive effects of trade openness and institutional factors on nutrition security, can be expected to reinforce each other. Besides that, the demographic development of a country, including the degree of urbanization and population growth, are shown to affect child malnutrition, which should be further elaborated in future research. Nevertheless, also controlling for these additional factors leaves the results of our baseline basic determinants model largely unchanged and trade openness remains a highly significant determinant of nutritional status.

Table 9: *Incorporating additional explanatory variables for stunting*

Depvar: Prevalence of stunting	Urban population share  (FE-EGMM)	Population growth rate  (FE-EGMM)	Public infrastructure  (FE-EGMM)	Foreign direct investment  (FE-EGMM)
GDP (log)	-7.7557*** (1.6996)	-10.794*** (1.7015)	-6.2774*** (2.2169)	-7.6412*** (2.1571)
Democracy	-0.8400 (1.4499)	-1.8430 (1.4908)	-2.5881 (1.7052)	-1.7244 (1.5508)
TradeOpen	-0.0823*** (0.0236)	-0.0784*** (0.0247)	-0.0997*** (0.0301)	-0.0906*** (0.0289)
MacroInstability	4.9771*** (0.8271)	5.4746*** (0.8097)	6.5732*** (1.2137)	5.6102*** (1.3637)
PoliticalViolence	0.7794** (0.3540)	0.5722 (0.3712)	0.7094 (0.5192)	0.7805** (0.3605)
FinancialDevelop	-0.0541*** (0.0189)	-0.0626*** (0.0192)	-0.0567** (0.0280)	-0.0631** (0.0276)
Urbanization	-10.824*** (3.3013)			
Population growth		3.0454* (1.7201)		
Infrastructure			-0.3386*** (0.0751)	
FDI				-0.7173* (0.4360)
Observations	471	452	368	403
Number of countries	113	107	93	101
Prob > F	0.000	0.000	0.000	0.000
R-squared	0.3884	0.4120	0.3944	0.4006
Kleibergen-Paap rk Wald F-stat	12.70 <sup>++</sup>	12.20 <sup>++</sup>	9.496 <sup>+</sup>	13.73 <sup>++</sup>
<i>Tests (p-values)</i>				
Underidentification test	0.000	0.000	0.000	0.000
Anderson-Rubin F- test	0.000	0.000	0.000	0.000
Hansen J statistic	0.139	0.215	0.718	0.856

Notes: <sup>++(+)</sup> of the Kleibergen-Paap rk Wald F-statistic indicates a rejection of the null that the maximal bias in the coefficient estimates for the potentially endogenous regressors exceeds 5 (10) per cent. Rejection of the null supports our model specification for the Underidentification and Anderson-Rubin F-test, whereas the null should not be rejected in case of the Hansen test. See text for details. Numbers in parentheses are robust standard errors.

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Table 10: *Incorporating additional explanatory variables for underweight*

Depvar: Prevalence of underweight	Urban population share  (FE-EGMM)	Population growth rate  (FE-EGMM)	Public infrastructure  (FE-EGMM)	Foreign direct investment  (FE-EGMM)
GDP (log)	-5.9809*** (1.2276)	-7.6368*** (1.3085)	-6.3359*** (1.4456)	-4.9421*** (1.6340)
Democracy	-1.8761* (1.0505)	-2.7511** (1.1750)	-2.6791** (1.0504)	-1.7844 (1.1368)
TradeOpen	-0.0516*** (0.0141)	-0.0558*** (0.0156)	-0.0699*** (0.0190)	-0.0578*** (0.0175)
MacroInstability	2.2425*** (0.6147)	2.6085*** (0.6340)	2.5764*** (0.9880)	0.9723 (0.8086)
PoliticalViolence	0.4535** (0.1990)	0.4714** (0.2108)	0.6540** (0.3022)	0.5161** (0.2441)
FinancialDevelop	-0.0250** (0.0104)	-0.0300*** (0.0108)	-0.0210* (0.0123)	-0.0261* (0.0147)
Urbanization	-8.5249*** (1.9980)			
Population growth		2.5199* (1.3332)		
Infrastructure			-0.2415*** (0.0489)	
FDI				-1.0004*** (0.3556)
Observations	487	473	376	411
Number of countries	113	109	93	101
Prob > F	0.000	0.000	0.000	0.000
R-squared	0.3923	0.3684	0.3721	0.3682
Kleibergen-Paap rk Wald F-stat	21.52 <sup>++</sup>	24.24 <sup>++</sup>	10.63 <sup>+</sup>	14.04 <sup>++</sup>
<i>Tests (p-values)</i>				
Underidentification test	0.000	0.000	0.000	0.000
Anderson-Rubin F- test	0.000	0.000	0.000	0.000
Hansen J statistic	0.823	0.822	0.109	0.596

Notes: <sup>++(+)</sup> of the Kleibergen-Paap rk Wald F-statistic indicates a rejection of the null that the maximal bias in the coefficient estimates for the potentially endogenous regressors exceeds 5 (10) per cent. Rejection of the null supports our model specification for the Underidentification and Anderson-Rubin F-test, whereas the null should not be rejected in case of the Hansen test. See text for details. Numbers in parentheses are robust standard errors.

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

### (c) Sensitivity analysis for underlying determinants model

Although, our focus being on the basic determinants of child's nutritional status as conceptualized in Section 2, in this section, we present some robustness checks and additional results for the underlying determinants model, which may provide the basis for future research.

#### **1. Are the results sensitive to the country sample composition?**

In the following, we test the sensitivity of the underlying determinants model results with respect to the sample composition. Similar to the case of the basic determinants model, we perform a regional jackknife analysis, in which all countries from a particular region are dropped from the analysis one at a time. As the results for the underweight prevalence as dependent variable were similar, we only present results for stunting, which are displayed in Table 11.

The results reveal that none of the regions substantially drives the results. It is striking that the explanatory power of the underlying determinants model is substantially higher when Sub Saharan African countries are excluded from the sample, which in turn suggests that this region is somewhat special and the captured underlying determinants only partly reflect what drives child malnutrition in these countries. Nevertheless, the underlying determinants retain its significant impact on child undernutrition in all cases. The impact of dietary energy supply is greatest when Developing Europe and Central Asian countries are excluded from the sample and smallest when the region East Asia and Pacific is excluded. The latter may reflect the fact that especially East Asian countries did comparably well in increasing food supplies during the last decades, resulting in considerable reductions in stunting prevalences. The results with the exclusion of South Asian countries suggest that the empowerment of women has a stronger effect in South Asia compared to other regions.

Overall, it is difficult to say, however, if the varying degrees of impact of some of the underlying determinants are due to the substantially reduced sample sizes in some cases or because they play a significantly greater (or smaller) role for nutrition security in these countries. Household-level analyses in specific regions may provide further evidence with

respect to the relative importance of the underlying determinants in different regions. In sum, also the results of the underlying determinants model are not very sensitive to the choice of the sample composition, suggesting that our findings are not driven by regional differences in the sample countries. Next, we are going to assess the robustness of the underlying determinants model results to the choice of the indicators employed.

Table 11: *Regional jackknife analysis for the underlying determinants model*

Sample without:	East Asia & Pacific	Europe & Central Asia	Latin America & Caribbean	Middle East & North Africa	South Asia	Sub Saharan Africa
Depvar: Prevalence of stunting	(FE-EGMM)	(FE-EGMM)	(FE-EGMM)	(FE-EGMM)	(FE-EGMM)	(FE-EGMM)
DES (log)	-16.7793** (7.5139)	-29.927*** (8.0401)	-21.4103** (9.1424)	-21.387*** (7.7234)	-18.3275** (8.0447)	-24.5480** (11.0331)
FemaleEduc	-0.2162*** (0.0394)	-0.1836*** (0.0387)	-0.2541*** (0.0531)	-0.2334*** (0.0422)	-0.1634*** (0.0353)	-0.1759*** (0.0456)
Women'sStatus	-77.693*** (25.4187)	-73.409*** (24.4820)	-72.5795*** (26.8436)	-66.842*** (23.8203)	-50.0806** (24.1671)	-92.1197** (44.6627)
WaterAccess	-0.1334** (0.0533)	-0.1407*** (0.0524)	-0.1188* (0.0650)	-0.1483*** (0.0527)	-0.1724*** (0.0625)	-0.1759*** (0.0456)
Observations	413	425	344	431	421	315
Number of countries	97	96	86	101	104	70
Prob > F	0.000	0.000	0.000	0.000	0.000	0.000
R-squared	0.2974	0.4052	0.3321	0.3724	0.2815	0.4517
Kleibergen-Paap rk Wald F-stat	81.07 <sup>++</sup>	18.70 <sup>++</sup>	67.93 <sup>++</sup>	88.32 <sup>++</sup>	55.76 <sup>++</sup>	34.32 <sup>++</sup>
<i>Tests (p-values)</i>						
Underidentification test	0.000	0.000	0.000	0.000	0.000	0.000
Anderson-Rubin F-test	0.000	0.000	0.000	0.000	0.000	0.000
Hansen J statistic	0.569	0.176	0.669	0.646	0.165	0.856

Notes: <sup>++(+)</sup> of the Kleibergen-Paap rk Wald F-statistic indicates a rejection of the null that the maximal bias in the coefficient estimates for the potentially endogenous regressors exceeds 5 (10) per cent. Rejection of the null supports our model specification for the Underidentification and Anderson-Rubin F-test, whereas the null should not be rejected in case of the Hansen test. See text for details. Numbers in parentheses are robust standard errors.

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

## **2. Are the results sensitive to the choice of indicators used?**

In order to check whether the results only apply to the specific indicators used to represent the underlying determinants of child malnutrition based on the conceptual framework presented in Section 2, we re-estimate the underlying determinants model with alternative measures (in case these are available). For brevity and because the results for underweight showed no differences, we only report the results for stunting, depicted in Table 12.

First, we test the sensitivity of the results to the employment of alternative food security indicators. In the baseline model, food security was represented by dietary energy supply (*DES*), which refers to the amount of food, expressed in kilocalories (kcal) per day, available for each individual in the total population. This measure has been used in previous studies as a proxy for calorie consumption and national food security and is, according to the FAO, one of the core indicators of food security closely linked to food consumption. Unfortunately, good alternative indicators covering a large number of countries and years and thus enabling meaningful cross-country comparisons are not readily available. One also has to accept the inability of any one indicator to fully capture the complexity and multidimensionality of food security and improvements in one dimension may mask deteriorations in other (FAO, 2013). We limit our focus to the employment of alternative food security indicators, which are available for a similar set of countries as in the baseline model.

As a first alternative, we employ a measure of the average dietary energy supply adequacy, which expresses the dietary energy supply as a percentage of the average dietary energy requirement in each country. The FAO (2013) lists this indicator as one of their food security indicators, measuring the availability of food in a country. The results, depicted in Column 1 of Table 12, reveal that also this alternative food security measure is significantly negatively related to child stunting and the other results remain unchanged.

As a second alternative food security indicator related to diet quality, we employ a measure of the average protein supply available for consumption in each country, which is one of the major macronutrient groups. According to Hoddinott et al. (2012), undernutrition with regard to macro- and micronutrients continues to be the dominant nutritional problem in

most developing countries. In light of the fact that most of the poor countries remain close to the lower bound of the FAO recommended daily value, increases in protein consumption can be seen as indicating food security improvements. According to the FAO (2013), increases in protein consumption can be closely associated with decreases in undernourishment and undernutrition. The results in Column 2 confirm this finding and show that an increase in the amount of protein available for consumption leads to a reduction in child undernutrition.

As a last alternative indicator for food security, we employ the prevalence of undernourishment (% of population), which is the percentage of the population whose food intake is insufficient to meet dietary energy requirements continuously (WDI). The prevalence of undernourishment is the traditional FAO hunger indicator, which is however not available for the 1980s, but may do a better job as *DES* in capturing the access dimension of food security. The results, depicted in Column 3, confirm our baseline model findings and reveal that an increase in the prevalence of undernourishment leads to a significant increase in child stunting. In light of these results, it can be concluded that the results are not sensitive to the food security measure employed.

Next, we note that it has been suggested that maternal and paternal education may be equally important factors in reducing child mortality (Breierova & Duflo, 2004; Webb & Block, 2004) and a bunch of studies point to strong effects of parental education (capturing both female and male education) on child health (see e.g. Strauss & Thomas, 1998; Currie, 2009). As a next step, we therefore replace female secondary school enrollment rate proxying for female education (*FemaleEduc*) with the average gross secondary school enrollment rate for both men and women, to measure parental education. The results shown in Column 4 of Table 12 reveal that this alternative measure of the educational level, partly determining mothers' and child care, does significantly negatively affect child undernutrition as well. The magnitude of impact is somewhat smaller compared to our baseline measure capturing female education. The results nevertheless suggest that both



male and female education affect child's nutritional status in a favorable manner, confirming recent findings for child health and mortality.<sup>55</sup>

In a next step, we replace the *female-to-male life expectancy ratio* by an alternative measure for women's social status, which may more directly measure women's empowerment. For this purpose, we use the ratio of female to male gross secondary enrollment rates, which measures women's educational attainment relative to men's (WDI). As reflected in Table 12, also this alternative indicator for women's social status or gender equality is negatively related with child stunting. We see this as further evidence for the favorable impact of women's empowerment on child's nutritional status.

Lastly, we employ an alternative measure for the overall health environment quality. For this purpose, we replace *WaterAccess* with the percentage of population having access to improved sanitation facilities (WDI). Access to sanitation is important for the maintenance of a sanitary environment and for preventing the spread of illness (see UNICEF, 2013). As revealed in the last column, access to sanitation reduces the prevalence of stunting, speaking again in favor of a positive impact of the health environment quality on child's health and nutritional status.<sup>56</sup> The other underlying determinants retain its negative impact on child stunting, confirming the baseline model results. Overall, the underlying determinants model results are not very sensitive to the employment of alternative indicators.

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<sup>55</sup> Note that when we only include male educational attainment in the underlying determinants model, it is significant as well, though with a smaller effect, suggesting that both female and male education are important, but that the education of women has a greater impact on child's nutritional status.

<sup>56</sup> Note that it was not possible to include both measures of the health environment quality simultaneously in the regression because of its very high correlation.

Table 12: *Alternative indicators for the underlying determinants model*

Depvar: Prevalence of stunting	Dietary energy supply adequacy	Protein supply quantity	Prevalence of under-nourishment	Secondary school enrollment (all)	Female to male secondary school enrollment	Access to sanitation
	(FE-EGMM)	(FE-EGMM)	(FE-EGMM)	(FE-EGMM)	(FE-EGMM)	(FE-EGMM)
DES (log)				-26.233*** (7.8257)	-19.6190** (7.9464)	-18.3650** (9.1713)
DES adequacy (log)	-22.372*** (8.3373)					
Protein supply (log)		-17.602*** (5.3955)				
Undernourishment			0.2572*** (0.0825)			
FemaleEduc	-0.2260*** (0.0364)	-0.2001*** (0.0377)	-0.2151*** (0.0399)		-0.1890*** (0.0374)	-0.1295** (0.0509)
School enrollment				-0.1510*** (0.0381)		
Women'sStatus	-73.108*** (23.8870)	-64.318*** (23.8832)	-83.2193*** (28.1253)	-78.039*** (25.1044)		-65.6585*** (25.3650)
Gender equality					-0.0755** (0.0336)	
WaterAccess	-0.1725*** (0.0526)	-0.1680*** (0.0477)	-0.2131*** (0.0783)	-0.1905*** (0.0523)	-0.1265** (0.0572)	
SanitationAccess						-0.4787*** (0.0949)
Observations	473	473	421	475	467	424
Number of countries	111	111	107	112	110	108
Prob > F	0.000	0.000	0.000	0.000	0.000	0.000
R-squared	0.3369	0.3600	0.3555	0.3122	0.3497	0.3970
Kleibergen-Paap rk Wald F-stat	30.79 <sup>++</sup>	141.5 <sup>++</sup>	322.2 <sup>++</sup>	99.72 <sup>++</sup>	100.7 <sup>++</sup>	49.48 <sup>++</sup>
<i>Tests (p-values)</i>						
Underidentification test	0.000	0.000	0.000	0.000	0.000	0.000
Anderson-Rubin F-test	0.000	0.000	0.000	0.000	0.000	0.000
Hansen J statistic	0.278	0.831	0.520	0.535	0.863	0.294

Notes: <sup>++(+)</sup> of the Kleibergen-Paap rk Wald F-statistic indicates a rejection of the null that the maximal bias in the coefficient estimates for the potentially endogenous regressors exceeds 5 (10) per cent. Rejection of the null supports our model specification for the Underidentification and Anderson-Rubin F-test, whereas the null should not be rejected in case of the Hansen test. See text for details. Numbers in parentheses are robust standard errors.

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

### **3. Incorporating additional explanatory variables**

We used a parsimonious model for the underlying causes of child malnutrition, based on the conceptual framework outlined in Section 2 and the results of Smith & Haddad (2000). However, there may be a number of additional factors determining child's nutritional status on the underlying determinants level. Therefore, we try to identify some of these factors and extend the underlying determinants model in this section. To detect if there are any differences with respect to the impact of these potential additional underlying determinants factors on child stunting and underweight, we report both results in Tables 13 and 14, respectively.

Besides food availability, recent studies point to the importance of dietary diversity for child's nutritional status. It has been recognized that young children need energy- and nutrient-dense foods to grow. Especially in developing countries, where diets are often to a great extent based on starchy staples such as cereals, roots and tubers, this undiversified diet may leave children vulnerable to nutrient deficiencies and lead to increased malnutrition (Arimond & Ruel, 2004). Thus, additional quality-related aspects of food security may form part of the underlying determinants of child's nutritional status. To test this hypothesis, we additionally include a measure of dietary diversity, based on the FAO food balance sheets and calculated as the share of dietary energy supply derived from non-staple foods, with staple foods being cereals, roots and tubers. Dietary diversity indicators have become increasingly popular and can be regarded as nutrition-relevant indicators of food security. Headey & Ecker (2012) show the usefulness of this dietary diversity indicator as food security indicator in a cross-country setting.<sup>57</sup> The results, depicted in Column 1 of Tables 13 and 14 reveal that increasing diversity of the diets lead to significant reductions in child malnutrition. This finding suggest that besides food security also dietary diversity plays a role for child's nutritional status and confirms country-level results of the FAO (2013), which show that low dietary diversity is often associated with poor utilization outcomes and high stunting rates. As trade openness leads to increased access to international food markets and the availability of a greater variety of foods makes it easier for the population

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<sup>57</sup> In line with Headey & Ecker (2012) and the FAO (2013), we consider the share of dietary energy supply derived from cereals, roots and tubers as an indicator of food security rather than nutrition security, indicating only the availability of high-value food products for consumption.

to diversify diets and enables households to complement consumption of staples with non-staple foods, it can be expected to affect child's nutritional status also through its effect on dietary diversity.<sup>58</sup>

To ensure that this finding is not due to the specific indicator employed, we additionally use a related indicator of diet quality, the share of kcal received from animal sources, where an increase corresponds to a diet upgrading. The analysis of kcal availability by source provides some important insights into the quality of diets as, for example, animal foods are generally considered as good sources of high-quality protein and essential micronutrients. According to the FAO (2013), people from worse off areas consume a diet that is much less diverse and contains much less protein in the form of meat, fish, eggs or milk than do people in better-off areas. The results show that also this alternative measure of dietary quality has a negative impact on child undernutrition, which is highly significant in the case of stunting, however, only marginally significant in the case of underweight. Nevertheless, the results support the increased interest in diet-quality related aspects of food security and point to its importance for child's nutritional status.

As the food security indicator of our baseline model, *DES*, is strictly speaking rather a measure of national food availability and may not sufficiently capture access to enough food, we assess the sensitivity of our results to the inclusion of an indicator that, according to the FAO (2013), is more closely related to food access. Therefore, in Column 3, we additionally include the percent of paved roads over total roads as access to food indicator in our underlying determinants model. Although the number of observations is reduced significantly, access to food has a highly significant impact on both child stunting and underweight, while *DES* retains its significant impact on child's nutritional status. One caveat for the reliability of these results is that the Kleibergen-Paap rk Wald F-statistic indicates that the maximal bias of the instrumental variables estimates exceeds 5%, pointing to somewhat weak instruments. However, the bias is still not excessive, being at less than 10%.<sup>59</sup> Taken

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<sup>58</sup> Note that the regression of our dietary diversity measure on TradeOpen and the other basic determinants returns a highly significant and positive coefficient for trade openness, supporting this view.

<sup>59</sup> Note that it is not entirely clear whether the percent of paved roads over total roads should be included as basic or underlying determinant of child malnutrition. According to the FAO, it can be seen as an access to food indicator, but as we have shown in Tables 9 and 10, it may more generally affect child's nutritional status in a favorable manner through all of the underlying determinants.

together, these results suggest that, besides national food availability, food access as well as dietary diversity and diet-quality related aspects of food security play a role for child's nutritional status.

Additionally, the literature suggests that *fertility*, child health and general household welfare are closely related (see e.g. Pitt, 1997, Chun & Oh, 2002, and Schultz, 2008). Changes in fertility rates represent one important facet of the demographic transition and capture time constraints in mother and child care, thereby potentially negatively affecting child's nutritional status. Parents who have more children are expected to commit less of their time and resources to each child, while parents who have fewer children may invest more in the human capital per child, thereby improving the health of their children (Schultz, 2008).<sup>60</sup> To test if fertility has an effect on child malnutrition, we add the fertility rate (births per woman) (WDI) to the underlying determinants model. Because of a potential endogeneity problem, as health outcomes and fertility may be jointly determined choice variables by households (Behrman et al., 1988; Schultz, 2008), we treat fertility as endogenous in our empirical model specification. The results, depicted in Column 4, show that high fertility rates are associated with increased rates of both stunting and underweight. We interpret this as evidence for a negative effect of high fertility rates on caring activities for both mothers and children, negatively affecting child health and nutritional status. As can be expected, because of the strong association between female education and fertility rates (see e.g. Strauss & Thomas, 1995), our indicator of female education loses part of its significance, at least in the case of stunting.

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<sup>60</sup> Note that although earlier cross-country studies on the determinants of child malnutrition (e.g. Smith & Haddad, 2000, 2001, 2002) did not account for fertility as child malnutrition determinant, fertility rates are have been included in recent household studies on the issue (see e.g. Jensen, 2012) and have also been included by a recent cross-country study (see Headey, 2013).

Table 13: *Incorporating additional underlying determinants for stunting*

Depvar: Prevalence of stunting	Share of DES from non-staples	Supply of kcal from animal sources	Food access	Fertility	Health services
	(FE-EGMM)	(FE-EGMM)	(FE-EGMM)	(FE-EGMM)	(FE-EGMM)
DES (log)	-20.5347*** (7.3255)	-21.8288*** (7.3067)	-23.2847** (11.5096)	-17.9931** (8.7848)	-18.0037** (8.8303)
DES non-staples	-0.3914*** (0.1150)				
Kcal animal sources		-0.5469*** (0.1752)			
Food access			-0.2678*** (0.0765)		
FemaleEduc	-0.1879*** (0.0370)	-0.1930*** (0.0379)	-0.2031*** (0.0465)	-0.0942* (0.0552)	-0.1700*** (0.0400)
Women'sStatus	-65.0729*** (23.8487)	-72.1154*** (23.6697)	-88.5639*** (28.2934)	-81.9266*** (27.9306)	-67.9940*** (26.1297)
Fertility (log)				16.2367*** (4.5855)	
WaterAccess	-0.1287*** (0.0497)	-0.1366*** (0.0489)	-0.2548*** (0.0875)	-0.1529* (0.0820)	-0.1794** (0.0843)
Health services					-0.1168*** (0.0437)
Observations	473	470	380	422	438
Number of countries	111	110	96	109	107
Prob > F	0.000	0.000	0.000	0.000	0.000
R-squared	0.3822	0.3828	0.4029	0.3931	0.3687
Kleibergen-Paap rk Wald F-stat	54.00 <sup>++</sup>	53.02 <sup>++</sup>	9.705 <sup>+</sup>	29.44 <sup>++</sup>	24.89 <sup>++</sup>
<i>Tests (p-values)</i>					
Underidentification test	0.000	0.000	0.000	0.000	0.000
Anderson-Rubin F-test	0.000	0.000	0.000	0.000	0.000
Hansen J statistic	0.631	0.666	0.389	0.615	0.113

Notes: <sup>++(+)</sup> of the Kleibergen-Paap rk Wald F-statistic indicates a rejection of the null that the maximal bias in the coefficient estimates for the potentially endogenous regressors exceeds 5 (10) per cent. Rejection of the null supports our model specification for the Underidentification and Anderson-Rubin F-test, whereas the null should not be rejected in case of the Hansen test. See text for details. Numbers in parentheses are robust standard errors.

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Lastly, we note that although access to safe water should be a reasonable good proxy for the overall health environment quality, it may not fully capture access to healthcare services. We try to capture access to health services by additionally including vaccination against measles (% of children ages 12-23 months) (WDI) in the underlying determinants model. This measure should be more directly related to healthcare services and also has wide variation at each income level (Masters, 2013).<sup>61</sup> According to the WHO, measles is still one of the leading causes of death among young children. The WHO further states that “vaccination coverage can be considered a marker of access to child health services” and that “overwhelming evidence demonstrates the benefit of providing universal access to measles vaccines”.<sup>62</sup> Access to vaccinations may not be strictly exogenous, as unobserved factors (e.g. specific health related policies) may simultaneously affect access to healthcare services and child malnutrition. We account for this by treating the variable as endogenous in our empirical model specification. As can be seen in the last column of Tables 13 and 14, greater vaccination coverage leads to reductions in both stunting and underweight, pointing to beneficial effects of access to health services for child’s nutritional status. However, access to vaccinations is also very highly correlated with access to safe drinking water, leading to imprecise estimates and making it difficult to disentangle the effects. Nevertheless, both the general health environment quality and access to healthcare services seem to simultaneously affect child’s nutritional status in a favorable manner. As noted in Section 2, increased openness to trade should facilitate technology spillovers, for example access to new medical technologies (Deaton, 2004) as well as the trade and transfers of medical supplies and drugs, for example vaccines, medical treatments, pharmaceuticals (Owen & Wu, 2007). Trade may therefore also affect nutritional status through its effect on the availability of health services.<sup>63</sup>

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<sup>61</sup> Note that immunization against measles is also very highly correlated (with correlation coefficients above 0.9) with other vaccination measures such as against tuberculosis or against diphtheria, pertussis and tetanus. We use immunization against measles because of its slightly greater data availability.

<sup>62</sup> For these quotes, see the WHO response to the problem of measles available at <http://www.who.int/mediacentre/factsheets/fs286/en/>.

<sup>63</sup> Note that the regression of our access to healthcare measure on TradeOpen and the other basic determinants returns a highly significant and positive coefficient for trade openness, supporting this view.

Table 14: *Incorporating additional underlying determinants for underweight*

Depvar: Prevalence of underweight	Share of DES from non-staples	Supply of kcal from animal sources	Food access	Fertility	Health services
	(FE-EGMM)	(FE-EGMM)	(FE-EGMM)	(FE-EGMM)	(FE-EGMM)
DES (log)	-15.7288*** (4.6202)	-16.1769*** (4.8308)	-25.1332*** (8.0270)	-14.5848** (5.7208)	-15.7924*** (4.7165)
DES non-staples	-0.2243*** (0.0803)				
Kcal animal sources		-0.1979* (0.1061)			
Food access			-0.1719*** (0.0527)		
FemaleEduc	-0.1332*** (0.0281)	-0.1383*** (0.0284)	-0.1040*** (0.0327)	-0.1194*** (0.0324)	-0.1313*** (0.0290)
Women'sStatus	-34.4140** (16.8221)	-38.9634** (16.5119)	-45.0598*** (14.6578)	-33.4635** (17.0341)	-32.1269** (15.4872)
Fertility (log)				6.3027** (2.9058)	
WaterAccess	-0.1018*** (0.0380)	-0.1117*** (0.0383)	-0.2152*** (0.0727)	-0.1169** (0.0549)	-0.0935** (0.0462)
Health services					-0.0624* (0.0325)
Observations	492	489	340	439	480
Number of countries	111	110	95	109	108
Prob > F	0.000	0.000	0.000	0.000	0.000
R-squared	0.3712	0.3708	0.3701	0.3939	0.3941
Kleibergen-Paap rk Wald F-stat	50.99 <sup>++</sup>	56.16 <sup>++</sup>	9.295 <sup>++</sup>	38.09 <sup>++</sup>	27.57 <sup>++</sup>
<i>Tests (p-values)</i>					
Underidentification test	0.000	0.000	0.000	0.000	0.000
Anderson-Rubin F-test	0.000	0.000	0.000	0.000	0.000
Hansen J statistic	0.848	0.890	0.285	0.691	0.148

Notes: <sup>++(+)</sup> of the Kleibergen-Paap rk Wald F-statistic indicates a rejection of the null that the maximal bias in the coefficient estimates for the potentially endogenous regressors exceeds 5 (10) per cent. Rejection of the null supports our model specification for the Underidentification and Anderson-Rubin F-test, whereas the null should not be rejected in case of the Hansen test. See text for details. Numbers in parentheses are robust standard errors.

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1



## 5. CONCLUSION AND POLICY RECOMMENDATIONS

Globally, interest in nutrition has increased dramatically. Although it is generally acknowledged that “non-nutrition” factors such as macroeconomic structural developments and policies can have profound effects on nutrition security, empirical evidence on this issue is scarce. In the present study, we assessed the impact of trade policy on child malnutrition, based on a large representative cross-country panel data set covering 113 developing countries for the time period 1985-2007. The study employed two-step feasible efficient GMM (Generalized Method of Moments) estimation of the fixed-effects (FE) panel data model that is robust to unobserved heterogeneity, correlated individual effects and endogeneity, to identify key determinants of child malnutrition, in particular the impact of trade openness.

The empirical analysis is based on the widely accepted UNICEF (1990) conceptual framework for the causes of child malnutrition, where we introduce trade policy as part of the political environment. We recognized that trade may have various effects on child malnutrition, with the pathways of influence working through the underlying determinants of child malnutrition, that is food security, care for mothers and children and the health environment quality and access to health services. The results showed that trade openness works to reduce both child stunting and underweight significantly. The results were robust to the methodology and openness indicator employed as well as to changes in the sample composition and the employment of additional control variables potentially affecting child malnutrition or the openness – malnutrition relationship.

We also conceptualized the main linkages between trade and malnutrition and identified the transmission channels through which trade policy affects child malnutrition. To give an indication of these pathways of impact, we run separate fixed effects regressions for each of the underlying determinants with the basic determinants as explanatory variables, while also taking into account the potential endogeneity of some of the determinants. We found that trade openness improves nutrition security *inter alia* by increasing the availability and diversity of food in a country. The results also indicated that the openness of a country improves child’s nutritional status through the care for mothers and children transmission channel. This may partly be explained by the fact that closer integration with the world

facilitates the transmission of health-related knowledge (see e.g. Babinard & Pinststrup-Andersen, 2001). Furthermore, opening up the economy for trade is associated with improvements in women's employment opportunities as well as increases in wages and returns to education and consequently leads to a greater accumulation of human capital, and to increased gender equality (see Oostendorp & Doan, 2013, and Schultz, 2006). We also found evidence suggesting that trade affects nutritional status through its effect on the health environment and the availability of healthcare services. Increased interaction with other countries can be associated with better health outcomes due to various reasons. Trade facilitates technology spillovers, for example access to new medical technologies (Deaton, 2004) as well as the trade and transfers of medical supplies and drugs, for example vaccines, medical treatments, pharmaceuticals (Owen & Wu, 2007). From a more general viewpoint, openness to trade can be associated with sound economic policies and impact positively on the quality of institutions that themselves may create a policy environment that is conducive to improved health, for example the development of healthcare systems and better access to healthcare for the poor. Through all these pathways trade openness eventually positively affects nutrition security, which leads us to conclude that the benefits of trade openness outweigh the costs when the objective is to attain improvements in nutrition security. The employment of alternative globalization and openness indicators confirmed the results that protectionist measures such as tariffs are in general detrimental and economic openness is beneficial for child's nutritional status.

The results for the other basic determinants of child's nutritional status revealed that improvements in income lead to significant reductions in both child stunting and underweight, confirming previous studies on this issue (see e.g. Smith & Haddad, 2000; Headey, 2013). Income growth improves child's nutritional status by improving food security and women's social status, and by facilitating access to safe water and education. The presence of democratic institutions leads to improvements in both stunting and underweight, but significantly so only in the case of underweight. Macroeconomic instability, proxied by consumer price inflation, leads to a deterioration of nutrition security. This can partly be explained by the fact that macroeconomic instability increases poverty (see e.g. Agénor, 2004), thereby potentially negatively affecting household food security and access to the other child health inputs. Besides that, the results reveal that political instability or

the presence of violent conflicts negatively affects child's nutritional status through all of the underlying determinants. Conflicts are a major cause of structural food insecurity and impede access to all of the inputs for child's nutritional status by disrupting transport, trade and markets. This finding further justifies the evolving interest in governance and confirms recent studies pointing to the potential importance of governance for health and nutrition (see e.g. Halleröd et al., 2013; Haddad, 2012). The baseline model results also reveal that the financial development and access to credit have a favorable impact on nutritional status. This finding suggests that the financial development of a country and better availability of credits positively affects household expenditure levels on and access to adequate quantities and qualities of resources important for child's nutritional status, e.g. food, education, and healthcare. As trade openness has been found to spur financial development and that relatively closed economies stand to benefit most from opening up their trade in terms of banking sector development (see e.g. Baltagi et al., 2009), there may be an additional indirect effect of trade openness on nutrition security working through the financial development link. Additional results of the extension of our baseline model further showed that the degree of urbanization, the level of infrastructure development and the availability of foreign direct investments tend to improve nutrition security, while high population growth adversely affects child's nutritional status.

Focusing on the underlying determinants, our results support the findings of earlier studies on the issue and speak to the importance of food availability, female education and women's relative status, and the health environment quality for child's nutritional status (see e.g. Smith & Haddad, 2000; Masters, 2013). Taking a closer look at household food security, one of the most important underlying determinants of child's nutritional status, we find that, besides national food availability, food access as well as dietary diversity and diet-quality related aspects of food security play a role for child's nutritional status. Our extension of the underlying determinants model revealed that high fertility rates lead to a deterioration of child's nutritional status, while access to health services improves it. Changes in fertility rates represent one important facet of the demographic transition and capture time constraints in mother and child care. We interpret this as evidence for a negative effect of high fertility rates on caring activities for both mothers and children as parents who have more children may commit less of their time and resources to each child,

eventually negatively affecting child health and nutritional status. The results for our access to vaccinations against measles reveal that better access to health services leads to reductions in both stunting and underweight, pointing to beneficial effects of healthcare for child's nutritional status. This confirms that both the general health environment quality and access to healthcare services simultaneously affect child's nutritional status in a favorable manner.

From a policy perspective, some recommendations can be derived from the empirical results. First, our findings point to the importance of a country's openness and market integration for nutrition security. Openness to international trade should therefore constitute a fundamental component of a policy mix to enhance nutrition security, and trade liberalization in the sense of progressive reductions in the levels of protection and the elimination of policies that distort trade can be an effective instrument for this purpose. It should be seen as a complement but not as a substitute for domestic development policies aimed at reducing child malnutrition, for example, investments in the domestic agricultural sector, domestic health and education policies as well as complementary policies to ensure that farmers benefit from liberalization (e.g. addressing production and transport constraints) and vulnerable groups are protected.

The findings of a detrimental effect of macroeconomic and political instability for nutrition security support claims of the international community that a peaceful, stable political, social and economic environment is a precondition for the achievement of food and nutrition security (see e.g. Thomson & Metz, 1999). This suggests that a stable macroeconomic and political environment should be seen as a necessary part of an enabling environment for improvements in nutrition security. Furthermore, public investment in infrastructure development can help to improve access to food and the other nutrition inputs. A stable macroeconomic environment along with investments in rural infrastructure leading to a reduction in transaction costs may then help producers to withstand foreign competition and expand into export markets. Third, the development of the financial sector with the aim to improve the delivery of financial services and to increase access to credit should form part of the policy mix for improving nutrition security. Financial development has the potential to facilitate the population's access to important inputs into child's nutritional status.

We believe that our findings and some limitations of the current study can provide the basis for future research aiming at improving our understanding of the determinants of child's nutritional status. First, the trends in stunting and underweight may not be fully evident at the national level, which calls for regional and micro-level analyses to complement our macro-level investigations, which may also provide deeper insights into the issue of how specific trade policy measures impact on the nutritional status of the most vulnerable groups within a society. Second, we only assessed the effects of a country's own trade policy stance. Although most gains from multilateral liberalization are expected to come from the countries' own liberalization efforts (Ingco, 1997), it would be interesting to assess how developed countries' trade policies affect nutrition security in developing countries. It has been argued, for example, that the health-improving effects of integration could be improved, if protectionism in the developed countries is further reduced (see e.g. Cornia, 2001). Third, we mainly focused on the effects of the general openness of a countries' trade policy. However, our sensitivity analysis additionally pointed to detrimental effects of distorting *agricultural* trade policy measures for nutrition security, a result that should spur further investigations in future research. Fourth, we provided an extension of the underlying determinants model of child's nutritional status showing that additional factors may play a role, which should be further elaborated in the future.

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## APPENDIX

Table A.1. List of countries used in baseline regressions (113)

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Albania	Cote d'Ivoire	Lebanon	Romania
Algeria	Czech Republic	Lesotho	Rwanda
Angola	Djibouti	Liberia	Samoa
Argentina	Dominican Republic	Libya	Senegal
Armenia	Ecuador	Macedonia, FYR	Sierra Leone
Azerbaijan	Egypt, Arab Rep.	Madagascar	Solomon Islands
Bangladesh	El Salvador	Malawi	South Africa
Belarus	Eritrea	Malaysia	Sri Lanka
Belize	Ethiopia	Maldives	Sudan
Benin	Fiji	Mali	Suriname
Bolivia	Gabon	Mauritania	Swaziland
Bosnia & Herzegovina	Gambia, The	Mauritius	Syrian Arab Republic
Botswana	Georgia	Mexico	Tajikistan
Brazil	Ghana	Moldova	Tanzania
Bulgaria	Guatemala	Mongolia	Thailand
Burkina Faso	Guinea	Morocco	Togo
Burundi	Guinea-Bissau	Mozambique	Trinidad & Tobago
Cambodia	Guyana	Namibia	Tunisia
Cameroon	Haiti	Nepal	Turkey
Cape Verde	Honduras	Nicaragua	Turkmenistan
Central African Republic	India	Niger	Uganda
Chad	Indonesia	Nigeria	Ukraine
Chile	Iran, Islamic Rep.	Pakistan	Uruguay
China	Jamaica	Panama	Venezuela, RB
Colombia	Jordan	Paraguay	Vietnam
Comoros	Kazakhstan	Peru	Yemen, Rep.
Congo, Dem. Rep.	Kenya	Philippines	Zambia
Congo, Rep.	Kyrgyz Republic	Romania	Zimbabwe
Costa Rica	Lao PDR		

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Table A.2. List of variables used, and sources

Variable	Source
Prevalence of stunting	Malnutrition prevalence, height for age (% of children under 5). <i>Source: UNICEF-WHO-The World Bank: Joint child malnutrition estimates</i>
Prevalence of underweight	Malnutrition prevalence, weight for age (% of children under 5). <i>Source: UNICEF-WHO-The World Bank: Joint child malnutrition estimates</i>
Dietary energy supply (DES)	Dietary energy supply per person refers to the amount of food, expressed in kilocalories (kcal) per day, available for each individual in the total population during the reference period. <i>Source: FAOSTAT</i>
FemaleEduc	School enrollment, secondary, female (% gross). <i>Source: WDI</i>
Women'sStatus	Female-to-male life expectancy ratio: Ratio of female life expectancy at birth to male life expectancy at birth. <i>Source: Own calculation based on data from WDI</i>
WaterAccess	Improved water source (% of population with access). <i>Source: WHO/UNICEF Joint Monitoring Program (JMP) for Water Supply and Sanitation</i>
Trade openness (TradeOpen)	Imports plus exports as a% of GDP. <i>Source: PENN World Table (PWT) 7.0. Heston et al. (2009). Accessed from <a href="https://pwt.sas.upenn.edu/php_site/pwt_index.php">https://pwt.sas.upenn.edu/php_site/pwt_index.php</a></i>
GDP	Log of real GDP <i>per capita</i> . <i>Source: PWT 7.0</i>
PoliticalViolence	Intensity of societal and interstate political violence episodes, measured on an eleven-point scale, from 0-10. <i>Source: Major Episodes of Political Violence (MEPV) database of the Center for Systemic Peace</i>
Inflation (MacrolnStability)	log [1 + inflation], with consumer prices inflation data taken from <i>WDI</i>
FinancialDevelop	Domestic credit provided by banking sector as a% of GDP ( <i>WDI</i> )
Policy openness	Residual of a regression of trade openness on the logs of area and population, and dummies for oil exporting and for landlocked countries. <i>Source: Authors' calculations following Chang et al. (2009)</i>
Globalization	KOF index of globalization (0–100); composite index measuring three dimensions (economic, social, political), with higher values indicating more globalization. <i>Source: Dreher (2006); updated in Dreher et al, (2008)</i>
SW Openness	Sachs-Warner openness dummy variable; classifies countries as open (1) or closed (0) based on different trade indicators (tariffs, nontariff barriers, and other measures of trade restrictions). <i>Source: Wacziarg &amp; Welch (2008)</i>
Tariffs	Tariff rate, applied, simple mean, all products (%). <i>Source: WDI</i>
Ag. distortions	Agricultural distortions trade bias index. <i>Source: Anderson &amp; Valenzuela, 2008</i>
Urbanization	Urban population (% of total). <i>Source: WDI</i>
Population growth	Population growth (annual %). <i>Source: WDI</i>
Infrastructure	Roads, paved (% of total roads). <i>Source: WDI</i>
FDI	Foreign direct investment, net inflows (% of GDP). <i>Source: WDI</i>
Foreign reserves	Total reserves in months of imports, in logs. <i>Source: WDI</i>
Democracy	Democracy-Dictatorship (DD) index between 0 and 1. <i>Source: Cheibub et al. (2010)</i>
Government burden	Government consumption as a% of GDP ( <i>WDI</i> )
Dietary energy supply adequacy	Dietary energy supply as a percentage of the average dietary energy requirement in each country. <i>Source: FAO (2013)</i>
Protein supply	Average protein supply (g/capita/day) available for consumption in each country. <i>Source: FAO (2013)</i>
Undernourishment	Prevalence of undernourishment (% of population). <i>Source: WDI</i>
School enrollment	School enrollment, secondary (% gross) <i>Source: WDI</i>
Gender equality	Ratio of female to male secondary enrollment (%). <i>Source: WDI</i>
SanitationAccess	Improved sanitation facilities (% of population with access). <i>Source: WHO/UNICEF Joint Monitoring Program (JMP) for Water Supply and Sanitation</i>
Dietary diversity	Share of dietary energy supply derived from non-staple foods, with staple foods being cereals, roots and tubers. <i>Source: FAO (2013)</i>
Diet quality	Average supply of kcal from animal sources (g/capita/day). <i>Source: FAO (2013)</i>
Fertility	Fertility rate, total (births per woman). <i>Source: WDI</i>
Health services	Immunization, measles (% of children ages 12-23 months). <i>Source: WDI</i>

Table A.3: Sample Summary Statistics (baseline models)

<b>Underlying determinants model &amp; <u>stunting</u></b>	Mean	Standard deviation	Minimum	Maximum
Prevalence of stunting	31.957	16.626	2.100	73.600
DES (log)	7.783	0.168	7.319	8.182
FemaleEduc	51.342	28.534	2.742	116.998
Women'sStatus (Female-to-male life expectancy)	1.065	0.037	0.958	1.199
WaterAccess	76.253	17.851	15.00	100.00
<i>Number of observations</i>	473			
<b>Underlying determinants model &amp; <u>underweight</u></b>				
Prevalence of underweight	17.652	13.885	0.600	66.800
DES (log)	7.787	0.167	7.319	8.182
FemaleEduc	51.073	28.092	2.742	116.998
Women'sStatus (Female-to-male life expectancy)	1.064	0.036	0.958	1.199
WaterAccess	76.516	17.629	15.00	100.00
<i>Number of observations</i>	492			
<b>Basic determinants model &amp; <u>stunting</u></b>				
Prevalence of stunting	31.474	16.376	2.100	73.600
GDP (log)	8.130	0.852	5.899	9.912
Democracy	0.500	0.501	0.00	1.00
TradeOpen	74.612	37.891	12.529	215.684
MacroInstability (log [1 + inflation])	0.140	0.283	-0.070	3.748
PoliticalViolence (intensity)	0.666	1.632	0.00	10.00
FinancialDevelop	39.626	33.567	-67.499	239.735
<i>Number of observations</i>	473			
<b>Basic determinants model &amp; <u>underweight</u></b>				
Prevalence of underweight	17.166	13.722	0.600	66.800
GDP (log)	8.158	0.844	5.899	9.912
Democracy	0.512	0.500	0.00	1.00
TradeOpen	74.638	38.833	12.529	215.684
MacroInstability (log [1 + inflation])	0.140	0.280	-0.070	3.748
PoliticalViolence (intensity)	0.722	1.727	0.00	10.00
FinancialDevelop	40.475	34.507	-67.499	239.735
<i>Number of observations</i>	492			

See text for a detailed description of the variables.

**Figure A.1: KOF index of globalization**

<b>Indices and Variables</b>	<b>Weights</b>
<b>A. Economic Globalization</b>	<b>[36%]</b>
i) Actual Flows	(50%)
Trade (percent of GDP)	(22%)
Foreign Direct Investment, stocks (percent of GDP)	(27%)
Portfolio Investment (percent of GDP)	(24%)
Income Payments to Foreign Nationals (percent of GDP)	(27%)
ii) Restrictions	(50%)
Hidden Import Barriers	(24%)
Mean Tariff Rate	(28%)
Taxes on International Trade (percent of current revenue)	(26%)
Capital Account Restrictions	(23%)
<b>B. Social Globalization</b>	<b>[38%]</b>
i) Data on Personal Contact	(33%)
Telephone Traffic	(25%)
Transfers (percent of GDP)	(3%)
International Tourism	(26%)
Foreign Population (percent of total population)	(21%)
International letters (per capita)	(25%)
ii) Data on Information Flows	(35%)
Internet Users (per 1000 people)	(36%)
Television (per 1000 people)	(38%)
Trade in Newspapers (percent of GDP)	(26%)
iii) Data on Cultural Proximity	(32%)
Number of McDonald's Restaurants (per capita)	(44%)
Number of Ikea (per capita)	(44%)
Trade in books (percent of GDP)	(11%)
<b>C. Political Globalization</b>	<b>[26%]</b>
Embassies in Country	(25%)
Membership in International Organizations	(27%)
Participation in U.N. Security Council Missions	(22%)
International Treaties	(26%)

Source: Dreher, Gaston & Martens (2008)

### **III. Key Determinants of Food Security at the National Level and the Impact of Trade: A Dynamic Panel Analysis**

#### **Abstract**

The second part of the thesis employs a system GMM approach that is robust to correlated individual effects and endogeneity to a large cross-section of countries for the period 1980-2007 to identify key determinants of food security, as well as the impact of trade openness. Most of the data used in this study come from FAOSTAT and the World Bank World Development Indicators. The results reveal, inter alia, that trade openness and economic growth exert positive and significant impacts on dietary energy consumption. The results are robust to the inclusion of additional variables capturing specific agro-climatic constraints (e.g. weather-related) and regional/country characteristics and to the sample composition. Most geographical regions are found to have significantly higher food security levels compared to Sub-Saharan Africa. Additional results indicate that besides calorie consumption trade openness also improves dietary diversity and diet quality-related aspects of food security. Results further point to the importance of complementary policies and reforms through which the beneficial effects of openness may be significantly improved.



## 1. INTRODUCTION

Despite significant progress in world agriculture and economic development during the last decades, food insecurity persists in many countries, especially developing ones. According to the FAO, with more than 800 million people still suffering from chronic undernourishment and additional population pressure, the eradication of hunger continues to be a major global challenge (FAO, 2012). Food insecurity has direct consequences for health and human development and more general for learning, individual productivity and economic development (among others, see Strauss & Thomas, 1998; World Bank, 2006). Because of these interrelationships, it has become apparent that a failure to eliminate hunger will undermine efforts to reach the other MDGs, for example those related to education, child mortality, maternal health, and disease (FAO, 2005). Consequently, the FAO (2014) emphasizes the need to place food security issues at the top of the political and international research agenda and to create an enabling environment for improving food security through adequate investments and better policies. As a response, numerous international initiatives have now placed high priority on food and nutrition security issues, for example the UN-led Scaling Up Nutrition (SUN) and the USAID's Feed the Future initiative.

The 1960s and 70s were periods of anti-agricultural and anti-export bias in many developing countries, as governments tried to isolate domestic from world markets through protectionist policies, aiming at protecting domestic producers and keeping domestically produced food in the country. These measures included macroeconomic, sectoral, trade and exchange rate policies that directly or indirectly taxed farm households exports (through export taxes or quantitative restrictions), tariffs imposed on the import price of food commodities as well as specific mechanisms such as controlled marketing systems. These policy measures were found to inhibit agricultural trade, lead to distorted farmer incentives with respect to investment in agricultural production, marketing and storage, as well as resource misallocation, and became fiscally unsustainable during the 1970s in most developing countries (FAO, 2003a). Tariffs and non-tariff barriers also encouraged unproductive activities such as rent seeking (e.g. lobbying for subsidies) and tax avoidance and evasion, which contributed to inefficiency in the economy. Since the mid-1980s, there

has been a substantial amount of policy reform and opening up of many developing countries, which initiated policy reforms under Structural Adjustment Programs (SAPs) of the World Bank and the International Monetary Fund (IMF) and based on trade negotiations at the international level (UNCTAD, GATT, and later WTO), leading to strong growth in international trade worldwide. These policies implied the removal of government subsidies (especially in the agricultural sector), liberalization of export and import trade (i.e. a reduction in tariffs and non-tariff trade barriers) and exchange rate liberalization (Anderson, 2010). Trade reforms have been justified by expected increases in efficiency, particularly in resource allocation, and output growth by improving transparency in incentives, thereby promoting economic growth and poverty alleviation and improving food availability for local consumption (FAO, 2000, 2003).

A considerable body of empirical research has focused on the impact of globalization and trade liberalization on certain dimensions of economic development, for example economic growth and poverty, however, with so far inconclusive results.<sup>64</sup> On the aggregate level, empirical evidence based on cross-country regression analysis reveals a positive link between trade and growth. Protection, on the contrary, has been found to encourage excess resources into inefficient sectors, in which a country does not have a comparative advantage, as well as to encourage unproductive activities such as rent seeking. Synthesizing from the literature, positive effects of trade liberalization on economic growth mostly stem from accelerated accumulation of human and physical capital and technology transmission (Frankel & Romer, 1999; Wacziarg & Welch, 2008) as well as the expansion of the exportables sector and more efficient allocation of resources (Greenaway et al., 2002). These effects have been found to be partly depending on policy complementarities (other macroeconomic, institutional and regulatory reforms) that help a country take advantage of international competition and trade (Dollar and Kraay, 2004; Chang et al., 2009). Although the impact of trade in the case of poverty is less obvious, it has been noted that trends toward poverty reduction are strongest in developing countries that have integrated with the global economy, with some researchers pointing to the importance of combining trade

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<sup>64</sup> For a survey of the openness-growth nexus, see Baldwin, 2003, and Rodríguez, 2007, and for a review of the evidence regarding trade liberalization impacts on poverty, see Winters et al., 2004.

reforms with complementary measures such as social protection policies.<sup>65</sup> Winters et al. (2004) conclude that trade liberalization reforms are easy to implement and may therefore be one of the most cost effective anti-poverty policies for governments.

Recognizing that poverty is a very broad indicator of the well-being of a country's population and thinking more in terms of basic needs, the issue of food insecurity has attracted a large and growing volume of literature over the past decade and there has been continuous controversy over the impact of trade reforms on food security (Traub & Jayne, 2008). The importance of trade policies for food security was recognized by the World Food Summit in 1996 as reflected in Commitment No. 4: "We will strive to ensure that food, agricultural trade and overall trade policies are conducive to fostering food security for all through a fair and market oriented world trade system" (Rome Declaration, 1996). There is, however, still surprisingly little empirical evidence on this issue. More generally, food security- in terms of research- receives less attention than poverty and only very few studies explicitly explore the impact of trade liberalization on food security (Guha-Khasnobis, Acharya & Davis, 2007). Indeed, also in terms of policy, it has been recognized that only few countries have well-developed food and nutrition policies. Although being aware that direct nutrition-specific interventions will impact on nutrition, governments are often unaware of the nutrition impact of national-level policies in other sectors, for example trade and agriculture, and these become unintentional but *de facto* food and nutrition policies (World Bank, 2006).

FAO (2006) summarizes the findings of 15 country case studies regarding the impact of trade reforms on food security. The majority of the studies, however, perform only descriptive analysis. Furthermore, they generally focus on only one aspect of the relationship between trade reforms and food security, for example the impact on income and prices, such that the overall effect on food security levels cannot be quantified. An additional problem comes from the fact that these studies largely use poverty indicators instead of direct food security indicators, which are seldom available at the household level (FAO, 2006). The few available case studies on the issue find either no significant effects of trade liberalization policies on aggregate food security indicators or positive effects, working mainly through resulting employment and income increases (e.g. due to the possibility to sell higher value crops on

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<sup>65</sup> See, for example, Agénor, 2004; Bardhan, 2006; Nissanke & Thorbecke, 2006; Ravallion, 2006.

export markets), and by enabling a rapid increase of food supplies following domestic production shortfalls (e.g. through climatic occurrences).<sup>66</sup> From the few existing studies, however, it proves difficult to synthesize anything with respect to the trade – food security relationship and no general conclusion as to the net effect of increased trade openness on food security can be derived.

In this study, we take a broader perspective and focus on the overall level of food security of the population as indicated by average dietary energy consumption, which is also one of the main determinants of child's nutritional status (Smith & Haddad, 2000, 2001). One immediate advantage over child malnutrition studies is the greater availability of national food security data, which is not limited by the availability of household survey data and leads to a significantly greater sample size and the possibility to employ more advanced econometric methods dealing with the potential complexity of the dynamic relationships. These circumstances enable a more convincing assessment of the key determinants of food security and of whether food security is responsive to trade policy. The focus of the study is justified as the impact of specific national-level developments and policies is still not well understood and food insecurity remains a problem of great magnitude in many countries.

Our aim is to identify the key determinants of food security at the national level for a large sample of countries and gain insight into the issue of whether or not trade openness generally promotes food security, based on (dynamic) cross-country regression. The study is intended to be complementary to the existing literature that explores the linkages between globalization, trade openness, growth and poverty, but which does not explicitly explore the implications for food security. This study extends previous research of trade openness impacts and the determinants of food security in various directions. First, as noted above, we adopt a dynamic modeling approach. Previous cross-country studies of food insecurity and malnutrition, for example Smith & Haddad (2000, 2002) and Webb & Block (2010), have examined cross-country variation in malnutrition rates (of children), controlling for country level fixed-effects, however, in a static context. An additional but related problem with pooled cross-sectional regressions is that they are more vulnerable to endogeneity biases

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<sup>66</sup> See, von Braun, 1995; Chilowa, 1998; Seshamani, 1998; Minot & Goletti, 2000; Dorosh, 2001; del Ninno, Dorosh & Smith, 2003; Dorosh, Dradri & Haggblade, 2009; Pyakuryal et al., 2010.

arising from simultaneity or reverse causality between variables, which is difficult to control for in a static pooled regression model. For these reasons and because most economic processes are dynamic, the majority of cross-country empirical analyses have moved away from static models to dynamic regression techniques (Headey, 2013), which may be especially important in the analysis of policy reforms that have long-term effects that persist into the future. These methodological issues are discussed in more detail in Section 3.

In addition to shifting to a more appropriate modeling approach to analyze the dynamics of food security and policy impacts, we also broaden the scope of the analysis. First, as has been noted above, most existing studies on food security focus on the determinants of child malnutrition.<sup>67</sup> While this branch of research provides important insights into the issue of nutrition in early childhood, it may not give a clear indication of the overall food security status of the population and may thus not be the most appropriate basis on which to study food security issues (see Headey, 2013). Second, although it is generally acknowledged that “non-nutrition” factors can have profound effects on food and nutrition security, there exists, to the best of our knowledge, no systematic quantitative analysis of the impact of these important macroeconomic structural factors and policies on overall food security levels.<sup>68</sup> Third, as has been noted earlier, available cross-country studies on the impact of globalization and trade openness have focused on economic growth and poverty and have made only passing reference with respect to the food security issue. In summary, we assess the combined effects of various factors on the food economy and the overall state of food security while putting special emphasis on the impact of trade openness.

The rest of the chapter is structured as follows. Section 2 discusses the potential relationships between trade reforms and food security. Section 3 explains the empirical specification and estimation methodology employed in the empirical analysis. Section 4 describes the data, while Section 5 presents the empirical results and a rigorous sensitivity assessment. Finally, Section 6 offers some concluding remarks and policy recommendations.

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<sup>67</sup> Among others, see Smith & Haddad, 2000, 2001, 2002; Haddad et al., 2003; Alderman et al., 2005; Apodaca, 2008; Gabriele & Schettino, 2008.

<sup>68</sup> Analysis of existing case studies and FAO reports are generally descriptive and qualitative in nature (among others, see: Feleke et al., 2005; Rena, 2005; FAO, 2010).

## **2. THE LINKS BETWEEN TRADE REFORM AND FOOD SECURITY**

Prior to the discussion of the conceptual framework linking trade reforms to food security, we will shortly describe what can be deduced from trade theory as regards the impact of trade on food security. Policies of trade openness have been advocated worldwide for their growth and welfare enhancing effects on the basis of propositions embedded in the well-known international trade theories, in particular Ricardo's theory of comparative advantage and the Heckscher–Ohlin factor proportions model (Nissanke & Thorbecke, 2006). The Ricardo theory explains why it is beneficial for countries to engage in trade based on the differences in productivity (technology) and opportunity costs of production between countries. Regarding agriculture, climate and the availability of extensive arable land and abundant water supply are factors that may explain these differences (FAO, 2003a). The Ricardo model is based on the assumption of perfect competition and constant returns to scale and free trade is predicted to maximize total output and to enable an increase in total consumption (including food products) in both countries.

The Heckscher-Ohlin or Heckscher-Ohlin-Samuelson model expands upon the Ricardian model by introducing a second factor of production (capital) and explains the benefits of engaging in trade based on a country's advantage in production arising from its relative factor abundance with respect to the production factors labor and capital. It predicts that a labor-abundant country has a comparative advantage in and will export labor-intensive goods (e.g. food commodities) and import capital-intensive goods (e.g. manufacturing goods) and vice versa. In moving from autarky (or full protectionism) to free trade, both countries can reach a higher consumption level and factor (and output) prices will converge (Factor Price Equalization Theorem) (see Gandolfo, 2014). Free trade thus promotes exports of products that are produced with the relatively abundant factor, in most developing countries presumably (low-skilled) labor, thereby increasing the demand for low-skilled labor and bidding up the price of labor and thus raising workers' incomes. This induced process could thus play an important role in reducing poverty and improving food security (FAO, 2000). However, as is the case in the Ricardo model, the Heckscher-Ohlin model is based on the unrealistic assumption of perfect competition.

The New Trade Theory (see e.g. Krugman, 1997) assumes monopolistic competition instead of perfect competition aiming at explaining why trade often occurs between similar countries (i.e. with similar technology and factor endowments). The New Trade Theory explains the benefits of engaging in trade based on efficiency improvements that can arise because of increasing returns to scale in production. Countries are expected to specialize in production and export of products for which there are increasing returns to scale, and the world market can support only a limited number of firms. In this case, consumers benefit from free trade through the availability of a greater variety of goods (including food) at a lower price. However, free trade will also involve short-term adjustment costs, as some firms will not be able to compete. The New Trade Theory of increasing returns to scale also explains why smaller countries tend to adopt more open trade policies, which is related to the small size of the domestic market. If production costs fall with increasing levels of production, firms have an incentive to seek for larger markets allowing them to increase production. On the contrary, larger countries generally have more opportunities for trade within their borders and therefore lower (international) trade intensities (see Alesina et al., 2005).

The New Trade Theory also offers explanations for cases where some form of border protection may be beneficial for countries, however, in most cases trade restrictions are found to be second-best options compared to domestic support policies to correct for market imperfections. One interesting reason for protection can be established in the case where an industry has large economies of scale and firms may need protection to allow them time to grow before competing head-on with more established firms from other countries, which is known as the infant industry argument. This remains an important justification of protectionism in developing countries, however, more so in the case of manufacturing industries than for agriculture (see, e.g., FAO, 2003a).

In summary, trade theory suggests that trade liberalization forces countries to focus on production of products, for which they have a comparative advantage and leads to a more efficient allocation of resources, such that countries are able to produce more goods and services with the same amount of resources. It further allows countries to access larger markets and opens up opportunities for specialization in production and the realization of

economies of scale. Most developing countries should have a comparative advantage in agriculture, since they tend to be highly endowed with land, labor, and natural resources (rather than with capital and technology). Changes in income levels of rural workers, which are expected to increase in aggregate through trade liberalization, have the potential both to reduce poverty levels and to improve the food security status by increasing the access to food (FAO, 2000, 2003). Moreover, trade liberalization affects food security through its effect on price levels and export earnings. If the underlying assumptions of the “conventional” or “neo-classical” models, in particular that of perfect competition, do not hold, however, these predictions may change. In the presence of inflexible labor markets and limited access to inputs and credit, rural workers will (in the short-run) not be able to switch to more profitable activities and to withstand foreign competition. Similarly, lack of marketing infrastructure like roads, ports, and telecommunications can hamper a country’s ability to participate in and benefit from international trade. Protection of domestic sectors (e.g. through an import tariff) may then avoid unemployment costs in import-competing sectors. Moreover, if the availability of cheap imports makes it unprofitable for domestic producers to produce for local or international markets, food supply may decrease in the long-run, especially if producers have less incentive to invest in productivity-enhancing and soil-conserving measures (see FAO, 2003). If trade liberalization involves tariff reductions, this may also decrease government revenues and thus the ability of the government in providing transfers to the poor. As the above discussion shows, from trade theory alone, no clear-cut conclusion as to the impact of trade on food security can be derived.

The World Food Summit of 1996 defined food security as existing “when all people at all times have access to sufficient, safe, nutritious food to maintain a healthy and active life”. Put differently, food security is defined as a situation where both food supply and demand are sufficient to cover food requirements on a continuous and stable basis. This general definition of food security applies, in principle, to individual households as well as to aggregate national food security (Thomson & Metz, 1999). The FAO defines food security as a situation in which all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life. This definition emphasizes the multidimensional nature of food security, which entails three dimensions: availability, stability, and access. Adequate food



availability means that, on average, sufficient food supplies should be available to meet consumption needs. Stability refers to the issue of ensuring adequate food supplies in years of severe food shortages, e.g. during drought years. Food security in the access dimension is about ensuring that all people at all times have *economic* access to the basic food they need (FAO, 2003a). In the following we will first describe which different food security strategies countries may pursue at the national level and second, how trade reforms can affect the different dimensions of food security.<sup>69</sup>

#### (a) Food self-sufficiency versus food self-reliance

Food security at the national level is traditionally discussed in terms of either food self-sufficiency or food self-reliance. The former requires production of food in the quantities consumed domestically, while the latter implies maintaining a certain level of domestic production plus a capacity to import food in order to ensure domestic food availability in the quantities needed by exporting other products (FAO, 2000). Historically, food self-sufficiency policies in many developing countries did not enable them to feed their own population, and often, domestic production shortfalls had severe consequences for domestic food availability. Besides that, the pursuit of food self-sufficiency may be a costly policy, making agricultural markets thinner and more volatile (Brooks & Matthews, 2015). Given the much greater worldwide capacity to produce food than to consume food and decreasing transport costs, self-sufficiency may not be regarded as an economically sound alternative these days. Instead, in general it makes better economic sense to follow a more flexible policy of food self-reliance and what countries need may be sufficient capacity to generate the foreign exchange necessary to import whatever quantities they consume over and above what is efficient to produce, based on comparative advantage (FAO, 2003a). The approach of food self-reliance thus gives more attention to the macro level availability of food and access to income streams (e.g. through export activities) as well as improved production capacity to acquire food (van Rooyen & Sigwele, 1998). Trade is an essential component of a food self-reliance strategy and impacts on all three dimensions of food security, i.e. availability, stability, and access.

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<sup>69</sup> Note that our discussion of potential links is not meant to be comprehensive. For a complete conceptualization and discussion of the potential linkages between trade reform and food security, see FAO (2000) and FAO (2003a), on which the elaborations in this section are based.

## (b) Trade and food availability

With respect to the issue of ensuring the national availability of food, the world market can function as an essential source of food supplies, especially for those countries where domestic food production is constrained by agro-climatic and other factors. The economic choice of importing a commodity generally implies that it can be procured from abroad more cheaply than it can be produced domestically and as such is no *a priori* reason for concern (FAO, 2000). For countries with heavily distorted production and trade, greater market liberalization reduces price distortions and brings about improved incentives for market participants. Trade may then lead to an increase in the total amount of goods, e.g. food, available to the national population (increased consumption argument) and make available a greater variety of goods (diversification argument). In order to rely on such a strategy of food self-reliance, countries must be able to produce other goods and services to generate the foreign exchange to import food in the necessary quantities. A second qualification concerns the reliability of the world market as a source of affordable food supplies, both affected by trade policies (FAO, 2000).

With regard to import capacity, trade liberalization policies allow access to larger markets, open up opportunities for specialization in production as well as the realization of dynamic efficiency gains from factors such as economies of scale, technology transfers and knowledge spillover effects and thus enhances the possibilities for generating export revenues (see Wacziarg, 1998, and Wacziarg & Welch, 2008). This can also be of special importance for developing countries, particularly for smaller ones where the limited size of domestic markets discourages full use of production potential (FAO, 2003a). Besides that, revenue generated from exports can be used for the import of inputs for domestic production, for example machinery, fertilizers and pesticides. According to the FAO (2000), there are a number of examples where the engagement of farmers in export crop cultivation has also resulted in increased domestic food production because of the general improvement of input and service delivery to agriculture. Furthermore, many studies have shown that total factor productivity growth is faster in more open economies and that spillovers from both importables and exportables also produce gains with respect to the

productivity of traditional (food) crops.<sup>70</sup> These factors may therefore contribute to a more efficient domestic agriculture and food production and thus increase domestic food availability. However, debt service obligations and deteriorating terms of trade between agricultural commodities and manufactured products, as has been observed during the 1980s and 1990s, may limit the possibilities to finance food imports for those countries for which agricultural commodities are the major source of foreign exchange (FAO, 2005).

As regards the second qualification, the world market can be thought of as a reliable source of affordable food supplies that can be accessed to close food supply gaps (FAO, 2003a). However, as has become apparent during the recent food price crisis, if countries adopt export restrictions on food products, a country being dependent on food imports faces an additional supply uncertainty for reasons outside its control. Besides that, domestic food production may be adversely affected, if farmers are not able to compete at artificially low prices caused by government subsidies in exporting countries (FAO, 2000). Thus, although a reduction of distortions in world agricultural markets may boost agricultural and food production in developing countries, a prerequisite may be that the farmers are given the opportunity to respond to the market signals. This points to the potential importance of complementary domestic policy measures to reduce the bias against agriculture and to support the possibilities of farmers to respond to increased production incentives. It has indeed been noted that problems of unrealized gains from trade are often related to policy bias and institutional failure rather than due to trade per se (FAO, 2000). Similarly, lack of marketing infrastructure like roads, ports, and telecommunications can hamper a country's ability to participate in and benefit from international trade. These important qualifications may potentially limit the benefits of a food self-reliance strategy. Additionally, if the availability of cheap imports makes it unprofitable for domestic producers to produce for local or international markets, food supply may decrease in the long-run, especially if producers have less incentive to invest in productivity-enhancing and soil-conserving measures.<sup>71</sup>

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<sup>70</sup> Amongst others, see cross-country studies of Coe et al., 1997, Edwards, 1998, and Alcalá & Ciccone, 2004, and country case studies of Jonsson & Subramanian, 2001, and Fleming & Abler, 2013.

<sup>71</sup> However, many studies have shown that a reduction in trade barriers were often followed by significant increases in productivity, generally because of increased import competition (see, for example, Jonsson & Subramanian, 2001, and Agénor, 2004) and that exporting activities contributed significantly to productivity growth (Mengistae & Patillo, 2004).

### (c) Trade and food supply stability

The second dimension of food security refers to the stability of food supplies. Trade may serve to smooth out excess demand or excess supply situations in domestic markets, thereby stabilizing national food supplies and reducing price fluctuations. A more open trade regime may thus reduce the supply variability of (staple) foods, as countries have more options to enhance food availability compared to the case of a self-sufficiency policy. It also relieves countries of part of the burden from costly stock holding interventions (FAO, 2000). Deeper world markets for food products, availability of foreign exchange from increased export earnings accompanied by an open trade policy can then help to stabilize domestic food availability and permits global production to take place in those regions most suited to it. The reduction of protectionist measures, e.g. removal of quantitative restrictions and tariffs, generally implies that the absorption of production shocks will be shared more widely, thus having a stabilizing effect on food supplies (FAO, 2000). On the other hand, a problem resulting from this process may be the reliance on exports of a small number of agricultural commodities for a large share of export revenues. High dependence on just a few export commodities<sup>72</sup> may leave some countries, in which export earnings are critical for ensuring staple food imports, extremely vulnerable to changing market conditions, for example international price fluctuations (FAO, 2003b). However, it cannot be said *a priori* whether domestic price variability will increase or decrease as a result of trade liberalization. In general, more openness to trade is expected to contribute to the stability of world market prices, especially in the case of multilateral trade liberalization (FAO, 2003a).

### (d) Trade and access to food

International trade further impacts on the access dimension of food security via its effect on prices, the availability of production factors, economic growth, household incomes and employment. Trade policy effects on food access can be best discussed within the entitlements framework of Sen (1981), who identified four entitlement relationships, which enable individuals and households to acquire food.<sup>73</sup> *Production-based entitlements* refer to

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<sup>72</sup> Note that rising opportunity costs due to changing resource allocation between the goods and resulting price increases in a country above the world price will in general prevent a complete specialization in one product (Gandolfo, 2014).

<sup>73</sup> This section describing the entitlements framework of Sen (1981) is to a great extent based on FAO (2003a, pages 54-55).

the possibility that households produce their own food for consumption. This may be especially important for smallholder farmers in developing countries who aim for self-sufficiency. Trade policies that change the access to input markets as well as the availability and prices of factors used in production, some of which are related to international trade, can affect production-based entitlements.

*Trade-based entitlements* refer to the exchange of goods to acquire food. Many farmers may, for example, sell some of their production surplus on local or export markets to acquire other food products. The amount of food they can acquire will be influenced by trade policies that affect the prices for food relative to what the households are able to exchange as well as the access to export markets. Producers may also indirectly benefit from increased demand for their goods from those who benefit from trade liberalization (Winters et al., 2004). In many developing countries, export opportunities are usually better for non-food cash crops, for example cocoa and coffee (FAO, 2000). However, even if trade liberalization induces a shift towards the production and export of non-food cash crops, this process does not necessarily have to be detrimental for household food security from an access perspective. For example, if incomes generated from cash crop production are higher compared to those from food crop production and revenues can be used to buy food on local markets, access to enough food may improve. Trade liberalization should also help to increase access to vital inputs and technology needed for production, thereby increasing productivity, crop income and access to food. Consumers, on the other hand, should benefit from improved access to a more reliable and affordable food supply.

*Labor-based entitlements* refer to the selling of labor power in order to generate income and to acquire food in the market. These entitlements are determined by the availability of employment opportunities, which may be affected by trade policy. According to economic theory, for example the Heckscher-Ohlin-Samuelson model, free trade promotes exports of products that are produced with the relatively abundant factor, in most developing countries presumably (low-skilled) labor, thereby creating employment opportunities (also for non-farm income) and bidding up the price of labor and thus raising workers' incomes (Stolper- Samuelson theorem). This induced process could thus play an important role in reducing poverty and improving access to food. FAO (2003a) note that it may well be the

poorer, small-scale farmers who are using more labor-intensive techniques and who are more able to adjust to changing demand patterns and should additionally benefit from receiving a larger share of export prices. Smallholders may also benefit from high-value export production, either directly, for example through contract farming, or indirectly through employment in production and processing companies (Maertens & Swinnen, 2009; Jaffe et al., 2011). Employment opportunities may partly arise in the off-farm sector, leading to increased off-farm income, which has been found to improve food security and nutrition (see e.g. Babatunde & Qaim, 2010). However, in the presence of inflexible labor markets and limited access to inputs and credit, rural workers may (in the short-run) not be able to switch to more profitable activities and to withstand foreign competition (FAO, 2000). The New Trade Theory, focusing on the effects of increasing returns to scale and monopolistic competition, offers explanations for cases where protection of domestic sectors (e.g. through an import tariff) allows firms to grow and helps to avoid unemployment costs in import-competing sectors.<sup>74</sup> Other models (for example, Lucas' (1988) skill-acquisition model of endogenous growth and the models of Grossman & Helpman, 1991, and Matsuyama, 1992) show that openness to trade could in some cases act as a poverty trap, if comparative advantage forces economies to concentrate resources in traditional production sectors, with relatively low long-term growth prospects, for example agriculture. A related risk factor is a deterioration in the terms of trade of developing countries (primary commodity exporters) vis-à-vis developed countries (industrial goods exporters), which may decrease competitiveness and reduce economic growth, commonly referred to as the Prebisch-Singer hypothesis. However, in most cases trade restrictions are found to be second-best options compared to domestic support policies to correct for market imperfections (see FAO, 2000).

Finally, *transfer-based entitlements* relate to government or other transfers through which individuals are able to acquire food. The openness of a country may positively affect the possibility to receive food aid (FAO, 2003a). For example, Alesina & Dollar (2000) show that the direction of foreign aid is influenced by political and strategic considerations and find that certain donors, most notably the Nordic countries, dedicate more aid to those countries that are more open and have better institutions in place. This can be seen as an indication

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<sup>74</sup> Note, however, that the New Trade Theory also argues that openness leads to efficiency gains through the realization of economies of scale, resulting in lower prices and greater product variety, thereby increasing access to enough and to a greater variety of food.

that some donors reward good economic policy (Alesina & Dollar, 2000). However, in some developing countries tariff revenues may constitute an important part of government revenue. If trade liberalization involves tariff reductions, this may therefore decrease government revenues and thus the ability of the government in providing transfers to the poor, which in turn may limit the access to enough food.<sup>75</sup>

#### (e) Conceptual framework

As has become apparent from the above discussion, whether trade liberalization improves food security is theoretically ambiguous. There are solid analytical arguments speaking in favor as well as against a favorable impact of trade openness on welfare and food security, which strongly calls for empirical analysis to assess whether the *net* effects are positive or negative. The FAO (2003a) presents a conceptual framework for understanding how trade reforms can impact upon national-level food security. Even though the agricultural sector is generally seen as the key to long-term food security in many developing regions, it is important to account for broader changes within the economy, and not just the agricultural sector, when determining the impact on national food security levels.<sup>76</sup> The conceptual framework for analyzing the impact of reforms on food security can be described as follows (see Figure 1):<sup>77</sup> Trade liberalization, among other domestic macro-economic reforms, external shocks/non-economic events like natural disasters and violent conflicts, as well as the economic and demographic development (*causal factors*), impact on prices and quantities of produced and traded goods (*intermediate effects*). Trade reforms, for example, are expected to lead to border price changes, changes in production incentives and consequently, to changes in domestic prices, the level and value of domestic production and availability of goods and services (including food). These effects will be dependent on (structural) *country characteristics* as the level of economic development, environmental conditions as well as the importance of agriculture and the availability of resources in the economy, and the *policy environment* in which reforms are carried out. The country

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<sup>75</sup> However, Winters et al. (2004) conclude that there is no direct evidence that trade liberalization leads to reductions in social spending.

<sup>76</sup> Also with respect to trade policies, it should be emphasized that the net effect of trade policy changes that impact differently on the various sectors of the economy may be very different from what might be deduced by just looking at the changes directed to agriculture (see e.g. Valdés & Foster, 2002, and Anderson, 2002).

<sup>77</sup> See FAO (2003a, p. 233 ff.) for a detailed presentation of the conceptual framework for empirical research linking trade reforms and food security.

characteristics and policy environment affect the functionality of markets and the ability of market participants to respond to induced changes in prices and incentives. Accordingly, they affect the extent to which policy reforms cause a change in prices and quantities of produced and traded goods and may imply differing impacts of trade reforms on economy-wide effects and consumers' welfare (FAO, 2003). Through these channels, trade reform finally has an effect on the different dimensions of food security (*outcomes*).

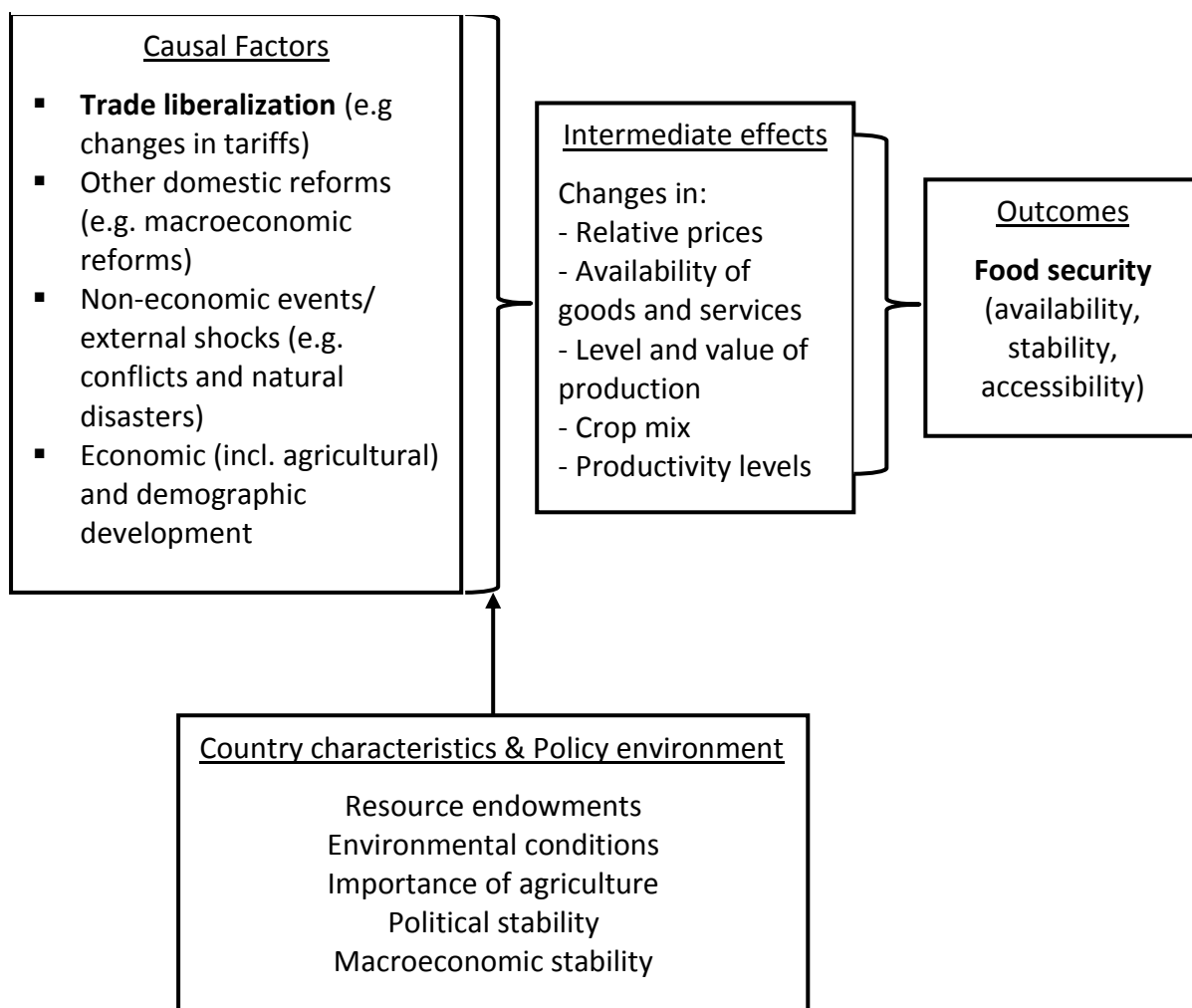
This framework also fits well into the UNICEF (1990) conceptual model on the causes of child malnutrition, where trade openness as part of the political and economic structure could be conceptualized as a basic cause/determinant, affecting incentives, food supplies and financial resources and in turn household food security. In this sense, our analysis can be seen as complementary to the studies on child malnutrition mentioned in the introduction, with our focus being exclusively on the food security link. Note, however, that the determinants of food insecurity and malnutrition need not necessarily be the same (see Webb & Lapping, 2002). A similar conceptual framework provides the analytical basis for recent studies of the Copenhagen Consensus, which conceptualize trade policy as part of the 'economic setting', which create both opportunities and constraints and eventually affect outcomes as food security and nutrition (see Hoddinott et al., 2012). Similarly, the Food Insecurity and Vulnerability Information and Mapping Systems (FIVIMS) of the FAO, linking the overall development context to the food economy, includes foreign trade as part of the political environment.<sup>78</sup> The specific supply and demand side factors, which are identified in the empirical analysis as main causes of food (in)security, are explained in more detail in Section 4. Prior to that, we describe the empirical model specification, which is based on the conceptual framework outlined above.

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<sup>78</sup> See <http://www.fivims.org>



**Figure 1:** Conceptual framework for analyzing the determinants of food security



Source: Own representation; based on FAO (2003)

### 3. EMPIRICAL METHODOLOGY

#### (a) Empirical specification

We adopt a dynamic modeling approach to study the evolution of food security over time and the impact of trade openness for a cross-section of countries. As has been noted in the introduction, a cross-country panel regression approach has some advantages compared to case studies and pure cross-sectional analyses, if the aim is to gain insights into the dynamic effects of policies and economic development.

First, the results are typically much more general than those from case studies, and we are interested in the overall (average) effect of trade openness and want to test whether or not more liberalized economies are more food-secure. Case studies have the advantage that they may be able to address the issue of food security at the individual or at least household level. However, it has also been argued and shown that the availability of economic resources at the national level largely determines the extent of overall food security of a nation (FAO, 2003a; IFPRI, 2006). In the same vein, macroeconomic relationships also affect very fundamentally the constraints and incentives that individuals face when trying to satisfy their food needs (Thomson & Metz, 1999).

Second, the use of a dynamic panel regression framework enables us to account for some of the dynamic aspects of trade reform and the potential problem of endogeneity can be dealt with adequately. As has been noted in the introduction, most economic processes are dynamic, meaning that the past matters to the current realizations of the process being studied, which can be assumed with some confidence in the case of policy reforms that have long-term effects, which persist into the future. Instead, a static model would imply that the history of the explanatory factors has no effect on current values of the dependent variable. A dynamic process modeled with a static model would then be miss-specified as it suffers from omitted dynamics/omitted variable bias (Baltagi, 2008). In addition, if the dependent variable is likely to be persistent, the inclusion of the lagged dependent variable accounts for this possibility. The idea is to use information on the past behavior of the variable of interest to model its current state. More specifically, we model current food security levels as a function of past food security levels (capturing also the effect of past reforms), and current

determinants.<sup>79</sup> Hence, in line with the theoretical considerations above, the core specification takes the form:

$$FS_{i,t} = \alpha + \beta FS_{i,t-1} + \gamma_1 TO_{i,t} + \gamma_2 CV_{i,t} + \eta_i + \mu_t + \varepsilon_{i,t} , \quad (1)$$

where the subscripts  $i$  and  $t$  represent country and time periods, respectively;  $FS$  denotes food security and is represented by dietary energy consumption, which is our preferred food security measure and refers to the amount of food, expressed in kilocalories (kcal) per day, available for each individual in the total population. It is calculated on the basis of food balance sheets and caloric content is derived by applying the appropriate food composition factors to the quantities of the commodities consumed. Per person supplies are then derived from the total amount of food available for human consumption by dividing total calories by total population actually partaking of the food supplies during the reference period (FAOSTAT).<sup>80</sup> While subject to error (see Svedberg, 1999), this measure is one of the most applied quantitative indicators of food security and has been used in previous studies as a proxy for calorie consumption and national food security. Per capita calorie consumption is, according to the FAO, one of the core indicators of food security closely linked to food consumption.<sup>81</sup> A great advantage is the large data coverage both across countries and time. The employment of alternative food security indicators, which are not available on an annual basis, would make it difficult to assess the effects of short-term shocks due, for example, to natural disasters and violent conflicts. Nevertheless, in the robustness section of the chapter, we assess the sensitivity of our results with regard to the employed food security measure. Lagged food security ( $FS_{i,t-1}$ ) is included in the model based on the theoretical considerations above and is treated as predetermined to the current period.

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<sup>79</sup> Inclusion of the lagged value of food security term can also be viewed as a way to control for potentially omitted variables. The lagged dependent variable will control for longer-term impacts of all our included control variables and would also pick up effects of other potentially omitted variables as it will be highly correlated with the current value of the food security variable.

<sup>80</sup> It should be noted that daily per capita calorie data represent the average available for the whole population and may differ from actual consumption, which can be lower because of wastage during storage, in preparation and cooking, as plate-waste or quantities fed to domestic animals or thrown or given away (FAOSTAT).

<sup>81</sup> Increases in per capita calorie availability have also found to be closely associated with decreases in the undernourishment prevalence and to contribute substantially to reductions in malnutrition among children and thus are very likely to lead to nutritional improvements (see, for example, Frongillo et al., 1997; Smith & Haddad, 2000, 2001; FAO, 2005; Dawson & Sanjuán, 2011).

TO is the employed trade openness measure, which is proxied by the volume of trade (real exports plus imports) over real GDP (Penn World Table (PWT) 6.3). This revealed openness measure is the measure usually employed in impact studies of trade liberalization and is arguably better than de jure measures (e.g. tariffs) to the extent that the latter are difficult to summarize in a single indicator.<sup>82</sup> We treat the trade openness measure as endogenous because of a potential reverse causality problem, as countries may adopt protectionist policies in response to past food security shocks. CV is a set of control variables that were hypothesized above to be important potential determinants of national food security and are explained in more detail below. Finally,  $\eta_i$  denotes country-specific effects, for example geographic characteristics or unobserved cultural and institutional factors that are rather stable over time,  $\mu_t$  is the time-specific effect, capturing changes in world prices and controlling for shocks that are common to all countries such as global demand shocks, and  $\varepsilon_{i,t}$  is the error term. Of most interest is the coefficient on the TO indicator, which a priori has an ambiguous effect on food security according to the above discussion.

#### (b) Estimation methodology

Before moving on to the empirical results, there are several specification issues that require attention, as the estimation of Eq. (1) poses a challenge given the presence of both unobserved heterogeneity and potential endogeneity of regressors resulting from simultaneous or reverse causation. One immediate problem of estimating (1) is that the lagged dependent variable is endogenous to the fixed effects in the error term, which gives rise to “dynamic panel bias” (also known as “Nickell (1981) bias”). Thus, OLS estimates of the model will be inconsistent, even in the fixed or random effects settings, because the lagged dependent variable would still be correlated with the error term, even if the latter is not serially correlated.<sup>83</sup> First-differencing Eq. (1) may seem to eliminate this potential source of bias, as it removes the individual effects. However, when we take first differences of explanatory variables that are not strictly exogenous, these become endogenous, since the first difference will be correlated with the error term (Roodman, 2009a). To illustrate this

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<sup>82</sup> Among others, see: Dollar, 1992; Dollar & Kraay, 2004; Chang et al., 2009; Loayza et al., 2012. Nevertheless, in the robustness section of the chapter, we assess the sensitivity of the results with regard to alternative trade policy measures.

<sup>83</sup> For a detailed representation and discussion of dynamic panel bias, see, for example, Nickell, 1981, and Arellano & Bond, 1991. Dynamic panel bias diminishes with large T. However, in simulations, Judson & Owen (1999) find a bias equal to 20% of the coefficient of interest even when T = 30.

endogeneity problem, consider the following simplified version of the original levels model, where only the lagged dependent variable is included as regressor:

$$FS_{i,t} = \beta FS_{i,t-1} + \varepsilon_{i,t} \quad \text{with} \quad \varepsilon_{i,t} = \mu_i + v_{it}$$

Taking first-differences to remove the fixed effects ( $\mu_i$ ) leads to the following equation:

$$FS_{i,t} - FS_{i,t-1} = \beta(FS_{i,t-1} - FS_{i,t-2}) + v_{it} - v_{it-1} .$$

As can be seen,  $FS_{i,t-1}$  shows up on both sides of the equation, such that the  $FS_{i,t-1}$  in  $FS_{i,t-1} - FS_{i,t-2}$  is correlated with  $v_{it} - v_{it-1}$  and needs to be instrumented. For example, one could instrument  $FS_{i,t-1} - FS_{i,t-2}$  with either  $FS_{i,t-2}$  or  $FS_{i,t-2} - FS_{i,t-3}$ , which are uncorrelated with  $v_{it} - v_{it-1}$  but correlated with  $FS_{i,t-1} - FS_{i,t-2}$ , as long as the error term is not serially correlated.

Based on Holtz-Eakin, Newey & Rosen (1988), Arellano & Bond (1991) developed a Generalized Method of Moments (GMM) estimator for linear dynamic panel data models that solves the above-mentioned problems. This GMM estimator is based on first differencing the original (levels) equation to control for time-invariant unobserved effects and using previous observations of the explanatory variables as instruments that will be uncorrelated with the fixed effects (Roodman, 2009a).

To eliminate the country-specific effect, we take first differences of Eq. (1):

$$FS_{i,t} - FS_{i,t-1} = \beta(FS_{i,t-1} - FS_{i,t-2}) + \gamma'(X_{i,t} - X_{i,t-1}) + (\mu_t - \mu_{t-1}) \\ + (\varepsilon_{i,t} - \varepsilon_{i,t-1})$$

with  $X_{i,t}$  including  $TO_{i,t}$  and  $CV_{i,t}$ . Instruments are required to deal with the problem that, by construction, the error term of Eq. (2),  $(\varepsilon_{i,t} - \varepsilon_{i,t-1})$ , is correlated with the lagged dependent variable  $(FS_{i,t-1} - FS_{i,t-2})$ . The instruments take advantage of the panel nature of the data and consist of previous observations of the lagged dependent variable. The same procedure can also be applied to account for the potential endogeneity of other explanatory

variables contained in  $X$ . Under the (identifying) assumptions that the error term,  $\varepsilon$ , is not serially correlated (see eq. (5)), and the explanatory variables are weakly exogenous (meaning that they are uncorrelated with future realizations of the error term), lagged levels of the explanatory variables can be used as instruments as specified by the following moment conditions (see DeJong & Ripoll, 2006):

$$E[FS_{i,t-s} \cdot (\varepsilon_{i,t} - \varepsilon_{i,t-1})] = 0 \text{ for } s \geq 2; t = 3, \dots, T \quad (3)$$

$$E[X_{i,t-s} \cdot (\varepsilon_{i,t} - \varepsilon_{i,t-1})] = 0 \text{ for } s \geq 2; t = 3, \dots, T \quad (4)$$

Besides these two orthogonality conditions stated above, the estimator is based on the following two (additional) identifying assumptions:

$$E[\varepsilon_{i,t}\varepsilon_{i,t-j}] = 0 \text{ for all } j \neq 0 \quad (5)$$

$$E[\mu_t \cdot (\varepsilon_{i,t+s})] = 0 \text{ for all } t \text{ and } s \geq 0 \quad (6)$$

, where equation (5) implies that the error term is not serially correlated and latter states that the period-specific effect is strictly exogenous.

First differencing accompanied with using the level of past values as instruments then gives rise to the well-known “Difference-GMM” estimator (Arellano & Bond, 1991). Despite its superiority over simpler panel data estimators, a problem with this Difference-GMM estimator is that lagged levels have been shown to be weak instruments for first-differences if the series are very persistent (Bound et al., 1995). Further, by taking first differences, one loses information that speaks to the (long-run) relationship between the explanatory variables and the dependent variable. The presence of weak instruments affects the asymptotic and small-sample performance of the Difference-GMM estimator and may lead to inefficient and biased coefficient estimates (Baltagi, 2008). According to Arellano and Bover (1995), efficiency can be increased by adding the original equation in levels to the system, which is known as the “System-GMM” estimator. This estimator has been shown to improve on the GMM estimator in the first differenced model in terms of bias and root mean squared error and generally produces more efficient estimates compared to Difference-GMM by improving precision and reducing the finite sample bias (see e.g.

Hayakawa, 2007). For the equation in levels (Eq. (1)), the instruments are given by the lagged differences of the explanatory variables (including the lagged dependent variable). These are appropriate instruments under the assumption that the correlation between the explanatory variables and the country-specific effects is the same for all time periods (Blundell & Bond, 1998).<sup>84</sup> Using this stationarity property, the following moment conditions can be added for the second part of the system (regression in levels):

$$E[(\mu_t - \mu_{t-1}) \cdot (\eta_i + \varepsilon_{i,t})] = 0 \quad (7)$$

$$E[(FS_{i,t-1} - FS_{i,t-2}) \cdot (\eta_i + \varepsilon_{i,t})] = 0 \quad (8)$$

$$E[(X_{i,t-1} - X_{i,t-2}) \cdot (\eta_i + \varepsilon_{i,t})] = 0 \quad (9)$$

The set of moment conditions specified in Eqns. (3-4) and (7-8) are used in System GMM to generate consistent and efficient estimates of the parameters of interest and their asymptotic variance-covariance (Arellano & Bover, 1995). We employ the two-step System-GMM estimator incorporating Windmeijer's (2005) finite-sample correction for standard errors in the empirical analysis. The two-step variant of the GMM estimator uses an optimal weighting matrix for the moment conditions (instruments). It weights the moment conditions by a consistent estimate of their covariance matrix, or more specifically, weights the moments in inverse proportion to their variances and covariances, such that highly correlated instruments get less weight in the estimation process. The optimal weight matrix thus attaches more weight to the moments that contain more unique identifying information, improving efficiency of the estimates (Roodman, 2009a). In the first step the residuals of the (consistent but inefficient) one-step estimation are obtained, while in the second step GMM estimation is rerun with the moments weighted by the optimal weight matrix, which is constructed using the residuals from the first step estimation (see Chang et al., 2009).

The consistency of the GMM estimator depends on whether lagged values of the explanatory variables are valid instruments. We consider the following specification tests of the validity of the identifying assumptions to address this issue: Arellano and Bond's (1991)

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<sup>84</sup> Put differently, this condition states that if the first-differences of the explanatory variables are not correlated with the individual effects, lagged values of the first-differences can be used as instruments in the levels equation.

AR(1) and AR(2) tests of the serial correlation properties of  $(\varepsilon_{i,t} - \varepsilon_{i,t-1})$ , and Hansen's (1982)  $J$ -test of overidentifying restrictions. The latter tests the validity of the instruments by analyzing the sample analog of the moment conditions used in the estimation process (Chang et al., 2009). The GMM estimator assumes that, while there will be first-order serial correlation in the error term in differences, there should not be second-order correlation in order for the estimator to be consistent. The reason is that if there is error serial correlation in levels (2nd order autocorrelation in differences), some instruments based on lags will not be valid (Roodman, 2009a). The AR(1) test tests for serial correlation of the differenced error term, which is expected to be present in the data, as  $\Delta\varepsilon_{i,t}$  is mathematically related to  $\Delta\varepsilon_{i,t-1}$  via the shared term  $\varepsilon_{i,t-1}$ . The AR(2) test tests for second-order autocorrelation in differences (error serial correlation in levels), which must be absent from the data in order for the estimator to be consistent. The model is supported when the null hypothesis of no second-order serial correlation (in differences) is not rejected (DeJong & Ripoll, 2006).<sup>85</sup> The "Hansen test" tests the null of joint validity of the moment conditions (full set of instruments), which amounts to testing the exogeneity of the covariates, i.e. if they are uncorrelated with the error term. Specifically, it tests whether the vector of empirical moments is randomly distributed around zero. Failure to reject the null hypothesis gives support to the model (Roodman, 2009a).<sup>86</sup> The "Difference-in-Hansen" test reported in the tables below focuses on the additional instruments that are introduced in the levels equation and tests whether changes in the instrumenting variables are uncorrelated with the fixed effects, thereby testing the stationarity assumption on which they are based (Chang et al., 2009). The test statistic is the *difference* of two Hansen tests, one performed on the model with and one without the suspect instruments. Again, failure to reject the null hypothesis gives support to the model. To reduce the potential biases and imprecision associated with the difference-GMM estimator and because the issue of the endogeneity of both the lagged dependent variable as well as some other explanatory variables is a vital issue to consider here, the GMM System estimator will be employed in the subsequent empirical analysis.

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<sup>85</sup> Note that second-order serial correlation of the differenced residual indicates that the original error term is serially correlated and follows a moving average process of at least order one (Loayza et al., 2012).

<sup>86</sup> Roodman (2009b) notes that it can also be viewed as a structural specification test, as omitting important explanatory variables may make the error term correlated with the instruments and invalidate them.



#### 4. DATA

To perform the estimations, we compiled a pooled cross-country and time-series data panel consisting of a total of 151 countries, covering 129 developing and transition and 22 developed (OECD) countries over the period 1980-2007, selected on the basis of data availability (see Table A.1 for a list of these countries). During this time period, substantial trade reforms have taken place in many countries, developing as well as developed ones. The choice of variables, described in this chapter, is guided by the conceptual framework, experience gleaned from past studies, and data availability. Most of the data used in this study are from the World Bank's World Development Indicators (WDI) and FAO's FAOSTAT. As has been explained in Section 2, to study the temporal dynamics of food (in)security one has to account for the chronic food insecurity associated with problems of continuing or structural poverty and low incomes, as well as transitory food insecurity, which involve periods of intensified pressure caused by natural disasters, economic collapse or conflict (World Bank, 1986). Both forms of food insecurity will be reflected in national food security levels. Next, we will therefore describe the other important determinants of national food security that we account for in the baseline model.<sup>87</sup>

In accordance with the conceptual model, we consider five groups of food security determinants: First, control variables that account for country context and characteristics; second, variables capturing the economic (including agricultural) and demographic development; third, control variables that capture non-economic events and external shocks; fourth, control variables that measure domestic macroeconomic policies and conditions other than trade policy (policy environment); and fifth, our trade openness measure, which is the explanatory variable of most interest in our study.<sup>88</sup>

With respect to important (structural) country characteristics that may imply differing impacts of trade reforms on economy-wide effects and consumers' welfare, we account for

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<sup>87</sup> Note that due to severe data constraints and because of the complexity of the employed econometric model, not all potential determinants could be captured in the empirical model. For example, poverty is excluded from the analysis due to scarcity of data, as data for more than one point in time are not always available. We follow common practice and employ per capita national income instead of a direct poverty measure (see Smith & Haddad, 2000, 2001). Indeed, several studies have confirmed the existence of a strong (negative) relationship between national incomes and poverty (see, for example, Ravallion & Chen, 1997).

<sup>88</sup> For a complete list of variables used, and sources, see Table A.2 in the appendix.

the level of economic development, the availability of resources for agricultural production as well as the importance of agriculture in the country. Similar to the cross-country specifications of Smith & Haddad (2000) and Gabriele & Schettino (2008) for the analysis of child malnutrition, logged per capita real (chain-weighted) GDP (PWT 6.3) is employed as a determinant to capture broadly the economic resources available to a country. A favorable impact of the level of GDP per capita on calorie consumption is expected, as it improves the resources available for purchasing food and thus the ability to afford food security. This measure also ensures that any impact of the other explanatory variables is not solely due to country differences in the level of economic development. The importance of agriculture, at the same time being one important facet of the demographic change, is accounted for by including the rural population share (WDI), which refers to people living in rural areas as a share of total population. On the one hand, as the poorest countries are typically predominantly rural and food insecurity is generally more prevalent in rural areas (see FAO, 2003), a greater rural population share may be negatively related to national food security. On the other hand, it also captures one important element of domestic resource endowments, namely rural population resources, including the agricultural labor force, which may positively affect food production and food availability.<sup>89</sup> The second important element of country resource endowments determining agricultural production potential and thus being one important supply side factor is arable land. Data on arable land (hectares per person) comes from WDI and includes land defined by the FAO as land under temporary crops (double-cropped areas are counted once), temporary meadows for mowing or for pasture, land under market or kitchen gardens, and land temporarily fallow. As an increase in available per capita arable land should have a favourable impact on domestic agricultural production, a positive effect on food security is expected.

With regard to the second group of food security determinants, the regressions include three variables capturing the agricultural and overall economic and demographic development. We use cereal yield (kg per hectare) (FAOSTAT), as a proxy for agricultural productivity, the growth rate of real GDP per capita (PWT 6.3) to capture cyclical movements in output or economic growth, and the annual population growth rate (WDI) to capture

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<sup>89</sup> Note that an alternative measure of the importance of agriculture, that is the share of agriculture in GDP, could not be included because of its very high correlation with our GDP per capita measure.

population pressures on food security. There is a wide geographic variation in crop yields around the world and closing the yield gap is generally seen as a way out of food insecurity (Godfray et al., 2010). Agricultural productivity should positively affect the supply of food from domestic production. Economic growth is expected to lead to wider availability of goods and services (including food) and is commonly regarded as the single most important factor influencing income-based and food poverty (Ames et al., 2001; Haddad et al., 2003). The growth rate of GDP is also intended to capture cyclical movements in output, as sharp output contractions (or cyclical downturns) have been found to increase poverty (see Agénor, 2004) and may thus affect food security as well. Annual population growth is intended to capture broadly one important facet of demographic development. Population pressures as indicated by high population growth lead to growing food requirements for the whole population and decrease, *ceteris paribus*, food availability per person. Besides that, population pressure has effects on development more generally, for example education rates and employment opportunities as well as various environmental consequences for e.g. cropland and water availability, with potential repercussions on food security.<sup>90</sup>

We account for two sorts of non-economic events/external shocks: natural disasters (EM-DAT) and human-induced disasters (UCDP/PRIO). As natural disaster variable, we employ an intensity measure of natural disasters, measured as the number of affected divided by the total population, based on data from the Emergency Events Database (EM-DAT).<sup>91</sup> A natural disaster is one form of external shock or non-economic event, which can lead to severe harvest losses and therefore have a detrimental impact on food availability from domestic production and exert serious pressure on farm incomes. Violent conflicts representing human-induced disasters are another form of external shock. According to the World Bank (2011), around 1.5 billion people live in conflict-afflicted countries. We employ an intensity measure of armed conflict, which takes the value 0 for no conflict, 1 for a minor conflict and 2 for war. This measure has been widely applied in macro-level research.<sup>92</sup> Conflict can be

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<sup>90</sup> For a more detailed representation of the neo-Malthusian perspectives on population pressure and its consequences, see Brown et al. (1999).

<sup>91</sup> Natural disaster comprise geophysical, meteorological, hydrological, climatological, and biological disasters (see <http://www.emdat.be/>).

<sup>92</sup> Among others, see: Collier et al., 2003; Miguel et al., 2004. The data on armed conflicts is available at <http://www.prio.no/Data/Armed-Conflict/UCDP-PRIO/>. A minor conflict corresponds to a conflict causing between 25 and 999 battle-related deaths in a given year, while a conflict causing at least 1,000 battle-related deaths in a given year is categorized as war.

seen as a factor of vulnerability and is a major cause of structural food insecurity. It has wide development consequences and may exert potential adverse impacts on food security through its effect on food supply from domestic production and on access to food by causing lower preferences for market participation, income losses and disrupting transport, trade and markets and thus domestic food chains (Gates et al., 2012; World Bank, 1986). Conversely, food insecurity may also lead to or exacerbate conflict, which is why it may not be strictly exogenous (see Messer et al., 2001).

The presence of violent conflicts is, to some extent, also related to political instability. As an additional measure to account more broadly for the domestic macroeconomic policy environment we employ the consumer price index (CPI) inflation rate (WDI) as a proxy for macroeconomic stabilization (also related to monetary policy), with high inflation being associated with bad macroeconomic policies.<sup>93</sup> Domestic stabilization policies creating an economically stable environment have welfare enhancing effects, whereas macroeconomic instability has been found to increase poverty, thereby potentially negatively affecting household food security (see e.g. Agénor, 2004). Easterly & Fischer (2001) indicate that the poor tend to mention inflation as a top national concern and find a significant association between lower inflation and improved well-being of the poor. On the contrary, macroeconomic instability hurts the poor, as for example high inflation rates erode real wages and the assets of the poor (Ames et al. 2001). It is therefore expected to lower purchasing power and decrease food consumption.<sup>94</sup>

## 5. EMPIRICAL RESULTS

Table 1 shows the results of the core regression model using the full sample and our preferred specification, which is the two-step System-GMM estimator incorporating Windmeijer's (2005) finite-sample correction for standard errors.<sup>95</sup> Additionally we present alternative consistent but potentially less efficient estimators, all addressing the

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<sup>93</sup> Among others, see Roodman, 2007, and Loayza et al., 2012. As customary in the literature, the inflation rate enters the regressions as  $\log [1 + \text{inflation}]$ .

<sup>94</sup> Food price inflation (of world prices) may at first sight seem more relevant for the issue of food security. However, first, available world food price indices show no variation across countries and second, as prices for other goods also determine the disposable income for food consumption, consumer price inflation is used in the present study.

<sup>95</sup> This estimator is sometimes called two-step efficient GMM as it uses an efficient or optimal weighting matrix for the moment conditions.

econometric problems induced by unobserved country-specific effects and endogeneity resulting from simultaneous or reverse causation. In the following, we will explain in more detail how the model specifications differ.

The estimation results of the baseline model are presented in Column 1. The lagged dependent variable is significant and its magnitude reveals that food (in)security levels change only slowly over time and depend on past levels. This result also justifies the dynamic model specification and suggests one should indeed lend greater credence to the system GMM estimation results, because of the weak instruments problem associated with difference GMM when the series in question is highly persistent.

As has been mentioned earlier, although the procedure of including the lagged dependent makes it more difficult to get statistically significant results for the other explanatory variables, as it already picks up a lot of the variation in the dependent variable, omitting these significant dynamics would lead to miss-specification of the model. Despite being theoretically ambiguous, the hypothesis that trade openness positively affects national food security receives clear empirical support. This implies that trade liberalization policies, increasing the volume of trade, have the potential to improve the food security status of a country. Given the inclusion of lagged food security, it is also possible to calculate the long-run effect of trade on food security. The estimates given in Column 1 of Table 1 imply that the long-term effect of a one-unit change in trade openness is to raise dietary energy consumption by about 2.27 ( $=0.529/(1-0.767)$ ). Accordingly, an increase in trade openness of one standard deviation would increase dietary energy consumption by 93 kcal. For example, would Cameroon be as open to trade as Ghana (in 2007), all else equal, it could increase its per capita dietary energy supply by about 114 kcal, from currently 2269 kcal to 2383 kcal. This could be achieved, for example, through a reduction in applied tariffs, which are currently at a high level of 18.9%<sup>96</sup>.

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<sup>96</sup> This value is the simple mean applied tariff rate for all traded products of Cameroon in 2012 (WDI), while the respective rate for Ghana is 12.5.

Table 1: *The effect of trade openness on food security (alternative model specifications)*

Depvar: Dietary energy consumption	(1)	(2)	(3)	(4)	(5)
	SYS-GMM (baseline)	All lags	Principal components	one-step SYS-GMM	IV/2SLS
Depvar_(t-1)	0.7670*** (0.0612)	0.7921*** (0.0511)	0.8083*** (0.0527)	0.7667*** (0.0558)	0.7524*** (0.0593)
Trade openness	0.5291*** (0.1964)	0.5277*** (0.1805)	0.5641*** (0.2104)	0.5484*** (0.2053)	0.5390* (0.3090)
GDP per capita	47.1681*** (16.8885)	42.5966*** (16.2947)	35.0699** (14.5495)	47.4382*** (16.5968)	51.3170*** (17.2762)
GDP growth	1.3052*** (0.2819)	1.4039*** (0.3562)	1.4395*** (0.3622)	1.4881*** (0.3374)	1.4052*** (0.3428)
Armed conflict	-11.1373** (4.8271)	-15.3399** (7.0069)	-14.1592** (6.7974)	-14.0021* (7.4419)	-13.8738* (8.1540)
Arable land	23.6506*** (6.7412)	20.9560*** (6.6516)	18.2549*** (6.5525)	24.9937*** (6.4922)	25.9623*** (8.0838)
Ag. productivity	35.7712*** (10.0595)	34.7070*** (9.5580)	29.1101*** (10.2449)	37.1236*** (10.1002)	38.7327*** (11.3934)
Rural population	-1.1410*** (0.4343)	-0.8657* (0.4428)	-1.0951** (0.4546)	-1.0977*** (0.3953)	-1.1368** (0.4477)
Population growth	-11.6252** (5.5672)	-14.5301** (7.2535)	-10.2969 (6.7309)	-11.8086** (5.2170)	-12.4307** (5.5292)
Natural disasters	-28.1717 (18.4913)	-28.2791 (21.1916)	-39.6937** (20.1051)	-29.2587 (18.2863)	-30.2560* (18.3397)
Inflation	-18.9095** (8.2408)	-12.6363 (8.0909)	-17.0336** (8.5936)	-16.5702** (7.6744)	-17.4749** (7.9960)
Observations	3,579	3,579	3,579	3,579	3,579
Number of id	151	151	151	151	151
Instruments	50	145	84	50	50
<i>Tests (p-values)</i>					
AR1 Test	0.000	0.000	0.000	0.000	0.000
AR2 Test	0.565	0.559	0.518	0.555	0.567
Hansen Test	0.891	0.220	0.189	0.891	0.892
Diff-Hansen	0.926	0.119	.	0.926	0.929
Portion of variance explained			0.941		
K-M-O measure of sampling adequacy			0.937		

In the baseline model only the first three lags of each instrumented variable are included and the instrument count reported is based on the number of “collapsed” instruments, using the `xtabond2` specification from Roodman (2009a). The other specifications are explained in the text. Diff-Hansen test reports the p-values based on the null hypothesis that the instruments in the levels equation are exogenous. For more details, see Roodman (2009a). Coefficients in (1) to (3) based on the two-step estimation, using the Windmeijer correction. Period fixed effects employed but not reported. Numbers in parentheses are robust standard errors.

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

As has been expected, higher economic resource availabilities are associated with higher food security levels and economic growth exerts positive effects on dietary energy consumption.<sup>97</sup> These findings point to the importance of general economic development for the fight against food insecurity. Nevertheless, during the last decades many developing countries, especially in Sub-Saharan Africa, were not able to make significant improvements in food security levels, despite rapid economic growth (see FAO, 2012). This may in part be explained by low agricultural productivity in these countries, which constraints food supply from domestic production and rural incomes. As our results reveal, agricultural productivity has a significant positive impact on food security, lending support to the hypothesis that closing the yield gap would contribute to increased food security. The results regarding the other explanatory variables also conform to our expectations.

The empirical findings also confirm that non-economic events can be important determinants of food security. Violent conflicts, which can be a major cause of structural food insecurity, significantly negatively impact on calorie consumption.<sup>98</sup> Besides that, also natural disasters have a detrimental impact on food security, although its coefficient is significant only in some of the alternative model specifications.<sup>99</sup> The coefficient on the share of per capita arable land capturing one important aspect of domestic resource endowments is positive and significant. This finding is in line with previous case study results, indicating that households with larger farmland are more likely to be food secure because of higher production levels (see e.g. Feleke et al., 2005).<sup>100</sup> The rural population share enters negatively into the regression, indicating that economies, which are predominantly rural, also entail higher levels of food insecurity. As the inverse of the rural population share is the urban population share, the results also indicate that urbanization is associated with increased calorie consumption. Therefore, although not being

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<sup>97</sup> As displayed in Table 7, additional estimations using a decomposition of our growth variable show that all parts of economic growth, i.e. agricultural, industrial, and services growth, exert positive effects on food security. We therefore report only the aggregate effect of general economic growth.

<sup>98</sup> The employment of alternative conflict measures did not qualitatively change the results. These additional results are discussed in the sensitivity analysis and displayed in Table A.3 in the appendix.

<sup>99</sup> Although natural disasters in general seem to have negative effects on food security, additional results (see Table 7) reveal that only climatological and hydrological disasters (including droughts and floods) exert significant negative effects on food security.

<sup>100</sup> Note that using agricultural land (% of land area) or total area equipped for irrigation (% of land area) instead of per capita arable land does not qualitatively change the results (see Table A.3 in the appendix).

uncontroversial (see e.g. Ruel et al., 1999), the benefits of urbanization in that it provides better access to essential goods and services (including food) seem to outweigh potential detrimental effects associated with additional population pressure.

The last two main determinants, population growth and inflation, are also significantly negatively related to calorie consumption, indicating the harmful consequence of high population growth and macroeconomic price instability and thus confirming previous case study results at the household and national level.<sup>101</sup> High population growth leads to growing food requirements in a country and *ceteris paribus* decreases the amount of food available per person. High inflation rates erode real wages and the assets of the poor and consequently lead to decreasing purchasing power of consumers, thereby leading to a decrease in a population's access to food. Besides that, it shows that macroeconomic instability, potentially affecting people's incentives and the allocation and utilization of resources in the economy, has a detrimental effect on food security. Moreover, as can be seen in the lower part of the table, the model specification is supported by all available specification tests, such that specification error or poor instruments do not appear to be driving the results. Autocorrelation of first-order, AR(1), is present in the data, as has been expected. Autocorrelation of second-order, AR(2), is absent from the data, which must be the case for the GMM estimator to be consistent. The Hansen-test does not reject the over-identifying restrictions (exogeneity of instruments) at conventional levels of significance, which implies that the whole instrument set is valid. The Difference-in-Hansen test suggests that the (additional) assumption of System-GMM is not violated and the additionally introduced instruments are valid, lending further support to the statistical properties of the results.

One important issue, which has received some attention during the last years, is that of which instruments to use in the GMM estimation. One can have "too many instruments," in which case the instruments fail to expunge their endogenous components and bias

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<sup>101</sup> See, for example, case studies of Feleke et al. (2005) and Rena (2005), which identified high population growth resulting in increased household sizes and lack of purchasing power resulting from high inflation rates as two of the main causes of food insecurity in Ethiopia and Eritrea, respectively.



coefficient estimates towards OLS.<sup>102</sup> In theory, the potential set of instruments spans all sufficiently lagged observations of the instrumented variables and, thus, grows with the number of time periods,  $T$ . However, when the sample size in the cross-sectional dimension is limited, it is recommended to use a smaller set of moment conditions in order to avoid over-fitting bias (Roodman, 2009b). In addition, the Hansen test is weakened by many instruments and may generate implausibly high  $p$ -values of 1 and thus fail to detect invalid instruments (Bowsher, 2002).

In Column 1 of Table 1, we have taken two steps to limit the instrument count. First, we restrict the lag ranges and use only three appropriate lags of each endogenous explanatory variable in the differenced equation and the contemporary first difference as instrument in the levels equation.<sup>103</sup> Second, we “collapse” the instrument set, which is equivalent to combining columns of the instrument matrix by addition. The estimation procedure then uses a common variance–covariance of moment conditions across periods. This results from substituting the assumption that the average (across periods) of moment conditions for a particular instrument be equal to zero for the conventional, but more restrictive, assumption that each of the period moment conditions be equal to zero (Roodman, 2009a).<sup>104</sup> At the cost of reduced efficiency, these two steps can significantly reduce the problems caused by instrument proliferation by accommodating cases where the unrestricted variance–covariance is too large for estimation and inversion (Loayza et al., 2012). This can be especially crucial in the case of both a large number of explanatory variables and the presence of several time periods. Roodman (2009b) demonstrates the superiority of using limited lag ranges and collapsing instruments in some common situations with simulations and finds that collapsed instruments cause less bias and reducing the instrument set dramatically increases the ability of the Hansen test to detect invalid instruments. For comparison and to test the robustness of the results to alternative model specifications, we additionally report the results of the GMM estimation using all available lags as instruments

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<sup>102</sup> For a detailed description of the problem of „too many instruments“ in GMM estimation, see Roodman (2009b).

<sup>103</sup> Blundell & Bond (1998) have shown that most of the additionally introduced moment conditions in the levels equation are mathematically redundant with the instruments for the differenced equation such that only one lag is ordinarily used for each period and instrumenting variable.

<sup>104</sup> The “collapse” option of `xtabond2` for Stata is used for this purpose. This procedure has become very common in the most recent empirical literature involving GMM estimation (see, for example, Williams, 2011, and Loayza et al., 2012).

(Column 2), replacing the “GMM-style” instruments with their principal components (Column 3)<sup>105</sup>, using one-step instead of two-step estimation (Column 4), and, finally, using two-stage least squares (2SLS), instead of System-GMM (Column 5)<sup>106</sup>. The results qualitatively stay the same and the coefficient on trade openness remains positive and significant.

In the following, we perform some additional analyses to assess the sensitivity of our results to the sample composition and country characteristics, alternative economic liberalization measures, and to the employment of additional variables potentially determining food security or modifying the trade openness – food security relationship.

(a) Are the results sensitive to the sample composition or specific country/regional characteristics?

Below, we test the robustness of our results with regard to the inclusion of variables capturing specific agro-climatic constraints (e.g. weather-related) and regional/country characteristics, as well as the sensitivity to the sample composition.

Sachs & Warner (1997) found that certain geographic features, such as distance from the equator, whether or not a country is landlocked, or whether a country is subject to a tropical climate, influence growth and development. Being landlocked might also influence the possibility to access world markets or more generally to participate in international trade. First, we therefore include an indicator variable that takes the value of 1 for landlocked countries and 0 otherwise. As can be seen in Column 1 of Table 2, the coefficient on the landlocked indicator variable is negative, albeit not significant, and the other results remain unchanged. Next, we include a variable that captures the share of the population in a given

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<sup>105</sup> The “pca” option of `xtabond2` for Stata is used for this purpose, which has been introduced just recently as another way to reduce the instrument set. For a theoretical representation of the estimation technique and simulation results, see Mehrhoff (2009). Note that no Difference-in-Hansen test statistic is reported in this case as the principle components are removed from the “GMM-style” instruments as a group such that there is no differentiation between the lagged level and difference instruments. Two additional specification tests are reported in this case: first, the portion of variance explained by the components and second, the Kaiser-Meyer-Olkin (K-M-O) measure of sampling adequacy. Both test results point to good sampling adequacy.

<sup>106</sup> Note that we do not refer to the traditional Anderson-Hsiao (1982) IV/2SLS estimator, which does not account for unobserved heterogeneity. Instead, we refer to one-step GMM, where setting the *a priori* estimate of the covariance matrix of the idiosyncratic errors equal to the identity matrix essentially gives 2SLS (Roodman, 2009a).

country living in geographical tropics. Countries of the tropics nearly all have low or middle incomes and are often geographically isolated. Furthermore, tropical climate is an important agro-climatic constraint and may negatively influence agricultural productivity (Gallup & Sachs, 2000), such that tropical countries may participate less in trade and at the same time be less food-secure. It turns out that tropical countries indeed have lower food security levels (see Column 2), but the other results only marginally change.<sup>107</sup> Most importantly, the coefficient of the trade openness variable remains positive and highly significant. Note that the coefficient on GDP per capita decreases in value, because of the high negative association between GDP per capita and the “Tropics” variable. It is, however, not entirely clear what these kinds of variables actually measure. They may represent a conglomeration of different aspects. The effects of geography include economic aspects of location, such as remoteness with respect to markets and trading costs, and physical aspects, such as climate, resource endowments (including water, minerals and energy resources) and access to the sea, which affect agricultural productivity, incidence of disease, transport costs, supply capacity and the transferability of technology (Olsson, 2005).

As a next step, we include region dummies, which is another way to account for different levels of food security due to geographic location. Because these variables are time-invariant, we include them only in the levels equation. Countries from the following regions are captured in the analysis, based on the country classification as suggested by the World Bank: East Asia & Pacific (EastAsiaPacific), Europe & Central Asia (EuropeCentralAsia), Latin America & the Caribbean (LatAmericaCaribbean), Middle East & North Africa (MidEastNorthAfrica), North America (NorthAmerica), South Asia (SouthAsia), and Sub-Saharan Africa, which we take as reference group. As can be seen in Column 3 of Table 2, most geographical regions have significantly higher food security levels compared to Sub-Saharan Africa. It is indeed the developing region with the highest proportion – one-third – of people suffering from chronic hunger (see FAO, 2013). However, also accounting for the regional differences in food security levels does again only marginally change the results, suggesting that our findings are not driven by regional differences in the sample countries.

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<sup>107</sup> Note that the employment of similar measures of geography-related agro-climatic constraints, like the share of land area in geographical tropics or the proportion of the population living in regions with malaria, which may also be a major public health problem, gave similar results.

As a last step, we test the robustness of our findings to the sample composition. First, we exclude East-Asian countries (e.g. China) to ensure that results are not driven by the exceptional performance of East Asian countries during the last decades. The coefficient on the trade openness variable, however, remains roughly the same when these eleven East-Asian countries are removed from the sample. Next, the inclusion of high-income (OECD) countries, who have (on average) high levels of food security and are (again, on average) more open to international trade, may be driving the results. As the fifth column shows though, once these 22 developed countries are removed from the sample, the coefficient on trade openness falls only marginally, but is still highly significant. As can be expected, the GDP per capita variable, controlling for differences in the level of economic development, loses part of its value. We therefore conclude that our results are also not driven by high-income countries.<sup>108</sup> As a last sensitivity test with respect to the sample composition, we restrict the focus on the net food-importing countries of our sample. FAO (2003a) notes that any analysis of trade liberalization should assess the question if net food-importing countries are affected differently by liberalization. This may be expected, as this group of countries should be particularly sensitive to changes in trade policy and subsequent changes in world and domestic prices. Therefore, we repeat the estimation of our baseline model for the sample of net food- importing countries as listed by Ng & Aksoy (2008). The results depicted in Column 6 reveal that trade openness has a similar positive and significant impact on food security for the net food-importing country sample. This is in line with findings of Brooks & Matthews (2015), showing that over two thirds of their developing country sample, which switched from being a net-food exporter in 1995-97 to being a net-food importer in 2008-2010 following trade liberalization, showed improvements in food security outcomes. In sum, the results seem to be quite robust with respect to the sample composition and the inclusion of variables capturing specific country/regional characteristics.

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<sup>108</sup> Similarly, inclusion of an interaction term of trade openness and the level of income did not change the results. The interaction term fails to be significant, which suggests that the impact of trade openness on food security does not vary significantly with different levels of economic development.

Table 2: Sample composition and specific country/regional characteristics

Depvar: Dietary energy consumption	(1)	(2)	(3)	w/o East-Asia	w/o High-Income	Net food importing countries
Depvar_(t-1)	0.7673*** (0.0607)	0.7717*** (0.0596)	0.7432*** (0.0636)	0.7735*** (0.0631)	0.7892*** (0.0654)	0.8512*** (0.0656)
Trade openness	0.5495*** (0.1963)	0.4685** (0.1825)	0.4059** (0.1788)	0.5735*** (0.2045)	0.4842** (0.1884)	0.5072*** (0.1360)
GDP per capita	46.4910*** (16.5826)	35.9221** (14.4760)	43.3895*** (16.0350)	47.1256*** (18.2404)	33.0565** (16.5496)	28.9942 (19.6052)
GDP growth	1.3203*** (0.2860)	1.3036*** (0.2820)	1.2846*** (0.2782)	1.2922*** (0.2856)	1.2609*** (0.2823)	1.3365*** (0.2977)
Armed conflict	-10.9291** (4.8407)	-10.3817** (4.7663)	-11.7448** (4.8048)	-11.1231** (5.0308)	-12.2236** (4.9823)	-15.8486*** (5.1297)
Arable land	24.9401*** (6.8097)	15.7089*** (5.2628)	21.2002*** (5.5671)	24.4912*** (7.1373)	16.3509** (7.0009)	21.0003*** (7.7399)
Ag. productivity	35.6961*** (10.0647)	30.7613*** (8.3824)	35.2767*** (10.5335)	35.2997*** (10.8310)	27.3820*** (9.0608)	22.5481** (8.9145)
Rural population	-1.0433** (0.4223)	-0.8494** (0.3981)	-0.9491** (0.4012)	-1.0482** (0.4311)	-1.2850*** (0.4524)	-0.6976* (0.3665)
Population growth	-12.1528** (5.5948)	-5.8584 (4.5806)	-9.1790* (5.2168)	-11.1408* (5.7297)	-5.9263 (5.5933)	-9.0430 (5.5675)
Natural disasters	-28.3507 (18.5633)	-30.2957* (18.1910)	-24.4163 (17.6261)	-25.8223 (18.2162)	-24.3332 (18.8496)	-31.2857 (22.6492)
Inflation	-18.9063** (8.2661)	-16.8108** (7.8264)	-14.6470* (8.4926)	-18.6370** (8.3014)	-17.8098** (7.7537)	-12.0585* (7.0575)
Landlocked	-18.7560 (15.1888)					
Tropics		-76.6706*** (24.6051)				
EastAsiaPacific			17.2531 (20.3174)			
EuropeCentralAsia			82.1860** (32.4929)			
LatAmericaCaribbean			-16.8419 (17.4566)			
MidEastNorthAfrica			107.4678*** (31.8089)			
NorthAmerica			88.0278** (44.3047)			
SouthAsia			20.2386 (19.1912)			
Observations	3,579	3,579	3,579	3,305	3,031	2,611
Number of id	151	151	151	140	129	111
Instruments	51	51	56	50	50	48
<i>Tests (p-values)</i>						
AR1 Test	0.000	0.000	0.000	0.000	0.000	0.000
AR2 Test	0.561	0.559	0.573	0.412	0.694	0.838
Hansen Test	0.895	0.822	0.901	0.930	0.899	0.927
Diff-Hansen	0.964	0.922	0.892	0.960	0.866	0.577

The instrument count reported is based on the number of “collapsed” instruments, using the xtabond2 specification from Roodman (2009a). Diff-Hansen test reports the p-values based on the null hypothesis that the instruments in the levels equation are exogenous. For more details, see Roodman (2009a). Coefficients based on the two-step estimation, using the Windmeijer correction. Period fixed effects employed but not reported. Numbers in parentheses are robust standard errors.

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

(b) Are the results sensitive to the measure of trade reform used?

In order to see whether the results only apply to the specific openness measure used, in Table 3, we employ alternative trade reform indicators. The volume of trade used as the basis of our trade openness measure is an outcome measure in principle related to trade policy, but not exclusively so. As a first alternative, we therefore employ a structure-adjusted trade openness measure that tries to strengthen the outcome-policy connection and captures the portion of trade volume not due to structural country characteristics such as population size, area, oil wealth, and access to the sea.<sup>109</sup> As shown in Column 1, this policy measure is also significantly positively related to food security and thus provides further evidence that an open trade policy is on average beneficial for food security.

Second, as a more direct policy indicator of trade openness, we employ a measure of ad-valorem tariffs, measured as import duties as a percentage of imports. Tariffs continue to be a significant source of trade restrictiveness in many developing countries (Hoekman & Nicita, 2011). The effects of import tariffs have been described earlier and it can be argued that a reduction of protectionist policies and trade barriers such as tariffs lead to freer trade and in a sense, more open economies.<sup>110</sup> As shown in Column 2, the ad-valorem tariff measure is significantly negatively related to dietary energy consumption, implying that trade restrictions, on average, have a detrimental effect on food security.

The focus of the present study is on the economic component of globalization as the benefits of globalization are expected to flow from trade (see FAO, 2003a). Additionally, as globalization is not only an economic phenomenon and trade openness measures do not capture other aspects of globalization or openness of a country, for example people or ideas flows, a multivariate approach to measuring globalization is used. In Column 3 of Table 3, we report the results when the KOF index of globalization is used instead of our trade openness measure. It is a more comprehensive measure of globalization that measures three

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<sup>109</sup> It is calculated as the residual of a regression of the trade to GDP ratio, on the logs of land area and population, and dummies for oil exporting and landlocked countries. For a more detailed description of the rationale behind the construction of this policy openness measure, see Chang et al. (2009), who applied this measure in the context of growth regressions.

<sup>110</sup> Although not incorporating non-tariff barriers, this measure does well in ranking countries according to their levels of protection (DeJong & Ripoll, 2006). We would like to thank Marla Patricia Ripoll for providing the tariff data, which is available for 125 countries until the year 2000.

dimensions of globalization (economic, political and social) and combines them into one index (Dreher, 2006).<sup>111</sup> As the results show, also this more comprehensive measure of openness is positively related to calorie consumption, supporting the view that general openness and integration into the world economy is beneficial for a countries' welfare and food security.

An alternative way, which has been considered in the previous empirical literature on trade liberalization impacts, is to classify countries as closed or open and to analyze if there are differences in outcome measures based on this classification. For this purpose, we use the Sachs-Warner policy openness indicator variable, which classifies economies as closed (0) or open (1), based on the level of average tariff rates, non-tariff barriers, the black market exchange rate, and if a state monopoly on major exports or a socialist economic system exists.<sup>112</sup> The results in Column 4 show that, controlling for the level of economic development and the other food security determinants, open economies based on this classification have significantly higher food security levels compared to closed ones. As a last step, we try to assess if it is both an open policy environment and trade-related aspects of openness that affect food security simultaneously. To test this idea, we include two measures of openness simultaneously—our volume based measure of openness and the Sachs-Warner policy openness measure. The results, depicted in Column 5, show that both the trade and policy indicator of openness retain its positive impact on food security. We interpret the continued significance of the volume-based and the policy-based measure of openness as an indication that both direct trade related aspects of openness as well as an open policy environment simultaneously affect food security. We conclude from the additional results using alternative indicators of trade reform that, on average, economic openness positively affects national food security.

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<sup>111</sup> For a more detailed representation of the globalization index, see Dreher, 2006, updated in Dreher, Gaston and Martens, 2008.

<sup>112</sup> We use the data provided by Wacziarg & Welch (2008), who extended the Sachs & Warner (1995) data to the 1990s, while accounting for some of the pitfalls of this openness indicator first identified by Rodríguez and Rodrik (2000). The data for the openness indicator variable is available for 123 countries.

Table 3: *Alternative trade reform indicators*

Depvar: Dietary energy consumption	(1)	(2)	(3)	(4)	(5)
Depvar_(t-1)	0.7560*** (0.0638)	0.7992*** (0.0507)	0.7860*** (0.0627)	0.8205*** (0.0732)	0.7923*** (0.0720)
Policy openness	0.5204*** (0.1768)				
Tariffs		-9.2691** (4.5862)			
Globalization			1.2923** (0.6255)		
SW_openness				31.2069** (13.6319)	32.8865** (13.8624)
(+ Trade openness)					0.3787** (0.1901)
GDP per capita	55.4684*** (17.4887)	51.5450*** (17.5091)	37.6173** (15.4154)	35.2487* (20.6302)	39.2199* (20.5713)
GDP growth	1.2412*** (0.2828)	1.8148*** (0.6229)	1.2891*** (0.3199)	1.2755*** (0.3296)	1.0917*** (0.2957)
Armed conflict	-10.3830** (4.9046)	-8.8909 (12.4385)	-8.5856* (5.0755)	-5.7681 (5.0101)	-7.2858 (5.0071)
Arable land	20.8660*** (7.0560)	6.8450 (7.1536)	12.2534** (6.2048)	14.1545* (8.5875)	21.0942** (8.7297)
Ag. productivity	29.9754*** (10.4455)	14.7321 (11.3719)	24.5462*** (9.3112)	23.2747* (12.6245)	31.5340** (12.5545)
Rural population	-1.0550** (0.4330)	-0.5164 (0.4021)	-0.7187** (0.3644)	-0.7474* (0.4375)	-0.9311** (0.4468)
Population growth	-12.4543** (5.7042)	-6.1404 (5.6365)	-8.6843* (4.7054)	-8.8491 (5.6806)	-8.8142 (5.9416)
Natural disasters	-32.4231* (18.8594)	-2.1794 (21.8017)	-28.4220 (21.0499)	-32.8143 (22.9493)	-32.7095* (19.8689)
Inflation	-21.4873*** (7.8650)	-10.6896 (6.6600)	-16.2550** (7.7136)	-12.8113 (8.4333)	-16.4417* (8.9961)
Observations	3,579	1,446	3,551	3,087	3,087
Number of id	151	122	150	129	129
Instruments	50	40	49	50	54
<i>Tests (p-values)</i>					
AR1 Test	0.000	0.000	0.000	0.000	0.000
AR2 Test	0.554	0.272	0.488	0.618	0.666
Hansen Test	0.606	0.802	0.615	0.592	0.761
Diff-Hansen	0.276	0.617	0.368	0.198	0.424

The instrument count reported is based on the number of “collapsed” instruments, using the xtabond2 specification from Roodman (2009a). Diff-Hansen test reports the p-values based on the null hypothesis that the instruments in the levels equation are exogenous. For more details, see Roodman (2009a). Coefficients based on the two-step estimation, using the Windmeijer correction. Period fixed effects employed but not reported. Numbers in parentheses are robust standard errors.

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1



### (c) Incorporating additional explanatory variables

The analysis so far has looked at the determinants of national food security with respect to the core explanatory variables, based on the conceptual framework outlined in Section 2. However, there may be a number of additional factors determining food security or modifying the trade openness – food security relationship. First, the level of infrastructure development in a country may affect the functioning of markets and agricultural marketing performance with positive repercussions on food security. We use telephone lines (per 100 people) as a proxy for infrastructure development.<sup>113</sup> A better infrastructure leading to an improved access to markets should positively affect household's access to food. Moreover, infrastructure development can significantly facilitate trade by reducing transaction costs and thus promotes market integration. Conversely, lack of an accurate physical and information infrastructure may reduce efficiency and hamper a country's ability to participate in and benefit from trade-related activities (FAO, 2003a).

Second, we include country size, measured as the log of total population, in the regression. According to Frankel & Romer (1999), the country size serves as a crude proxy for the domestic scale of production and the amount of trade within a country. Accordingly, it can be used to assess whether countries also benefit from within-country trade. Second, it has been observed that smaller countries tend to adopt more open trade policies, because of the small size of the domestic market. The New Trade Theory of increasing returns to scale offers explanations why this should be the case. If production costs fall with increasing levels of production, firms have an incentive to seek for larger markets allowing them to increase production. On the contrary, larger countries generally have more opportunities for trade within their borders and therefore tend to have lower (international) trade intensities (see Alesina et al., 2005).

As a third additional potentially important determinant of food security, we include the coefficient of variation from (annual) mean values of the consumer price index as a measure

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<sup>113</sup> Data comes from WDI. Note that data on paved roads, which may be a better proxy for trade-relevant infrastructure provision, is only available from 1990 onwards, and therefore telephone lines have been used as a proxy for infrastructure development. However, these variables are highly correlated, with a correlation coefficient of 0.6586 for our country sample.

of price volatility in the regression (in addition to the consumer price inflation rate).<sup>114</sup> While food security studies generally rather focused on the effects of price spikes, recently political and public interest in price volatility impacts has increased dramatically, because of its potential adverse effects for food and nutrition security (see e.g. HLPE, 2011). As poor households generally spend a large fraction of their income on food and do not have the means to respond to large price increases, they may be particularly vulnerable to increasing price volatility. Besides that, although domestic price volatility in developing countries is often mainly of domestic origin (Byerlee et al. 2006), trade policy may also affect price volatility as, for example, market distorting practices may cause subsequent increases in volatility or countries open to trade may import price instability from international markets. It is therefore interesting to assess if price volatility directly affects our food security measure and whether the impact of trade openness is affected by including this potential determinant.

As a last potential additional determinant of national food security, we include a country's total foreign reserves expressed in terms of the number of months of imports of goods and services it could pay for. Foreign reserves may be seen as a proxy for import capacity, which in turn affects the possibilities of financing food imports. An increase in a country's import capacity may thus be expected to contribute to national level food security.

The results for the extended models are shown in Table 4. The coefficient on the infrastructure variable (Column 2) is positive, albeit significant at the 10% level, pointing to beneficial effects of infrastructure development as hypothesized above. The fact that the infrastructure variable is not more significantly related to food security may partly be attributed to its very high correlation with the included GDP per capita variable (with a correlation coefficient of 0.8752) and hence this variable was not included in the core regression model. Nonetheless, the coefficient on the trade openness variable remains positive and significant.<sup>115</sup>

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<sup>114</sup> As in the case of our inflation variable, we stick to the consumer price index instead of using a food price index, which is only available as world food price index and hence does not show any variation across countries.

<sup>115</sup> Note, however, that when we regress the Infrastructure variables on GDP per capita and use the residual as explanatory variable, it still enters the regression positive and significant. The residual may then be interpreted

The coefficient on country size suggests that bigger countries tend to have higher food security levels, which may suggest that these countries have greater domestic production potential and benefit more from within-country trade than small countries. Thus, it seems that although high population growth exerts significant pressures on food security, a larger country size is generally beneficial for within-country trade and national food security. The impact of trade openness on calorie consumption remains positive and highly significant.

Although the number of observations and considered countries is reduced slightly, as the results in Column 3 show, price volatility significantly negatively affects food security. The consequences of price volatility on food security are not clearly understood. Price volatility may transmit uncertainty into the whole food system and discourage longer-term investments. It can also be seen as a factor of vulnerability, and thus adversely affect household incomes and purchasing power. Thus, although producers may benefit from high prices during periods of high volatility, the overall effect on food security seems to be negative. This finding is in line with the HLPE (2011) report, which concludes that the recent increase in price volatility has pushed many consumers in developing countries into poverty and increased food insecurity. As can be expected, the inflation variable loses some of its significance, but the other results remain largely unchanged, with the trade openness coefficient even increasing in magnitude.

The last column shows the regression results when additionally including a country's total reserves in months of imports as a proxy for import capacity. As expected, increasing foreign reserves have a favorable impact on overall food security levels. However, the coefficient fails to be statistically significant at conventional levels. The other results remain largely unchanged. We can conclude that the estimation results are not very sensitive to the employment of additional explanatory variables, potentially affecting national food security or modifying the trade openness – food security relationship.

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as each country's willingness to allocate resources towards infrastructure development, independent of the influence exerted by pure economic development (Gabriele & Schettino, 2008).

Table 4: *Incorporating additional explanatory variables*

Depvar: Dietary energy consumption	(1)	(2)	(3)	(4)
Depvar_(t-1)	0.7637*** (0.0564)	0.7569*** (0.0635)	0.7568*** (0.0549)	0.7889*** (0.0491)
Trade openness	0.4936** (0.1981)	0.4553*** (0.1747)	0.6405*** (0.2288)	0.5240** (0.2375)
GDP per capita	32.7252** (12.9341)	55.6320*** (17.7693)	47.7640*** (15.0070)	46.0667*** (15.8978)
GDP growth	1.2989*** (0.2773)	1.2627*** (0.2716)	1.3625*** (0.2983)	1.1492*** (0.3585)
Armed conflict	-10.6587** (4.8357)	-10.0278** (4.7207)	-11.3403** (5.1022)	-10.3300 (7.0417)
Arable land	23.4218*** (6.3114)	17.5420*** (6.3952)	27.0970*** (6.8204)	22.3524*** (6.7649)
Ag. productivity	32.0543*** (8.7434)	24.8454** (10.0614)	38.4234*** (10.2243)	30.6939*** (9.3624)
Rural population	-0.9243** (0.4013)	-1.0616** (0.4339)	-1.2192*** (0.4676)	-0.8697** (0.3949)
Population growth	-8.1564 (5.3390)	-13.1220** (5.6744)	-12.5897** (5.8422)	-11.5587** (5.5763)
Natural disasters	-25.9877 (17.9498)	-33.4237* (19.9257)	-25.2812 (18.5910)	-17.8995 (20.2441)
Inflation	-16.8921** (7.2538)	-22.5350*** (8.0589)	-14.3420* (8.0513)	-14.8890* (7.8056)
Infrastructure	15.3336* (9.1079)			
Country size		10.8544*** (3.8212)		
Price volatility			-4.3467*** (1.2417)	
Foreign reserves				5.6733 (4.0690)
Observations	3,561	3,565	3,401	3,171
Number of id	151	151	143	146
Instruments	51	51	51	51
<i>Tests (p-values)</i>				
AR1 Test	0.000	0.000	0.000	0.000
AR2 Test	0.562	0.533	0.273	0.982
Hansen Test	0.965	0.788	0.978	0.706
Diff-Hansen	0.770	0.800	0.831	0.263

The instrument count reported is based on the number of “collapsed” instruments, using the xtabond2 specification from Roodman (2009a). Diff-Hansen test reports the p-values based on the null hypothesis that the instruments in the levels equation are exogenous. For more details, see Roodman (2009a). Coefficients based on the two-step estimation, using the Windmeijer correction. Period fixed effects employed but not reported. Numbers in parentheses are robust standard errors.

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

#### (d) Domestic policy environment and institutions

Although we already included proxies for political and macroeconomic instability, which account for the domestic policy environment to some extent, it is not clear whether there might be some other political or institutional factors exerting an effect on food security or modifying the trade – food security relationship, which may depend on the political environment in which it is carried out. In democracies and/or countries with strong institutions, specific policies may facilitate the process of adjustment, improve the functioning of markets, minimize potentially adverse impacts of trade liberalization policies and protect the right to food (Ames et al., 2001). Unfortunately, good proxies for institutions or institutional quality, setting the regulatory framework for economic activity, for a great range of countries and years are not readily available. As a first proxy for the strength of democratic institutions, we construct a democracy index based on the well-known Freedom House indices of political rights (PR) and civil liberties (CL)<sup>116</sup>. The democracy index is between 0 and 1, with 0 for pure dictatorship (no PR and CL) and 1 for pure democracy (full PR and CL). As a second indicator, we employ the release of information index developed by Williams (2009) as a proxy for institutional quality or, more specifically, the quality of governance as revealed by the level of transparency. It represents the proportion of data reported to the World Development Indicators and the IMF's International Financial Statistics.

Although we already included inflation as a proxy for macroeconomic stabilization, another source of macroeconomic instability may arise from *growth* volatility, with high volatility being associated with possibly bad macroeconomic policies. We test the hypothesis if high growth volatility, being associated with sharp economic downturns, has adverse effects on food security. For this purpose, we construct an indirect policy measure reflecting to some extent the domestic policy environment, which may indirectly affect food security, as it depresses private investment and growth and increases poverty (Agénor, 2004). Macroeconomic (growth) volatility is measured as the three-year rolling standard deviation of the GDP growth rate.

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<sup>116</sup> A similar combined index of political rights and civil liberties as proxy for democracy has *inter alia* been used by Smith & Haddad (2000). The index of civil liberties reflects among other things the freedom of expression and religion and the index of political rights the extent of people's participation in the political process. Data is available at <http://www.freedomhouse.org/report-types/freedom-world>.

As a last step, we include two measures closely related to the financial development of a country and its fiscal policy, which have been used in cross-country growth regressions to capture the role of structural and stabilization policies, and institutions (Loayza et al., 2012). Financial depth is measured as the ratio of domestic credit provided by the banking sector to GDP (WDI) and proxies for the degree of monetization in the economy. It has been shown to be positively associated with growth, but besides that may also capture to some extent the availability of (rural) credit and thus potentially affects the supply response of producers to market signals and the potential of adopting new and more productive agricultural technologies. As fiscal policy measure, we employ a proxy for the government burden calculated as the ratio of general government consumption to GDP. A large fiscal burden may lead to a reduction of public investments in various fields, for example agricultural support services, such as the provision of extension services and inputs for production. It may also negatively affect the possibilities of the government to provide transfers to the poor or to maintain support measures, for example, consumer food subsidy programs (see FAO, 2003).

Table 5: *Domestic policy environment and institutions*

Depvar: Dietary energy consumption	(1)	(2)	(3)	(4)	(5)
Depvar_(t-1)	0.7612*** (0.0622)	0.7570*** (0.0523)	0.7535*** (0.0613)	0.7777*** (0.0521)	0.7904*** (0.0556)
Trade openness	0.5196*** (0.1987)	0.5138** (0.2281)	0.5637*** (0.2058)	0.5892** (0.2332)	0.4597*** (0.1757)
GDP per capita	50.7448*** (17.6217)	50.4562*** (16.3093)	50.6011*** (17.4941)	44.4276*** (15.6860)	41.8965*** (16.1497)
GDP growth	1.2987*** (0.2828)	1.3516*** (0.2884)	1.2312*** (0.2790)	1.3845*** (0.3234)	1.3110*** (0.3152)
Armed conflict	-11.1754** (4.8324)	-11.1799** (5.3118)	-8.5843* (4.8625)	-9.1429* (4.9629)	-10.0056* (5.2051)
Arable land	24.1618*** (6.8366)	24.1042*** (7.0397)	24.2962*** (6.7459)	23.1921*** (6.2087)	20.1330*** (6.3044)
Ag. productivity	35.9194*** (10.1400)	35.6798*** (10.7406)	35.4376*** (10.1058)	29.3206*** (9.0823)	32.7232*** (9.8919)
Rural population	-1.1337** (0.4413)	-1.0863** (0.4345)	-1.2049*** (0.4513)	-1.0074*** (0.3649)	-1.0472*** (0.3974)
Population growth	-12.3087** (5.6994)	-12.3256** (5.6938)	-12.5128** (5.7080)	-8.8409* (4.9464)	-11.3274*** (5.3221)
Natural disasters	-29.0450 (18.6382)	-28.3799 (19.3201)	-30.1346 (18.5788)	-25.0886 (18.3273)	-23.1698 (18.0936)
Inflation	-18.8341** (8.3560)	-18.4035** (8.2890)	-17.4121** (7.6521)	-13.8877* (8.0430)	-18.3136** (7.8824)
Democracy	-11.6162 (18.7898)				
Institutional quality		23.6123 (41.6299)			
Macroecon. volatility			-5.4006** (2.3627)		
Financial depth				12.8760** (6.3409)	
Government burden					-0.0267 (0.6841)
Observations	3,570	3,233	3,576	3,299	3,378
Number of id	151	148	151	148	149
Instruments	51	49	51	51	51
<i>Tests (p-values)</i>					
AR1 Test	0.000	0.000	0.000	0.000	0.000
AR2 Test	0.592	0.836	0.618	0.917	0.360
Hansen Test	0.888	0.947	0.968	0.980	0.943
Diff-Hansen	0.874	0.867	0.909	0.884	0.905

The instrument count reported is based on the number of “collapsed” instruments, using the xtabond2 specification from Roodman (2009a). Diff-Hansen test reports the p-values based on the null hypothesis that the instruments in the levels equation are exogenous. For more details, see Roodman (2009a). Coefficients based on the two-step estimation, using the Windmeijer correction. Period fixed effects employed but not reported. Numbers in parentheses are robust standard errors.

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

The democracy index and the institutional quality proxy do not enter significantly into the regression, and the other results remain unchanged.<sup>117</sup> This finding may be attributed to several factors. First, these variables may not adequately capture the institutional environment and are subject to measurement error.<sup>118</sup> Second, institutional factors are less important as determinants of food security or third, its effects are mainly indirect and transmitted through and therefore already accounted for by the other included food security determinants. The latter justification seems most likely as democratic and institutional development has *inter alia* been found to positively affect economic development and political stability (see e.g. Acemoglu et al., 2014; Cervellati & Sunde, 2011) and the indicators are indeed highly correlated in our sample. Macroeconomic volatility enters negatively and highly significant into the regression, supporting the view that volatility associated with output shocks are detrimental to food security and indicating that domestic stabilization policies creating an economically stable environment have welfare enhancing effects. The degree of monetization of the economy is significantly positively related to food security, indicating beneficial effects of financial development and better availability of credits. The government burden carries a negative coefficient, is albeit not statistically significant. The other results remain qualitatively unchanged and trade openness remains a highly significant determinant of food security. It thus seems to be that both trade and a beneficial domestic policy environment play a role when it comes to the goal of achieving national food security.

#### (e) Alternative food security and nutrition indicators

Finally, we try to assess the sensitivity of our results with respect to alternative food security indicators, as different indicators of food security may sometimes provide contrasting results (see Barrett, 2010). Unfortunately, good indicators covering a large number of countries and years and thus satisfying the relatively large data requirements of our employed empirical model and enabling meaningful cross-country comparisons are not readily available. One also has to accept the inability of any one indicator to fully capture the complexity and

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<sup>117</sup> Data for our institutional quality proxy is available until 2005. For a more detailed description of the release of information index, see Williams (2009). Note that we also carried out estimations using the well-known measures of institutions and democracy drawn from the POLITY project (available at <http://www.systemicpeace.org/polity/polity4.htm>). However, none of these was found to be statistically significant in our empirical work.

<sup>118</sup> Support for this hypothesis comes, for example, from Acemoglu et al. (2014) who state that “existing democracy indices are typically subject to considerable measurement error, leading to spurious changes in the democracy score of a country even though its democratic institutions do not truly change (p. 1)”.



multidimensionality of food security and improvements in one dimension may mask deteriorations in other form of malnutrition (FAO, 2013). We limit our focus to the employment of alternative food security indicators, which are available for the same time horizon and a similar set of countries as in the baseline model.

As a first alternative, we employ a measure of the average dietary energy supply adequacy, which expresses the dietary energy supply as a percentage of the average dietary energy requirement in each country. According to the FAO (2013), the adequacy of food supply is strongly linked to the prevalence of undernourishment, the traditional FAO hunger indicator, which is however not available for the 1980s.

As a second alternative food security indicator, we employ a measure of dietary diversity, based on the FAO food balance sheets and calculated as the share of dietary energy supply derived from non-staple foods, with staple foods being cereals, roots and tubers. Dietary diversity indicators have become increasingly popular and can be regarded as nutrition-relevant indicators of food security. Headey & Ecker (2012) show the usefulness of this dietary diversity indicator in a cross-country setting, which performs well in terms of cross-correlations with other food security indicators and anthropometric indicators of child malnutrition. Country-level results of the FAO (2013) also suggest that low dietary diversity is often associated with poor utilization outcomes and high stunting rates.<sup>119</sup>

As a third food security indicator related to diet quality, we employ a measure of the average protein supply available for consumption in each country, which is one of the major macronutrient groups. According to Hoddinott et al. (2012), undernutrition with regard to macro- and micronutrients continues to be the dominant nutritional problem in most developing countries. In view of the fact that most of the poor countries remain close to the lower bound of the FAO recommended daily value, increases in protein consumption should be seen as indicating food security improvements. Increases in protein consumption are also closely associated with decreases in undernourishment and undernutrition (FAO, 2013).

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<sup>119</sup> Note that dietary diversification, leading to the consumption of a larger proportion of high-value food products such as vegetables, fish and meat, has direct consequences for nutrition security. However, in line with Headey & Ecker (2012) and the FAO (2013), we consider the share of dietary energy supply derived from cereals, roots and tubers as an indicator of food security rather than nutrition security, indicating only the availability of high-value food products for consumption.

As a measure of diet upgrading also related to the quality of the diet, we consider the average supply of protein of animal origin, which as the before mentioned indicators belongs to the suite of food security indicators described in the FAO's (2013) "The State of Food Insecurity in the World". The analysis of protein availability by source provides some important insights into the quality of diets as animal foods are generally considered as good sources of high-quality protein. According to the FAO (2013), people from worse off areas consume a diet that is much less diverse and contains much less protein in the form of meat, fish, eggs or milk than do people in better-off areas. Because of this observed animal protein deficiency in many poor countries and the generally better nutritional value of animal protein compared to that of most plants, we consider an increase in animal protein consumption to indicate a process of diet upgrading leading to better nutritional outcomes.

Table 6 shows the results for the alternative food security indicators, employing the same empirical specification as in our baseline model, which is the two-step System-GMM estimator incorporating Windmeijer's (2005) finite-sample correction for standard errors. The results depicted in Column 1 of Table 6 show that trade openness positively impacts on a country's average dietary energy supply adequacy and is thus likely to lead to decreases in undernourishment. This finding suggests that opening up the economy for trade can help to reduce the structural food supply inadequacy still prevalent in many developing countries. The other food security determinants remain valid, with armed conflicts only marginally failing to be a significant determinant of dietary energy supply adequacy.

Column 2 shows that trade openness is also associated with higher dietary diversity as indicated by the share of dietary energy supply derived from non-staple foods. This finding can be expected as increased access to international food markets and a greater variety of food makes it easier for the population to diversify diets and enables households to complement consumption of staples with non-staple foods. Besides that, consumption of non-staples rises with incomes, whereas dietary diversity seems to be lower in countries with higher population growth and a higher rural population share. The last point reflects a general observation that urban households usually have a more varied consumption basket

than rural households and as such, the process of urbanization can be expected to be associated with overall more diversified diets (see e.g. Webb & Lapping, 2002).

Related to the above finding, openness also contributes to improved diets as indicated by the average protein supply available for consumption in each country and is thus likely to lead to decreases in undernourishment and undernutrition (see Column 3). The other food security determinants remain valid and exert significant effects on the quality of the diet. Going one-step deeper into the assessment of diet quality, Column 4 shows that also the consumption of animal protein indicating a form of diet upgrading is positively affected by trade openness, which for example increases the availability of meat from imports. The results further indicate that animal protein consumption increases with income, which does not come as a surprise as animal protein is generally more expensive than plant protein and in many countries, higher income results in increased demand for meat products (see Regmi, 2001). Besides that, animal protein consumption does not seem to be significantly affected by short-term shocks or risk factors such as violent conflicts and natural disasters, while the significant impact of the other determinants remains valid. These additional results suggest that the beneficial effects of openness to trade hold true for dietary energy supply adequacy as well as for dietary diversity and diet quality-related aspects of food security.

Table 6: *Alternative food security and nutrition indicators*

Dependent variable:	Dietary energy supply adequacy	Dietary diversity (share of kcal from non-staple foods)	Protein consumption (g/capita/day)	Diet upgrading (Average Supply of Protein of Animal Origin in g/capita/day)
Depvar_(t-1)	0.7917*** (0.0580)	0.7433*** (0.0718)	0.7400*** (0.0621)	0.6554*** (0.1098)
Trade openness	0.0194** (0.0083)	0.0112** (0.0053)	0.0255*** (0.0055)	0.0132*** (0.0041)
GDP per capita	1.0498* (0.5457)	1.9355*** (0.6853)	2.6290*** (0.7880)	3.6382*** (1.2091)
GDP growth	0.0620*** (0.0132)	0.0011 (0.0061)	0.0316*** (0.0100)	-0.0067 (0.0114)
Armed conflict	-0.3427 (0.2210)	-0.2226 (0.1540)	-0.3948* (0.2018)	-0.1460 (0.1563)
Arable land	0.8289*** (0.2664)	0.2959 (0.1934)	1.1847*** (0.3890)	0.9659*** (0.3664)
Ag. productivity	1.1601*** (0.3874)	0.2044 (0.2971)	1.0261*** (0.3515)	0.8539* (0.4577)
Rural population	-0.0377** (0.0150)	-0.0320** (0.0141)	-0.0366** (0.0180)	-0.0431* (0.0238)
Population growth	0.0202 (0.1862)	-0.5962*** (0.2244)	-0.6288** (0.2740)	-1.1554*** (0.4423)
Natural disasters	-1.6251** (0.8155)	-0.0966 (0.5513)	-0.5091 (0.5750)	-0.7862 (0.7161)
Inflation	-0.7323** (0.3066)	0.0430 (0.3959)	-0.7129** (0.3309)	-0.6302* (0.3559)
Observations	3,581	3,579	3,578	3,554
Number of id	152	151	151	151
Instruments	50	50	50	50
<i>Tests (p-values)</i>				
AR1 Test	0.000	0.000	0.000	0.000
AR2 Test	0.491	0.378	0.094	0.130
Hansen Test	0.940	0.106	0.906	0.611
Diff-Hansen	0.911	0.208	0.757	0.683

The instrument count reported is based on the number of “collapsed” instruments, using the xtabond2 specification from Roodman (2009a). Diff-Hansen test reports the p-values based on the null hypothesis that the instruments in the levels equation are exogenous. For more details, see Roodman (2009a). Coefficients based on the two-step estimation, using the Windmeijer correction. Period fixed effects employed but not reported. Numbers in parentheses are robust standard errors.

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

#### (f) Decomposition of GDP growth and natural disasters effect

In order to gain some additional insights into the effect of economic growth on calorie consumption, we disaggregate total economic growth into its sectoral components, i.e. agricultural, industrial and services growth, based on an approach from the poverty-growth literature. Agricultural growth (value added) includes forestry, hunting, and fishing, as well as the cultivation of crops and livestock production; industry growth (value added) includes manufacturing, mining, manufacturing, construction, electricity, water, and gas; services growth includes value added in wholesale and retail trade, transport, and government, financial, professional, and personal services such as education, health care, and real estate services (WDI). As the impact of each sector's growth rate on calorie consumption will depend on the size of the sector in the economy ("participation effect"), each sector's growth rate is weighted by its initial GDP share. The estimated effect of the sectoral growth rates is then conditional upon participation in the sector. The rationale behind this approach is that, for example, a given agricultural growth rate will have a larger effect in an agrarian economy, whereas a given industrial growth rate will have a larger effect in an industrial country (see Christiaensen et al., 2011; Headey, 2013). Dietary energy consumption is then regressed on the "weighted" sectoral growth rates (and the other determinants).

The very poorest countries are typically predominantly rural, such that agricultural growth in particular should be an important source of income growth at the household level and thus contribute to reduced poverty and hunger, in particular in developing countries. It may also be associated with increased domestic production of food for consumption and thus directly enhance food availability and lower food prices for consumers. Therefore, it seems reasonable to expect that agricultural growth is relatively more important in reducing rural poverty and food insecurity compared to growth in other sectors, as also stated by the FAO (2012). Although the number of observations is reduced as data is not available for every country and has gaps for some years, the results displayed in Column 2 of Table 7 show that all parts of economic growth exert positive and significant effects on food security, with agricultural growth having the strongest impact.<sup>120</sup> Noting that the results may differ for

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<sup>120</sup> Note that, although the displayed coefficients are no elasticities, calculated elasticities at the mean confirm the result that the effect of agricultural growth on food security is larger compared to growth in the other sectors.

developing and developed countries, we exclude high-income countries from the full sample and repeat the estimation.<sup>121</sup> The results are depicted in Column 3 and confirm the previous conclusion that agricultural growth is relatively more important for improving food security as compared to growth in other sectors, which seems to be particularly true for developing countries. This finding also indicates that policies strengthening the agriculture sector and fostering agricultural productivity, which in turn positively affects agricultural growth, have a great potential to contribute to enhanced food security.

In the baseline regression, we employed an overall measure of natural disasters, covering geophysical, meteorological, hydrological, climatological, and biological disasters, based on data from the Emergency Events Database (EM-DAT). As can be seen in Table 1, the natural disasters variable was significant only in some of the different model specifications. To see if this is due to aggregation of the various natural disaster types and to assess the differential impacts of these disaster sub-groups on food security, we include geophysical, meteorological, hydrological, climatological and biological disasters, all measured as the number of affected divided by total population, separately in one regression. As Column 3 of Table 7 shows, only climatological disasters (including extreme temperature, drought and wildfire) and hydrological disasters (including flood and mass movement wet) exert significant negative effects on food security, while the other disaster types (except for the case of meteorological disasters) also impact negatively on food security, but not significantly so. These additional results suggest that climatological and hydrological disasters are the types of natural disasters, which have the strongest effects on food security. Indeed, this does not come as a surprise, as drought ranks as the single most common cause of severe food shortages in developing countries and excess rain creating flooding can cause serious damage to agricultural output (FAO, 2005).

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<sup>121</sup> Unfortunately, there are not enough observations available to repeat the estimation for the sample of developed countries only.

Table 7: *Decomposition of GDP growth and natural disasters effect*

Depvar: Dietary energy consumption	(baseline)	(2)	(3) w/o High-Income countries	(4)
Depvar_(t-1)	0.7670*** (0.0612)	0.7599*** (0.0622)	0.7907*** (0.0696)	0.7627*** (0.0615)
Trade openness	0.5291*** (0.1964)	0.3919** (0.1854)	0.4489*** (0.1603)	0.5567*** (0.1959)
GDP per capita	47.1681*** (16.8885)	49.0780*** (18.0634)	30.6151* (16.5283)	47.4575*** (16.7838)
GDP growth	1.3052*** (0.2819)			1.2911*** (0.2808)
Agricultural growth		2.8030*** (0.9965)	3.2170*** (1.1211)	
Industrial growth		1.8280* (0.9350)	1.5908 (0.9983)	
Service growth		1.2341** (0.5542)	1.1842** (0.5882)	
Armed conflict	-11.1373** (4.8271)	-7.0151 (5.0414)	-4.8533 (6.1942)	-10.7600** (4.7857)
Arable land	23.6506*** (6.7412)	22.9908*** (7.0711)	15.0254** (7.3452)	24.1703*** (6.7912)
Ag. productivity	35.7712*** (10.0595)	35.3383*** (11.8331)	28.8625** (11.6261)	36.9200*** (10.2812)
Rural population	-1.1410*** (0.4343)	-1.2496*** (0.4233)	-1.4641*** (0.4853)	-1.1686*** (0.4401)
Population growth	-11.6252** (5.5672)	-12.4830** (5.9483)	-6.3576 (5.5437)	-12.0189** (5.6499)
Natural disasters	-28.1717 (18.4913)	-8.2939 (16.3802)	-7.8391 (17.9025)	
Climatological disasters				-48.4228* (25.8773)
Hydrological disasters				-99.8035** (50.4824)
Geophysical disasters				-106.1093 (85.3578)
Meteorological disasters				16.8039 (30.4542)
Biological disasters				-154.8682 (220.4020)
Inflation	-18.9095** (8.2408)	-13.8747 (9.4125)	-13.6366 (9.5946)	-19.4763** (8.2387)
Observations	3,579	2,945	2,509	3,575
Number of id	151	141	123	151
Instruments	50	58	58	54
<i>Tests (p-values)</i>				
AR1 Test	0.000	0.000	0.000	0.000
AR2 Test	0.565	0.593	0.721	0.590
Hansen Test	0.891	0.889	0.703	0.923
Diff-Hansen	0.926	0.327	0.420	0.914

The instrument count reported is based on the number of “collapsed” instruments, using the xtabond2 specification from Roodman (2009a). Diff-Hansen test reports the p-values based on the null hypothesis that the instruments in the levels equation are exogenous. For more details, see Roodman (2009a). Coefficients based on the two-step estimation, using the Windmeijer correction. Period fixed effects employed but not reported. Numbers in parentheses are robust standard errors.

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

### (g) Interactions between trade openness and other food security determinants

To assess if the strength of the trade openness impact on food security varies significantly with the development of other food security determinants, we assess the interactions between trade openness and some of the explanatory variables for which it might be reasonable to expect such a relationship. First, one might expect that the food security impact of openness is dependent on the level of economic development or the economic resource availabilities of a country, as more developed countries may be better able to benefit from the opportunities created by trade openness or to respond to potential constraints. As can be seen in Column 1 of Table 8, however, the trade openness impact does not seem to vary significantly with increasing incomes.<sup>122</sup> Second, the presence of conflicts may worsen the possibilities of a country to take advantage of trade openness, for example by disrupting transport, trade and markets and thus domestic food chains. The interaction effect between trade openness and conflict is negative, but only marginally significant, as can be seen in Column 2 of Table 8. This finding weakly supports the hypothesis that the food security improving effect of trade openness declines with higher intensity of armed conflicts, or political instability. Third, as has been noted earlier, if agricultural productivity in a country is at low levels and the country opens up for trade, producers may not be able to withstand foreign competition or to respond to increased production incentives. Therefore, the beneficial impact of trade openness on food security may be expected to be lower for countries with lower agricultural productivity levels. As can be seen in Column 3, this hypothesis is not supported by the data.

Fourth, the strength of the trade openness impact on food security may differ between predominantly rural and other economies. For example, if the opportunities associated with trade openness evolve mainly in industrial or services sectors, agrarian countries may not benefit as much. We try to get some insights into this issue by including an interaction term between trade openness and the rural population share. As displayed in Column 4 of Table 8, the food security improving effect of trade openness increases with rising rural population shares, with the coefficient of the interaction term just failing to be significant at conventional levels. Thus, contrary to what might be expected, the benefits of trade

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<sup>122</sup> Similarly, interacting trade openness with the regional indicator variables did not reveal any significant regional differences in the trade openness effect on food security.



openness (at least in terms of food security) may even be greater in rural economies. As a last step in the analysis of interaction effects, we test the hypothesis if the effect of trade openness on food security depends on the macroeconomic policy environment. A stable macroeconomic environment may positively affect a country's ability to take advantage of international competition as it may help producers to withstand foreign competition and expand into export markets. Similar to the study of Chang et al. (2009) for the relation between trade and economic growth, we assess the interaction between trade openness and inflation stabilization in Column 5 of Table 8. As can be seen, the food security improving effect of trade openness indeed declines with a less stable macroeconomic policy environment. We see this as further evidence for the importance of complementary policies and reforms through which the beneficial effects of openness may be significantly improved.

Table 8: *Interactions between trade openness and other food security determinants*

Depvar: Dietary energy consumption	(1)	(2)	(3)	(4)	(5)
Depvar_(t-1)	0.7667*** (0.0614)	0.7706*** (0.0590)	0.7538*** (0.0586)	0.7683*** (0.0652)	0.7499*** (0.0588)
Trade openness	0.5263*** (0.2034)	0.5418*** (0.1955)	0.5032*** (0.1852)	0.4370** (0.1885)	0.8599*** (0.2596)
GDP per capita	47.2376*** (16.9717)	46.7086*** (16.7386)	50.6743*** (15.7092)	46.9464*** (18.0446)	47.5779*** (16.8735)
GDP growth	1.3061*** (0.2833)	1.2933*** (0.2643)	1.2601*** (0.2831)	1.2656*** (0.2896)	1.3775*** (0.2999)
Armed conflict	-11.0676** (4.8196)	-11.4750** (4.6199)	-10.5883** (4.8274)	-9.8095** (4.8126)	-11.0276** (5.1247)
Arable land	23.5348*** (6.7933)	22.8243*** (6.6548)	24.1056*** (6.6349)	21.4682*** (7.0166)	28.1298*** (7.1016)
Ag. productivity	35.8386*** (10.0780)	35.2579*** (9.9455)	37.1102*** (9.7874)	36.5940*** (10.1290)	39.2621*** (10.0472)
Rural population	-1.1423*** (0.4353)	-1.1048*** (0.4234)	-1.1520*** (0.4389)	-1.1617*** (0.4403)	-1.3534*** (0.4916)
Population growth	-11.5572** (5.5641)	-11.5005** (5.5504)	-12.9427** (5.5873)	-10.7255* (5.5905)	-12.9255** (5.8825)
Natural disasters	-28.2307 (18.4901)	-32.6494* (18.4210)	-30.3341 (18.8027)	-31.4179* (18.8049)	-27.7279 (18.1979)
Inflation	-19.0170** (8.2918)	-17.4418** (7.2989)	-20.5309** (8.0959)	-18.1555** (7.9385)	-22.3210*** (8.3554)
TO*GDP per capita	0.0552 (0.5402)				
TO*Armed conflict		-0.3482* (0.1855)			
TO*Ag. productivity			-0.2096 (0.2927)		
TO*Rural population				0.0681 (0.0500)	
TO*Inflation					-0.6914** (0.2870)
Observations	3,579	3,579	3,579	3,579	3,579
Number of id	151	151	151	151	151
Instruments	54	54	54	54	54
<i>Tests (p-values)</i>					
AR1 Test	0.000	0.000	0.000	0.000	0.000
AR2 Test	0.565	0.545	0.582	0.574	0.607
Hansen Test	0.888	0.928	0.937	0.753	0.813
Diff-Hansen	0.917	0.911	0.950	0.775	0.625

The instrument count reported is based on the number of “collapsed” instruments, using the xtabond2 specification from Roodman (2009a). Diff-Hansen test reports the p-values based on the null hypothesis that the instruments in the levels equation are exogenous. For more details, see Roodman (2009a). Coefficients based on the two-step estimation, using the Windmeijer correction. Period fixed effects employed but not reported. Numbers in parentheses are robust standard errors.

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

#### (h) Additional results using alternative explanatory variables

As a last step to test the sensitivity of our results with respect to the employed explanatory variables, we use alternative proxies for some of the variables, for which data is available. As proxy for political instability or the presence of conflict, we used an intensity measure of armed conflicts with 0 indicating no conflict, 1 minor conflict, and 2 indicating war. An alternative way to capture the incidence of conflicts would be to transform the data to obtain an indicator variable, taking the value of 0 for no conflict and 1 for minor conflict or war. As can be seen in Column 1 of Table A.3 in the appendix, the use of an indicator variable instead of an intensity measure of conflict does only marginally change the results. The coefficient even loses some of its significance, which suggests that the intensity measure of conflict contains somewhat more identifying information and is therefore preferred in the baseline model. An alternative database for conflict measures is the Major Episodes of Political Violence (MEPV) database of the Center for Systemic Peace.<sup>123</sup> Major episodes of political violence are defined by the systematic and sustained use of lethal violence by organized groups that result in at least 500 directly-related deaths over the course of the episode. We use the variable “ACTOTAL” as alternative conflict measure, which is the total sum of all societal and interstate political violence episodes, comprising international violence and warfare as well as civil and ethnic violence and warfare, where the magnitude of societal-systemic impact is measured on an eleven-point scale, from 0-10. As can be seen in Column 2 of Table A.3, also the employment of this alternative conflict measure does not change the results.<sup>124</sup> As our armed conflict measure used in the baseline regression model is the one usually employed in empirical analyses, we decided to use this one instead of the other available conflict measures described above.

We included arable land, measured in hectares per person, as important element of a country’s resource endowments determining agricultural production potential in the core regression model. An alternative and somewhat broader measure of a country’s land resource endowments determining agricultural production potential would be agricultural

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<sup>123</sup> The database as well as a detailed description of the construction of the violence measured is available online at <http://www.systemicpeace.org/inscrdata.html>.

<sup>124</sup> Note that we also constructed an indicator variable taking the value of 0 for no political violence and 1 if one of the abovementioned major episodes of political violence occurred in a certain year in a specific country. The use of an indicator variable instead of the categorical variable did again not change the results.

land (% of land area), which besides arable land also captures the share of land area under permanent crops and under permanent pastures (WDI). As can be seen in Column 3 of Table A.3, including the share of agricultural land instead of per capita arable land, does only marginally change the results. While per capita arable land entered the core regression model with a highly significant coefficient, the coefficient on the variable capturing the share of agricultural land is only marginally significant. This may be due to two reasons. First, the *per capita* measure of a country's land resource endowments determining agricultural production potential is more closely related to *per capita* calorie consumption. Second, land under permanent crops and under permanent pastures is less relevant for calorie consumption. The latter seems to be the case, as arable land, no matter if measured in per capita terms or as a share of land area is a more significant determinant of calorie consumption.

As a last a last step in our sensitivity assessment of the empirical results, we include an alternative agricultural productivity measure in the regression. Instead of cereal yield in kg per hectare, one could use agricultural value added per worker, measured in constant 2005 US\$ (WDI), where the value added in agriculture measures the output of the agricultural sector less the value of intermediate inputs. The results in Column 4 of Table A.3 shows that like in the case of cereal yield, also this alternative agricultural productivity measure is significantly positively related to our food security measure. Agricultural value added per worker, however, is very strongly correlated with our GDP per capita measure (which loses its significance as can be seen in Column 4 of Table A.3), such that we decided to use cereal yield as measure of agricultural productivity.

Therefore, we conclude that the main empirical results remain valid and are not very sensitive to the employment of alternative proxies that are available for some of the explanatory variables. Most importantly, trade openness remains a significant driver of higher food security levels in our country sample.

## 6. CONCLUSION AND POLICY RECOMMENDATIONS

Food security- in terms of research and policy- generally receives less attention than poverty, and only very few studies explicitly explore the impact of trade policy on food security (Guha-Khasnobis, Acharya & Davis, 2007). In the present study, we tried to provide a remedy to this fact and identified the key country-level determinants of food security. Furthermore, we also gained insight into the issue of whether or not trade openness generally promotes food security. Moreover, most existing studies on food security so far focused on the determinants of child malnutrition and did account neither for trade policy effects nor for potential endogeneity problems. While this branch of research provides important insights into the issue of nutrition in early childhood, we tried to take a broader perspective and focused on the overall level of food security of the population as indicated by average dietary energy consumption. As this measure has been found to be closely associated with reduced underweight prevalence and to contribute substantially to reductions in malnutrition among children, our results provide insights for this branch of research as well.

We found that trade openness does, on average, have a statistically significant positive net impact on food security, which leads us to conclude that the benefits of trade outweigh the costs when the objective is to attain national level food security. The beneficial effects of openness to trade hold true for dietary energy supply adequacy as well as for dietary diversity and diet quality-related aspects of food security. Besides that, economic and agricultural development, a beneficial domestic policy environment as well as the availability of domestic resources for agricultural production impact positively on food security. On the contrary, violent conflicts and natural disasters, a high rural population share, high population growth and inflation negatively affect food security. The causal relationship running from trade openness to food security is robust to different sample compositions, to the inclusion of variables capturing specific agro-climatic constraints (e.g. weather-related) and regional/country characteristics, as well as the inclusion of a range of additional variables. Most geographical regions have been found to exert significantly higher food security levels compared to Sub-Saharan Africa. Employing alternative globalization and trade reform indicators confirmed the results that protectionist measures are in general

detrimental and economic openness is beneficial for food security.<sup>125</sup> These findings speak to the importance of essential macroeconomic structural factors in determining food security, which previous research has not thoroughly examined.

From a policy perspective, some recommendations can be derived from the empirical results. First, the finding that conflict indicators impact negatively on calorie consumption supports claims of the international community that conflict prevention and mitigation should be incorporated into food security policies (see e.g. FAO, 2006). It therefore provides empirical evidence and supports the first commitment of the World Food Summit, which recognizes the establishment of a peaceful stable political, social and economic environment as a precondition for the achievement of food security (see Thomson & Metz, 1999). In light of the fact that conflicts can also lead to reductions in trade, there may be additional adverse indirect effects of violent conflicts on food security.<sup>126</sup> This result suggests that it should be beneficial to integrate conflict analysis and indicators into traditional food security early warning systems. Governments should also pay close attention to these early warning systems in order to dampen the effects of droughts and other climatological phenomena on food security for the affected population. Public sector investments should aim at helping farmers to adapt to climate change, which leads to more frequent and extreme weather events (see Nelson et al., 2010). In this context, the improvement of water management and irrigation systems as well as the cultivation of drought resistant varieties of staple foods should play a central role for securing food production in arid areas. Trade liberalization can also help to stabilize food supplies during periods of intense pressures for domestic agricultural production caused, for example, by droughts or floods. In this respect, trade openness and the stabilizing role of trade will become even more important in the future for many developing countries, in which climate change is expected to lead to an increase in domestic production shocks.

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<sup>125</sup> Although our findings reveal a generalizable pattern among a large set of countries that openness has a favorable impact on food security, we acknowledge the uniqueness of every country. Consequently, more disaggregated analysis for single countries can reveal exceptions to this “rule”, in particular when focusing on specific population groups, which may be adversely affected by opening up the economy.

<sup>126</sup> Glick & Taylor (2010) emphasize that conflicts represent added transaction costs and find large and persistent impacts of wars on trade. Blomberg & Hess (2006) state that conflicts lead to lower capital formation and an inefficient reallocation of resources across sectors and calculate that the presence of terrorism, as well as internal and external conflict is equivalent to as much as a 30 percent tariff on trade.

General economic and agricultural development is critical for enhanced food security, such that policies strengthening the agriculture sector and helping to increase agricultural productivity and expand food production, for example the dissemination of new technologies and provision of credit and inputs such as machinery, fertilizers and seeds, should be an element of any domestic food security strategy. At the same time, however, these strategies have to be sustainable. A promising way in this direction is the promotion of sustainable agricultural intensification as a broader effort to ensure food security while protecting the natural resource base (see Marble & Fritschel, 2014). However, the focus should not be restricted to the agriculture sector. Indeed, sustainable food security may not be achieved by only focusing on agriculture at the expense of other sectors and agriculture and the rural economy itself is greatly influenced by macro-level policies and outcomes in the rest of the economy (Timmer, 2000). Beyond that, therefore the establishment of effective institutions in order to protect and improve the natural resource base, for example agricultural and arable land, will be helpful for sustainable domestic food production. Domestic stabilization policies that are able to reduce inflation and output volatility can also be critical to sustainable long-term food security. In this respect, countries should refrain from adopting protectionist measures (e.g. export restrictions) in the face of high food prices, as it may reduce global food supplies, and therefore contribute to rising prices and price volatility. Anderson & Martin (2012) conclude that price insulation policies via export restrictions are ineffective on average in stabilizing domestic prices, and estimate that 45 percent of the increase in rice prices and 30 percent of the increase in wheat prices in the 2006-8 period was due to insulating behavior. Storage policies should generally be a better option for developing countries to stabilize domestic food prices (see e.g. Gouel & Jean, 2012). In summary, a stable macroeconomic environment along with investments in rural development leading to a reduction in transaction costs may then also help producers to withstand foreign competition and expand into export markets. In line with this, our findings point to the importance of complementary policies and reforms through which the beneficial effects of openness may be significantly improved.

At the global level, international trade can link production and consumption of food and hence may play an important role in securing enhanced food security, as it permits global production to take place in those regions most suited to it and enables food to flow from

countries with abundant food supplies to ones with insufficient supplies (Runge et al., 2003). Conversely, if this mechanism is disrupted by trade barriers, it may have negative consequences for food security. Our analysis confirmed the hypothesis that trade openness impacts positively on food security and protectionist measures, for example tariffs, which raise the cost of food, are detrimental to national food security. Openness to international trade should therefore constitute a fundamental component of a policy mix to enhance food security, and trade liberalization in the sense of progressive reductions in the levels of protection can be an effective instrument for this purpose. Trade reforms and the elimination of policies that distort trade can improve production incentives and lead to more efficient international markets. It should be seen as a complement but not as a substitute for domestic development policies aimed at reducing hunger, for example investments in the domestic agricultural sector, and complementary policies to ensure that farmers benefit from liberalization and vulnerable groups are protected. For example, promoting efficient information flows and improving access to important production inputs may help farmers to respond to changing market conditions. In this respect, the formation of smallholder cooperatives may be useful for risk sharing and improved bargaining power. These farmer groups may also function as important catalysts for the adoption of new technologies through promoting efficient information flows and reducing transaction costs (see e.g. Fischer & Qaim, 2012). Although arguments for protection can be made on both economic and non-economic grounds with respect to the issue of food security, trade barriers are costly and are often fiscally unsustainable and, besides that, are usually neither the most direct nor the most efficient measures to use (FAO, 2000). Furthermore, as there are generally both poor people who buy and sell food, price distorting measures to help one constituency by definition harms the other (Brooks & Matthews, 2015).

Therefore, the negative side effects of trade liberalization should be managed by non-trade policies, including social protection and the provision of risk management tools, such that the aggregate benefits of trade are not foregone.<sup>127</sup> This reasoning is generally also reflected in the Uruguay Round Agreement on Agriculture (AoA), administered by the World Trade Organization (WTO) and agreed upon in 1994, which brought agricultural trade more fully

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<sup>127</sup> See Brooks & Matthews (2015) for a recent summary of the OECD view on the „Trade Dimensions of Food Security“, which is generally in line with this reasoning.



under the General Agreement on Tariffs and Trade (GATT). It aims at converting non-tariff barriers to tariffs and for a phased reduction of tariffs and favors domestic support measures that do not distort trade over border measures to support domestic production as part of a strategy for food security. The industrial countries can contribute to global food security through a further reduction of protectionist measures, e.g. subsidies as well as import quotas and tariffs, especially for the commodities of export interest to developing countries. Besides that, food safety and quality standards for agricultural products must not be misused as a trade barrier to protect domestic producers. These barriers to market access for agricultural exporters of developing countries limit their ability to pursue a food security strategy based on self-reliance by restricting the possibilities to benefit from international trade (FAO, 2000).

We believe that our findings and some limitations of the current study can provide the basis for future research that aim at improving our understanding of the causes of food insecurity. The trends in food security (as in poverty) may not be fully evident at the national level, which calls for regional and micro-level analyses to complement our macro-level investigations. These may provide deeper insights into the issue of how specific trade policy measures impact on the food security status of specific population groups, especially those who are the most vulnerable to food insecurity. With this kind of analysis, it may also be possible to assess the determinants of food security at a lower level of causality and to identify the most important transmission channels in the trade reform-food security nexus to get additional relevant insights for policy makers. Second, we only assessed how a country's own trade liberalization affects its food security levels. While most gains from multilateral liberalization are expected to come from the countries' own liberalization efforts (Ingco, 1997), it would be interesting to assess how developed countries' trade liberalization or protectionism affects the food security situation in developing countries. The developments of global food supply chains and issues related to agricultural subsidies as well as product and process standards may be a vital issue to consider here. Besides that, we find enough evidence to suggest that the development of the agricultural sector is one of the most important ways to enhance food security. The finding that agriculture is one of the central contributors to food security in most countries is indeed not surprising and seems to justify the recent increased interest in agricultural interventions for nutrition (among others,

see Fan & Pandya-Lorch, 2012; Hoddinott et al., 2012). The linkages between the two sectors are, however, very complex, and possibly highly context specific. Hence, future studies may try to take a closer look at the agricultural sector and assess in more detail how different agricultural strategies and conditions affect food security.

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## APPENDIX

Table A.1. List of countries used in baseline regressions (151)

Albania	Cyprus	Kuwait	Sao Tome & Principe
Algeria	Czech Republic	Kyrgyz Republic	Saudi Arabia
Angola	Denmark	Lao PDR	Senegal
Antigua & Barbuda	Djibouti	Lebanon	Sierra Leone
Argentina	Dominica	Lesotho	Slovak Republic
Armenia	Dominican Republic	Liberia	Slovenia
Australia	Ecuador	Libya	Solomon Islands
Austria	Egypt, Arab Rep.	Macedonia, FYR	South Africa
Azerbaijan	El Salvador	Madagascar	Spain
Bahamas	Eritrea	Malawi	Sri Lanka
Bangladesh	Ethiopia	Malaysia	Sudan
Barbados	Fiji	Maldives	Suriname
Belgium	Finland	Mali	Swaziland
Belize	France	Malta	Sweden
Benin	Gabon	Mauritania	Switzerland
Bolivia	Gambia, The	Mauritius	Syrian Arab Republic
Bosnia & Herzegovina	Germany	Mexico	Tajikistan
Botswana	Ghana	Mongolia	Tanzania
Brazil	Greece	Morocco	Thailand
Brunei Darussalam	Grenada	Mozambique	Togo
Bulgaria	Guatemala	Namibia	Trinidad & Tobago
Burkina Faso	Guinea	Nepal	Tunisia
Burundi	Guinea-Bissau	Netherlands	Turkey
Cambodia	Guyana	New Zealand	Turkmenistan
Cameroon	Haiti	Nicaragua	Uganda
Canada	Honduras	Niger	United Arab Emirates
Cape Verde	India	Nigeria	United Kingdom
Central African Republic	Indonesia	Norway	United States
Chad	Iran, Islamic Rep.	Pakistan	Uruguay
Chile	Ireland	Panama	Uzbekistan
China	Israel	Paraguay	Vanuatu
Colombia	Italy	Peru	Venezuela, RB
Comoros	Jamaica	Philippines	Vietnam
Congo, Dem. Rep.	Japan	Poland	Yemen, Rep.
Congo, Rep.	Jordan	Portugal	Zambia
Costa Rica	Kazakhstan	Romania	Zimbabwe
Cote d'Ivoire	Kenya	Rwanda	
Croatia	Korea, Rep.	St. Vincent & the Grenadines	
Cuba			

Table A.2. List of variables used, and sources

Variable	Source
Dietary energy consumption	Dietary energy consumption per person refers to the amount of food, expressed in kilocalories (kcal) per day, available for each individual in the total population during the reference period. <i>Source: FAOSTAT</i>
Trade openness	Imports plus exports as a% of GDP. <i>Source: PENN World Table (PWT) 6.3. Heston et al. (2009). Accessed from <a href="https://pwt.sas.upenn.edu/php_site/pwt_index.php">https://pwt.sas.upenn.edu/php_site/pwt_index.php</a></i>
GDP per capita	Per capita real (chain-weighted) GDP, ln logs. <i>Source: PWT 6.3</i>
GDP growth	Growth rate of Real GDP Chain per capita, in percent. <i>Source: PWT 6.3</i>
Armed conflict	Intensity of armed conflict with 0 for no conflict, 1 for minor conflict, and 2 for war. <i>Source: Gleditsch et al. (2002). Accessed from <a href="http://www.prio.no/Data/Armed-Conflict/">http://www.prio.no/Data/Armed-Conflict/</a></i>
Arable land	Arable land in hectares per person, in logs. <i>Source: World Development Indicators (WDI)</i>
Ag. productivity	Cereal yield (kg per hectare), in logs. <i>Source: FAOSTAT</i>
Rural population	Rural population as a% of total population. <i>Source: WDI</i>
Population growth	Population growth (annual %), in logs. <i>Source: WDI</i>
Natural disasters	Intensity of natural disasters, measured as the number of affected divided by total population, based on data from the <i>Emergency Events Database (EM-DAT)</i> . Accessed from <a href="http://www.emdat.be/">http://www.emdat.be/</a>
Inflation	log [1 + inflation], with consumer prices inflation data taken from <i>WDI</i>
Landlocked	Indicator variable taking the value of 1 for landlocked countries and 0 otherwise. <i>Source: CEPII. Accessed from <a href="http://www.cepii.fr/anglaisgraph/bdd/distances.htm">http://www.cepii.fr/anglaisgraph/bdd/distances.htm</a></i>
Tropics	Share of the population in a given country living in geographical tropics. <i>Source: Gallup et al. (2001). Accessed from <a href="http://www.cid.harvard.edu/ciddata/geographydata.htm">http://www.cid.harvard.edu/ciddata/geographydata.htm</a></i>
Policy openness	Residual of a regression of trade openness on the logs of area and population, and dummies for oil exporting and for landlocked countries. <i>Source: Authors' calculations following Chang et al. (2009)</i>
Tariffs	Ad-valorem tariffs, measured as import duties as a percentage of imports, in logs. <i>Source: DeJong &amp; Ripoll (2006)</i>
Globalization	KOF index of globalization (0–100); composite index measuring three dimensions (economic, social, political), with higher values indicating more globalization. <i>Source: Dreher (2006); updated in Dreher et al, (2008)</i>
SW Openness	Sachs-Warner openness dummy variable; classifies countries as open (1) or closed (0) based on different trade indicators (tariffs, nontariff barriers, and other measures of trade restrictions). <i>Source: Wacziarg &amp; Welch (2008)</i>
Infrastructure	Telephone lines (per 100 people). <i>Source: WDI</i>
Country size	Population, total. <i>Source: WDI</i>
Price volatility	Coefficient of variation from (annual) mean values of the consumer price index. <i>Source: Authors' calculations</i>
Real exchange rate	Real effective exchange rate index (2005 = 100), in logs. <i>Source: WDI</i>
Foreign reserves	Total reserves in months of imports, in logs. <i>Source: WDI</i>
Democracy	Democracy index between 0 and 1. <i>Source: Authors' calculation using data from Freedom House on civil liberties and political rights</i>
Institutional quality	Release of information index. <i>Source: Williams (2009)</i>
Macroeconomic volatility	Macroeconomic volatility, measured as the three-year rolling standard deviation of the GDP growth rate, with GDP data taken from <i>PWT 6.3</i>
Financial depth	Domestic credit provided by banking sector as a% of GDP (WDI)
Government burden	Government consumption as a% of GDP (WDI)
Dietary energy supply adequacy	Dietary energy supply as a percentage of the average dietary energy requirement in each country. <i>Source: FAO (2013)</i>
Dietary diversity	Share of dietary energy supply derived from non-staple foods, with staple foods being cereals, roots and tubers. <i>Source: FAO (2013)</i>
Protein consumption	Average protein supply (g/capita/day) available for consumption in each country. <i>Source: FAO (2013)</i>

Table A.3.: *Additional results using alternative explanatory variables*

Depvar: Dietary energy consumption	(1)	(2)	(3)	(4)
Depvar_(t-1)	0.7694*** (0.0606)	0.7719*** (0.0614)	0.7525*** (0.0630)	0.7733*** (0.0574)
Trade openness	0.5209*** (0.1984)	0.5554*** (0.1940)	0.5324*** (0.1996)	0.5970*** (0.2159)
GDP per capita	47.3765*** (16.7306)	44.8119*** (16.9479)	46.5819*** (17.6230)	18.7736 (12.2304)
GDP growth	1.3434*** (0.2994)	1.3170*** (0.2919)	1.2290*** (0.2726)	1.2679*** (0.3177)
Armed conflict			-9.1886** (4.6353)	-10.7927** (5.0198)
Armed conflict indicator	-13.2805* (7.0443)			
Political violence		-4.2962* (2.3518)		
Arable land	23.3785*** (6.5917)	22.9694*** (6.6699)		17.6738*** (5.9276)
Agricultural land			0.5208* (0.2946)	
Ag. productivity	35.7890*** (10.0893)	35.1563*** (9.6831)	33.9122*** (9.9339)	
Ag. value added per worker				30.5622*** (11.3068)
Rural population	-1.1217*** (0.4279)	-1.1693*** (0.4283)	-1.3200*** (0.4824)	-0.7443** (0.3715)
Population growth	-11.2835** (5.4298)	-11.4769** (5.5627)	-13.8918** (6.3605)	-15.3178*** (5.3704)
Natural disasters	-28.5255 (18.8522)	-31.2905* (17.5961)	-36.8392* (20.7435)	-22.8039 (16.7523)
Inflation	-19.0192** (8.4134)	-19.6614** (8.2168)	-17.4406** (8.8428)	-12.7469* (7.5321)
Observations	3,578	3,579	3,566	3,260
Number of id	151	151	151	152
Instruments	50	50	50	50
<i>Tests (p-values)</i>				
AR1 Test	0.000	0.000	0.000	0.000
AR2 Test	0.602	0.580	0.518	0.352
Hansen Test	0.828	0.798	0.931	0.967
Diff-Hansen	0.875	0.848	0.865	0.893

The instrument count reported is based on the number of “collapsed” instruments, using the xtabond2 specification from Roodman (2009a). Diff-Hansen test reports the p-values based on the null hypothesis that the instruments in the levels equation are exogenous. For more details, see Roodman (2009a). Coefficients based on the two-step estimation, using the Windmeijer correction. Period fixed effects employed but not reported. Numbers in parentheses are robust standard errors.

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1



#### IV. Trade and Child Health: A panel cointegration analysis

##### **Abstract**

Globally, interest in the issue of how to improve child health and reduce child mortality has increased dramatically in recent years. Reducing the under-five mortality rate by two-thirds until 2015 has also been included as one of the United Nations Millennium Development Goals (MDGs). While much is known about the positive effects of specific behaviors such as care taking and breastfeeding and direct interventions such as vaccination campaigns, much less is known about the indirect effects of specific national-level policies on child health and empirical evidence on the issue is scarce. In the third part of the thesis, we assess the impact of trade on child health, based on a cross-country panel data set covering 66 countries for the period 1960-2013. To account for the time-series properties of the data and potential cross-country heterogeneity in the impact of trade, the study employs heterogeneous panel cointegration techniques that are robust to omitted variables and endogeneity, to identify the long-run cointegrating relationship between trade and child health. The results reveal that trade and child health are cointegrated and that trade works to reduce the under-five mortality rate significantly in the long-run. The results are robust to the methodology and openness indicator employed as well as to the presence of cross-sectional dependence and changes in the sample composition. Additional analyses suggest that the trade-child health relationship tends to be stronger in countries with a favorable policy and institutional environment.

## 1. INTRODUCTION

Trade liberalization policies led to a strong increase in international trade during the last decades. The 1960s and 70s were periods of anti-agricultural and anti-export bias in many developing countries, as governments tried to isolate domestic from world markets through protectionist policies. These policy measures were found to inhibit trade, led to distorted incentives and resource misallocation, and became fiscally unsustainable during the 1970s in most developing countries. Tariffs and non-tariff barriers also encouraged unproductive activities such as rent seeking (e.g. lobbying for subsidies) and tax avoidance and evasion, which contributed to inefficiency in the economy (FAO, 2003). Since the mid-1980s, there has been a substantial amount of policy reform and opening up of many developing countries, which initiated policy reforms under Structural Adjustment Programs (SAPs) of the World Bank and the International Monetary Fund (IMF) and based on trade negotiations at the international level (UNCTAD, GATT, and later WTO), leading to strong growth in international trade worldwide. These policies included the removal of government subsidies, liberalization of export and import trade (i.e. a reduction in tariffs and non-tariff trade barriers) and exchange rate liberalization (Anderson, 2010). Trade reforms have been justified by expected increases in efficiency, particularly in resource allocation, by improving transparency in incentives and the transmission of knowledge and technology, thereby promoting economic growth and poverty alleviation and leading to increased access to a greater range of goods and services (FAO, 2000). Through these and other channels, trade may have contributed to improvements in health, as will be discussed in more detail in Section 2.

Globally, substantial progress has been made in improving child health during the last decades, with large but uneven reductions in child mortality in different regions (see Table 1). The global under-five mortality rate has dropped by 49 percent between 1990 and 2013—from 90 deaths per 1,000 live births in 1990 to 46 deaths per 1,000 live births in 2013. This corresponds to an absolute reduction in the number of under-five deaths worldwide from 12.7 million in 1990 to 6.3 million in 2013. Despite these significant improvements in child health during the last decades, high child mortality rates persist in many countries, particularly in Sub-Saharan Africa, Central and Southern Asia. According to UNICEF, progress

has been insufficient to meet the MDG 4 target at the global level and still about 17,000 children under the age of five die every day in 2013 (UNICEF et al., 2014). High prevalence of disease and resulting early childhood undernutrition causes irreversible damage and has significant long-term consequences because of its adverse effects for school attendance and performance as well as for cognitive capacity and future earnings (Deaton & Arora, 2009; Currie, 2009; Hoddinott et al., 2011). Because of these interrelationships, it has become apparent that improvements in child health in pre-school children provide substantive economic benefits. As a response, numerous international organizations and initiatives have now placed high priority on improving child health, for example the United Nations Children’s Fund (UNICEF), the World Health Organization (WHO) and other UN organizations who are joining public, private and civil society partners to accelerate progress in improving child health (UNICEF et al., 2014).

**Table 1:** Under-five mortality rate in different regions

Region	Under-five mortality rate (deaths per 1,000 live births)							Annual rate of reduction (percent)					
	1990	1995	2000	2005	2010	2013	MDG target 2015	Decline (percent) 1990–2013	1990–2013	1990–1995	1995–2000	2000–2005	2005–2013
<b>Developed regions</b>	<b>15</b>	11	10	8	7	<b>6</b>	<b>5</b>	58	3.8	5.3	2.5	4.0	3.5
<b>Developing regions</b>	<b>100</b>	94	83	69	57	<b>50</b>	<b>33</b>	50	3.0	1.2	2.4	3.7	4.0
<b>Northern Africa</b>	<b>72</b>	57	44	33	26	<b>24</b>	<b>24</b>	67	4.8	4.8	5.3	5.9	3.9
<b>Sub-Saharan Africa</b>	<b>179</b>	172	156	129	103	<b>92</b>	<b>60</b>	48	2.9	0.8	1.9	3.8	4.2
<b>Latin America and the Caribbean</b>	<b>54</b>	43	32	25	23	<b>18</b>	<b>18</b>	67	4.8	4.7	5.5	5.2	4.1
<b>Caucasus and Central Asia</b>	<b>73</b>	74	64	50	39	<b>35</b>	<b>24</b>	52	3.2	-0.3	3.0	5.0	4.3
<b>Eastern Asia</b>	<b>53</b>	46	37	24	16	<b>13</b>	<b>18</b>	76	6.2	2.7	4.7	8.7	7.7
Excluding China	<b>27</b>	33	31	20	17	<b>15</b>	<b>9</b>	45	2.6	-4.0	1.6	8.2	3.8
<b>Southern Asia</b>	<b>126</b>	109	92	76	62	<b>55</b>	<b>42</b>	56	3.6	2.9	3.4	3.9	4.0
Excluding India	<b>126</b>	109	94	78	67	<b>60</b>	<b>42</b>	52	3.2	2.8	3.1	3.6	3.3
<b>South-eastern Asia</b>	<b>71</b>	58	48	39	33	<b>29</b>	<b>24</b>	59	3.9	4.0	3.8	4.3	3.5
<b>Western Asia</b>	<b>65</b>	54	43	36	28	<b>25</b>	<b>22</b>	61	4.1	3.8	4.3	3.9	4.3
<b>Oceania</b>	<b>74</b>	69	67	64	58	<b>54</b>	<b>25</b>	28	1.4	1.4	0.7	1.0	2.2
<b>World</b>	<b>90</b>	<b>85</b>	<b>76</b>	<b>63</b>	<b>51</b>	<b>46</b>	<b>30</b>	<b>49</b>	<b>3.0</b>	<b>1.2</b>	<b>2.3</b>	<b>3.8</b>	<b>4.0</b>

Source: UNICEF et al. (2014)

Several direct causes of child deaths have been identified in the past. For example, Black et al. (2013) estimated that undernutrition was the underlying cause of 45 per cent of all deaths among children under-five years of age, around 3.1 million children worldwide in 2011. Therefore, much of the reduction in child mortality can be attributed to the progress that has occurred in reducing child undernutrition globally during the last decades. According

to UNICEF (2013), the global prevalence of stunting has declined by about 36 per cent over the last two decades, while the underweight prevalence has declined by approximately 37 per cent. The leading direct causes of death among children under age five further include preterm birth complications, pneumonia, intrapartum-related complications, diarrhea and malaria. Accordingly, direct health-specific interventions such as immunization, insecticide-treated mosquito nets, rehydration treatment for diarrhea, and nutrition supplements can be used to tackle these preventable direct causes of ill health (UNICEF et al., 2014). These direct measures tend to be the focus of health professionals, such that the health sector has traditionally avoided to focus on trade-health issues and to get involved in trade debates (MacDonald & Horton, 2009). However, as countries are increasingly integrated with the world, health is also affected increasingly by factors beyond the health system, including trade (see Smith, Lee, & Drager, 2009). As a response, a recent *Lancet* (2009) series on trade and health provided an overview on this topic and aimed for strengthening the evidence of trade and health links (see MacDonald & Horton (2009) for an introductory comment on the series).

The analysis of child's health can be usefully placed in the context of the UNICEF (1990) model for the causes of child's nutritional status, which combines the elements of dietary intake and child health (see Figure 1). This framework emphasizes that the health status of a child is also affected by other factors and policies lying at a broader level of causality, affecting child's health and nutritional status through the underlying determinants.<sup>128</sup> The *underlying* determinants manifest themselves at the household level and include care for mothers and children, and the health environment quality and access to healthcare services. Child feeding practices, cognitive stimulation, and general health-seeking behaviors form part of the child caring activities. In addition, care for mothers, for example during pregnancy, affects child's health status. The health environment and services includes access to safe water and sanitation as well as the availability of and access to healthcare services, for example vaccinations, and therefore partly determines the incidence of disease or child's

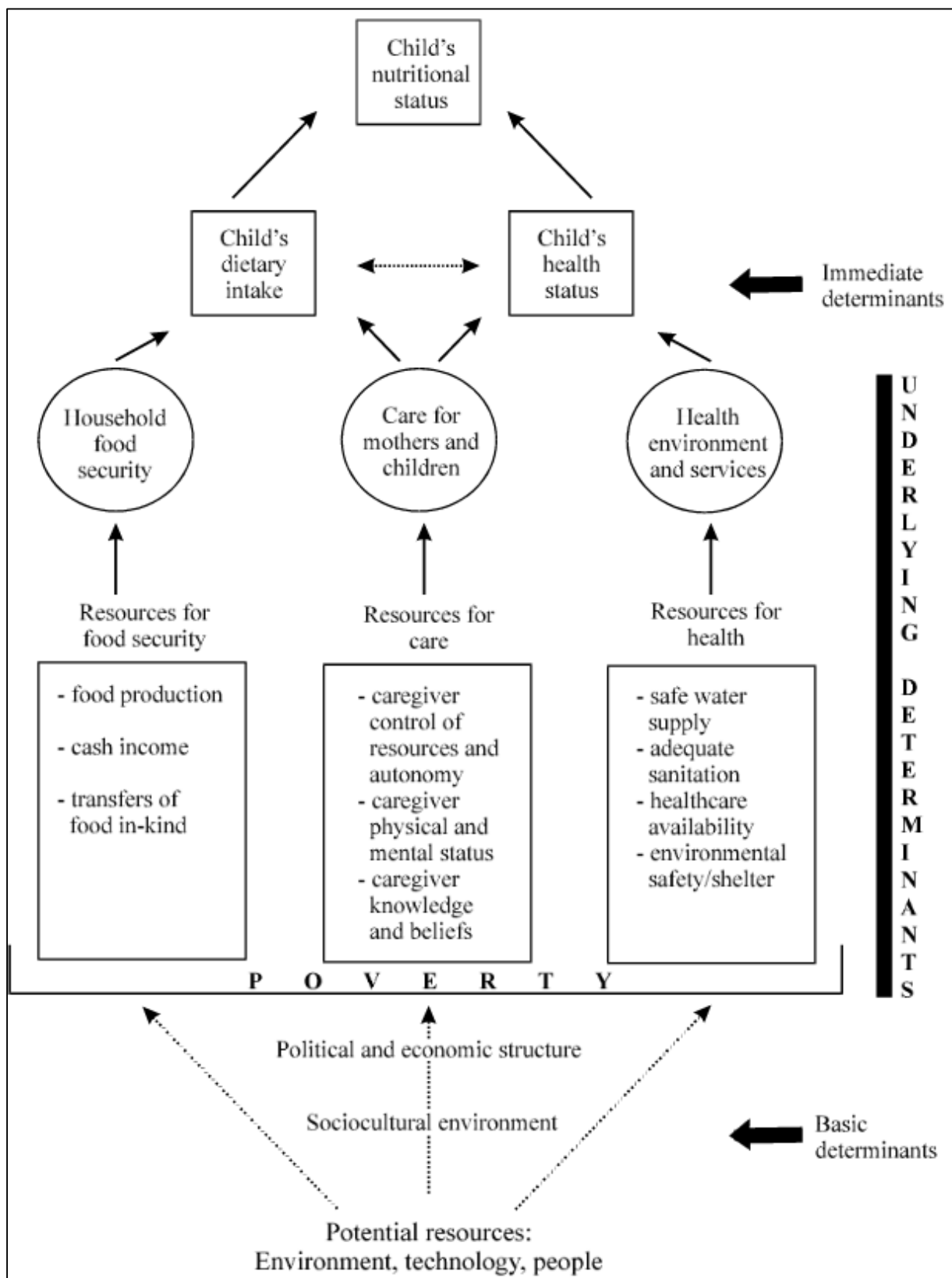
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<sup>128</sup> Noting that a similar concept can be used for the determinants of child's health and nutritional status, our analysis also provides insights into the issue of trade and nutrition, the latter being commonly reflected in underweight and stunting rates. However, insufficient data availability on the prevalence of underweight and stunting precludes us from using these data for the kind of analysis performed in this study. Thus, we only refer to child health, with the under-five mortality rate as dependent variable that, according to the WHO, is one of the leading indicators of the level of child health.

health status. These underlying determinants are influenced, in turn, by *basic* determinants at the societal or country level that affect child health (and nutritional status) through their impact on the underlying determinants. These basic or structural causes include the potential resources available to a country and the political and economic structure as well as the sociocultural environment, which affect people's incentives, the utilization of potential country resources and how they are translated into resources for care, and the health environment quality and services (Smith & Haddad, 2000).

We put special emphasis on the basic (or root) causes and focus on trade openness as part of the political context to assess the long-run effect of trade on child health as reflected by the under-five mortality rate. Employing panel cointegration estimation methods, which account for omitted variables, endogeneity and cross-country heterogeneity, allows us to use a parsimonious model and focus only on the trade-child health relationship, without having to consider the other determinants of child health. This has become common practice in (panel) cointegration studies (see e.g. Herzer, 2013; Dawson & Sanjuán, 2011; Moscone & Tosetti, 2010; Baltagi & Moscone, 2008; Canning & Pedroni, 2008; Westerlund, 2007). This constitutes one big advantage over traditional estimation methods, which explicitly have to account for endogeneity and may be plagued by omitted variable bias problems (as will be discussed in more detail in Section 3). According to UNICEF et al. (2014), a great part of child's deaths occurs due to preventable causes and treatable diseases, even though the knowledge, technologies, and medicines are available elsewhere. In case a more open trade regime leads to improvements in the availability and accessibility of these factors, international trade should lead to long-run improvements in child health. On the other hand, health may deteriorate if economic integration facilitates the transfer of infectious disease or unhealthy consumer goods and practices across borders (see Blouin et al., 2009; Owen & Wu, 2007). In addition, there may be several other channels through which trade affects child health, which will be described in more detail in Section 2. Therefore, whether trade openness ultimately improves child health is theoretically ambiguous, which strongly calls for empirical analysis to assess whether the net effects are positive or negative. Despite recent calls of the international health community aimed at strengthening the evidence on the trade-health nexus, there is still surprisingly little empirical evidence on this issue.

**Figure 1:** The determinants of child's health and nutritional status



Source: Smith & Haddad (2000)

In this study, we aim to contribute to the empirical evidence base needed to identify the causes of child mortality and assess the impact of trade on child health, based on a cross-country panel data set of 66 countries for the period 1960-2013. The focus of the study is justified, as the impact of specific national-level developments and policies is still not well understood. In line with this reasoning, the WHO (2003, p. 28) emphasizes that “trade aspects need to be considered in the context of improving diet, nutrition and the prevention of chronic diseases”. However, there exists, to the best of our knowledge, no systematic quantitative analysis of the impact of trade on child health and mortality, and only very few studies focusing on the effect on trade on general population health as reflected in life expectancies.

Owen & Wu (2007) use a panel of 219 countries for the period 1960-1995 to examine the relationship between trade openness and life expectancy and find that increased trade is associated with higher life expectancies. However, they employ a fixed effects estimator assuming cross-country homogeneity in the trade effect and only use observations at five-year intervals, which are two major shortcomings of the study, potentially biasing the results. First, trade may not be strictly exogenous, as trade can be both a cause and a consequence of increased population health, as better health is generally associated with higher productivity (see Strauss & Thomas, 1998) and thus potentially more trade. Secondly, the effect of trade on life expectancy may vary across countries that have different structural country characteristics and policy environments, potentially affecting the functionality of markets and the ability of market participants to respond to induced changes in prices and incentives. Third, the use of five-year intervals throws away a lot of information potentially important for identification of the trade effect on health, especially when the data are highly persistent (see Nair-Reichert & Weinhold, 2001). Moreover, studies using large cross-sections and averaged data resulting in a small number of time units, mainly use cross-sectional variability to identify the parameters of interest and may not sufficiently account for the time-series properties of the data (see Attanasio, Picci, & Scorcu, 2000). Using the same methodology for the more recent period 1970-2005, Stevens, Urbach, & Wills (2013) confirm the positive effect of trade openness on average life expectancies. The same critique applies here.

A related study of Bergh and Nilsson (2010) examines the impact of a globalization index on life expectancy using a panel of 92 countries and five-year averaged data for the period 1970-2005. They find that the economic component of globalization has a robust positive effect on life expectancy, while political and social globalization have no such effects. They estimate the trade-health relationship using a panel-corrected standard errors (PCSE) procedure, allowing for contemporaneously correlated errors across countries. While this procedure should be more suitable for analyzing globalization effects that imply increasing inter-country linkages, the study again does not account for the time-series properties of the data nor endogeneity issues.

We try to fill this gap by employing heterogeneous panel cointegration techniques that are robust to a variety of estimation problems such as non-stationarity of the data, omitted variables and endogeneity, to estimate the long-run cointegration relationship between trade openness and child health. The study is intended to be complementary to the existing literature that explores the linkages between globalization, trade openness and economic growth<sup>129</sup> and between trade and poverty<sup>130</sup>, but which does not explicitly explore the implications for child health and mortality.

The rest of the chapter is structured as follows. Section 2 describes the links between trade and child health. Section 3 describes the data and explains the empirical specification and estimation methodology employed in the analysis. Section 4 presents the empirical results for the panel unit root tests, the panel cointegration tests and the long-run effect of trade openness on the under-five mortality rate. In addition, we perform various robustness checks and provide some additional insights into the trade-child health nexus. Finally, Section 5 concludes and derives some policy recommendations.

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<sup>129</sup> Among others, see: Dollar, 1992, Sachs & Warner, 1995; Edwards, 1998; Frankel & Romer, 1999; Rodriguez & Rodrik, 2000; Greenaway et al., 2002; Baldwin, 2003; Dollar & Kraay, 2004; DeJong & Ripoll, 2006; Chang et al., 2009; Herzer, 2013.

<sup>130</sup> Among others, see: Dollar & Kraay, 2004; Agénor, 2004; Winters et al., 2004; Dollar, 2005; Bardhan, 2006, Nissanke & Thorbecke, 2006; Ravallion, 2006; Goldberg & Pavcnik, 2007; Fosu & Mold, 2008.



## 2. THE LINKS BETWEEN TRADE AND CHILD HEALTH

We take the UNICEF (1990) conceptual model on the causes of child malnutrition, as a basis to discuss the potential links between trade and child's health status. The health status partly determines child malnutrition, because it affects both appetite as well as the absorption of nutrients. In other words, child's dietary intake combines with the health status to produce what is called child's nutritional status (UNICEF, 2013). We focus on the linkages between the basic determinants and, more specifically, trade openness as part of the political and economic structure, and child's health status, being transmitted through the underlying determinants as depicted in Figure 1. Child's health status is affected directly by child's dietary intake and two *underlying determinants* manifesting themselves at the household level: care for mothers and children, and the health environment quality, including access to healthcare services. Child's dietary intake is itself affected by household food security, which indicates how much food resources are available for allocation between the household members and thus directly determines child's dietary intake. However, also caring behaviors and feeding practices of women in particular (who are commonly the primary caretakers) partly determine child's dietary intake as well as its health status. Child feeding practices, cognitive stimulation, and general health-seeking behaviors belong to these child caring activities. In addition, care for mothers, for example during pregnancy, affects child's health. The health environment and services as third underlying determinant includes access to safe water and sanitation as well as the availability of and access to healthcare services, for example vaccinations, and therefore partly determines the incidence of disease and child's health status (Smith & Haddad, 2000).

These underlying determinants are influenced, in turn, by *basic determinants* at the societal or country level that affect child health through their impact on the underlying determinants. These basic or structural causes include the potential resources available to a country and the political and economic structure as well as the sociocultural environment, which affect people's incentives, the utilization of potential country resources and how they are translated into resources for food security, care, and the health environment quality (Smith & Haddad, 2000). We focus exclusively on trade openness as part of the political and economic structure, potentially affecting child health through the underlying determinants, as will be described in more detail below. The effect of trade in this context can essentially

flow through two channels: it may change the level, accessibility or relative prices of factors in the production function for health, and it may affect the parents' decisions impacting on the health of their children.

Generally, trade creates both opportunities and constraints and affects the allocation and utilization of resources in the economy. It also affects the incentives and choices regarding productive activities undertaken by households and the parents' decisions impacting on the health of their children, for example through its effect on income, education, and time dedicated to care. Lastly, it changes the level, accessibility or relative prices of factors in the production function for child health, i.e. dietary intake, care, and the health environment and services. This may have a significant impact in many developing countries that generally start from a low level with respect to most health inputs, such that the size of the response in child health to changes in the inputs can be expected to be large (Currie, 2000). From this general reasoning outlined above, we expect that trade eventually affects outcomes such as child health and mortality. In the following, the potential linkages between trade and child health will be described in more detail.

#### (a) Trade and child's dietary intake

An important link between child health and trade may work through the *food security* transmission channel, which also directly affects child's dietary intake. To understand how trade policy may affect child's health status through its effect on dietary intake, some important linkages between trade and household food security will be discussed in the following.<sup>131</sup> To understand the potential effects of trade on child's dietary intake, we briefly repeat how trade affects the different dimensions of food security (see again chapter 1).

Trade may affect all of the different dimensions of food security. International trade can link production and consumption of food and allows food to flow from countries with abundant food supplies to ones with insufficient supplies, thereby stabilizing national food supplies (see Runge et al., 2003). Moreover, participation in the export market may induce spillovers for domestic food production, related for example to a general improvement of input and

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<sup>131</sup> Note that our discussion of potential links is only exemplarily and is not meant to be comprehensive. For a complete conceptualization and discussion of the potential linkages between trade and food security, see FAO (2000, 2003).

service delivery to agriculture and infrastructure development. International trade also impacts on the access dimension of food security via its effect on prices, economic growth, infrastructure investment, household incomes and employment, thereby contributing to a more efficient domestic agriculture and food production. Consuming households should additionally benefit from lower food prices following a reduction in trade barriers. Trade may then lead to a higher and more stable domestic food supply, make available a greater variety of foods, and increase food access, which will contribute to better nutrition.

The expected gains from trade are, however, not guaranteed and trade liberalization may even have adverse effects. For example, high dependence on just a few export commodities to generate the foreign exchange necessary to finance food imports may leave some countries vulnerable to changing market conditions. Besides that, opening up the economy for trade may involve short-term adjustment costs, for example, unemployment costs in import-competing sectors, and the availability of cheap imports can make it unprofitable for some of the less efficient domestic producers to keep on producing food for local markets (see FAO, 2003). Trade may then lead to a decrease in domestic food supply, food supply stability, and access to food, which could adversely affect household food security and child's dietary intake.

#### (b) Trade and care for mothers and children

Trade affects child health not only through the food security link, but may more generally influence the choices regarding productive activities undertaken by households and affect the utilization of potential resources and how these are translated into resources for care and the health environment and services (see Hoddinott et al., 2012). In general, as has been described above, the parents' decisions impacting on the health of their children as well as the accessibility or relative prices of factors in the production function for health (including for care) are affected by trade openness. Deaton (2004) emphasizes that closer integration with the world facilitates the transmission of health-related knowledge. Furthermore, trade openness can bring about new employment opportunities as well as increases in wages and returns to education (Oostendorp & Doan, 2013). Confirming this, Schultz (2006) finds that opening up the economy for trade is associated with improvements in women's employment opportunities and consequently leads to a greater accumulation of human capital and to

increased gender equality. Related to this, though not uncontroversial (see e.g. Rodríguez & Rodrik, 2000; Yanikkaya, 2003), trade openness accelerates the accumulation of human and physical capital and raises economic growth, thereby increasing household and national income (Frankel & Romer, 1999; Wacziarg & Welch, 2008). Taken together, increased incomes and better education combined with a better status of women in the society, accompanied by greater control over the allocation of resources within the household should then positively affect the quality of care that mothers dedicate to themselves and their children. On the other hand, if increased employment of women (in case they are mothers), leads to less time dedicated to care, it may adversely affect child's health status. For example, Paolisso et al. (2002) find that cash crop adoption in rural Nepal partly detracted parents, who spent more time in cultivation activities, from sufficient child care provision. If the positive effects outweigh the negative remains an empirical question.

#### (c) Trade and the health environment quality

Trade also affects child's health status through its effect on the health environment and the availability of healthcare services, which may be the most important link between trade and health. First, higher incomes promote better health, such that economic integration and trade-induced poverty reductions, amongst others leading to increased access to improved water and sanitation, can be a powerful force for improvements in population health (see Pritchett & Summers, 1996; Dollar, 2001). Besides that, trade facilitates the international transmission of health-related ideas and practices, new knowledge and technologies, leading to an accumulation of health-relevant knowledge, for example knowledge about appropriate treatments for disease and good health practices, as well as better access to new medical technologies (see e.g. Deaton, 2004). Related to that, opening up the economy, for example by reducing tariffs, can be accompanied by increased trade and transfers of medical supplies and drugs, for example vaccines, medical treatments, pharmaceuticals, as well as better sanitation and water facilities, which are important for child health (Owen & Wu, 2007). In line with this, Papageorgiou et al. (2007) show that technology diffusion through medical exports is an important contributor to health outcomes. Accordingly, Cutler et al. (2006) argue that a great part of the decline in mortality in developing countries after World War II happened because health-improving measures developed in richer countries, such as improvements in water supply, the use of antibiotics and the widespread immunization of

children, were transmitted to the rest of the world very quickly. Lastly, openness to trade can be associated with sound economic policies and impact positively on the quality of institutions (see e.g. Rodrik et al., 2004, and Acemoglu & Robinson, 2006) that themselves may create a policy environment that is conducive to improved health, for example the development of healthcare systems and better access to health services for the poor. Cornia (2001) argues that the positive health effects associated with globalization may be dependent on domestic conditions in terms of human development and physical infrastructure as well as on complementary policies, for example, the creation of democratic institutions that ensure that markets are non-exclusionary and safety nets in place.

On the negative side, child health may deteriorate if increased trade is associated with a deterioration of environmental quality that causes subsequent decreases in health (see e.g. Grossman & Krueger, 1991). Briggs (2003) estimates that about 8 to 9 percent of the global burden of disease may be attributed to environmental pollution.<sup>132</sup> Similarly, health may decrease as a result of trade openness if economic integration facilitates the transfer of infectious disease or unhealthy consumer goods and practices across borders (Owen & Wu, 2007; Deaton, 2004). Besides that, if tariff reductions lead to decreasing government revenues, this may adversely affect public expenditure on health.

As has become apparent from the above discussion, trade exerts substantial impacts on the determining factors of child health, whereas the direction of impact cannot be stated *a priori*, which strongly calls for empirical analysis to assess whether the *long-run* net effect is positive or negative.

### **3. DATA AND ESTIMATION STRATEGY**

#### **(a) Data**

To perform the estimations, we compiled a balanced cross-country and time-series data panel consisting of 66 countries over the period 1960-2013, for which a complete annual data series on trade and child mortality was available. The country sample includes countries

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<sup>132</sup> However, more recent empirical analyses suggest that the net effect of trade on environmental quality tends to be positive, which can to some extent be attributed to better transmission of environmentally-friendly technologies (see Frankel & Rose, 2005; Antweiler et al., 2001).

from the following regions: East Asia & Pacific, Europe & Central Asia, Latin America & the Caribbean, Middle East & North Africa, North America South Asia, and Sub-Saharan Africa (see Table A.1 in the appendix for a list of these countries). During the considered period, a substantial increase in trade openness has taken place in many of these countries, while in most countries significant reductions in child mortality have been observed. We use the under-five mortality rate (per 1,000 live births) as an indicator of child health (*CH* hereafter). The under-five mortality rate represents the probability per 1,000 that a newborn baby will die before reaching the age of five (World Development Indicators (WDI)). Data comes from WDI, based on estimates developed by the UN Inter-agency Group for Child Mortality Estimation (UNICEF, WHO, World Bank, UN DESA Population Division) using nationally representative data.<sup>133</sup> The under-five mortality rate is a key indicator of child's health status and varies considerably across countries and over time (UNICEF et al., 2014). As can be seen in Figure 2, which plots the under-five mortality rate (log) for the whole period ranging from 1960 to 2013, child mortality decreased in all of the sample countries over that period. However, many developing countries, especially Sub-Saharan African and South Asian countries, are still characterized by high under-five mortality rates. The data on trade openness (*TO* hereafter), measured as the sum of exports and imports of goods and services as a share of gross domestic product, also come from WDI. This revealed openness measure is the measure usually employed in impact studies of trade.<sup>134</sup> As can be seen in Figure 3, which plots the trade-to-GDP ratio (log) for the whole period ranging from 1960 to 2013, a positive trend in trade openness is evident for most of the sample countries over that period.

Given that we are interested in the identification of the long-run effect of trade on child health and that the employed cointegration methods are based on large T asymptotics, we compiled a data set spanning the longest period available. Besides that, the employed estimators are mainly designed for balanced panels. Therefore, we constructed a balanced panel and only included those countries for which complete time-series data on the trade-to-GDP ratio and the under-five mortality rate for the period 1960 to 2013 was available. We

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<sup>133</sup> Data and further descriptions of the estimation method for child mortality can be found at <http://www.childmortality.org>.

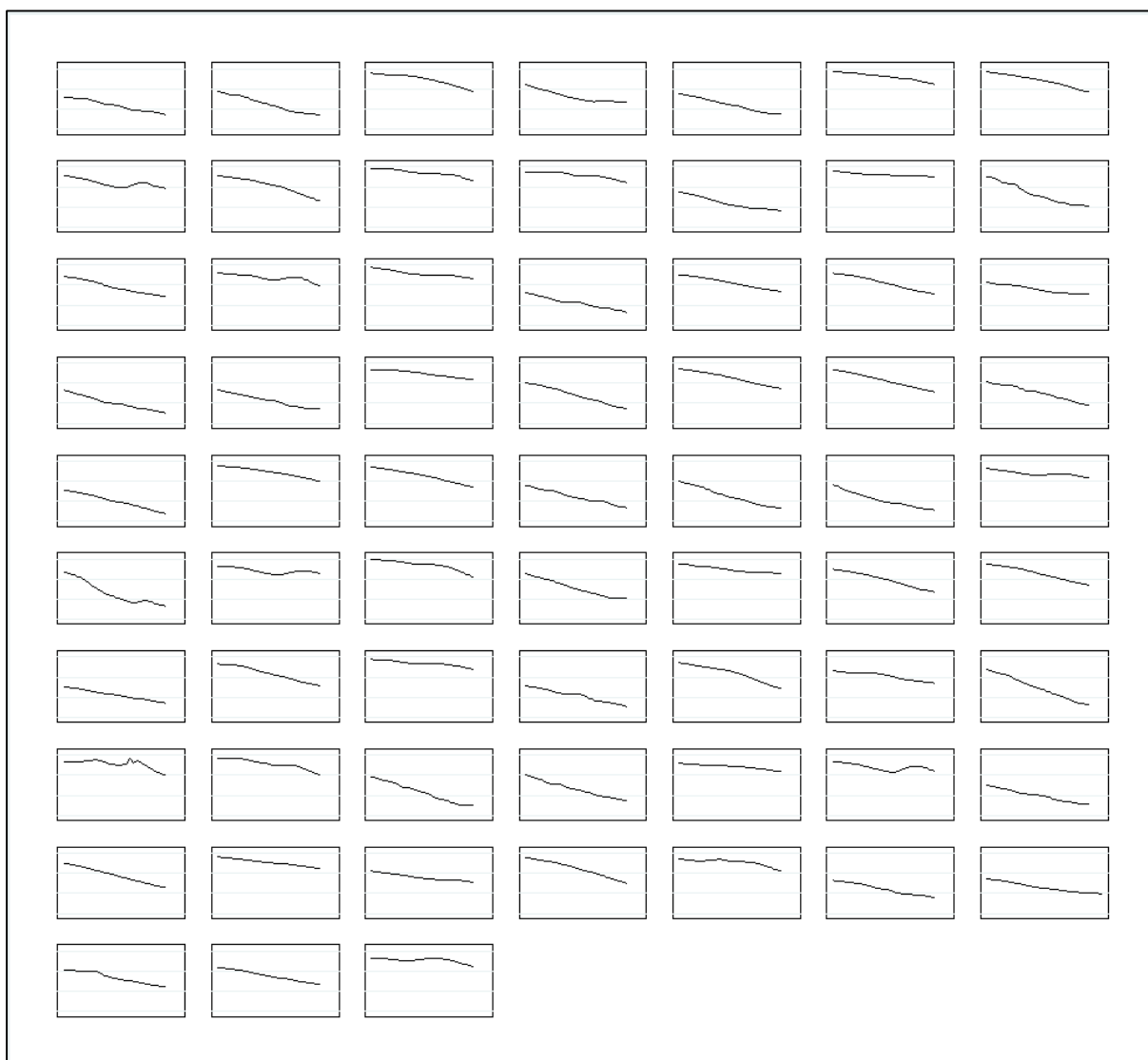
<sup>134</sup> Among others, see: Dollar, 1992; Dollar & Kraay, 2004; Chang et al., 2009; Loayza et al., 2012. Nevertheless, in the robustness section of the chapter, we assess the sensitivity of the results with regard to alternative trade openness measures.

ended up with a sample of 66 countries over the period 1960-2013, yielding 54 observations per country and a total of 3564 observations.<sup>135</sup> As panel cointegration techniques exploit both the time-series *and* the cross-sectional dimensions of the data, a period of 54 years should suffice for their implementation. Indeed, most cointegration studies are based on much shorter periods (Herzer, 2013).

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<sup>135</sup> See Table A.2 in the appendix, for the summary statistics of the variables employed.

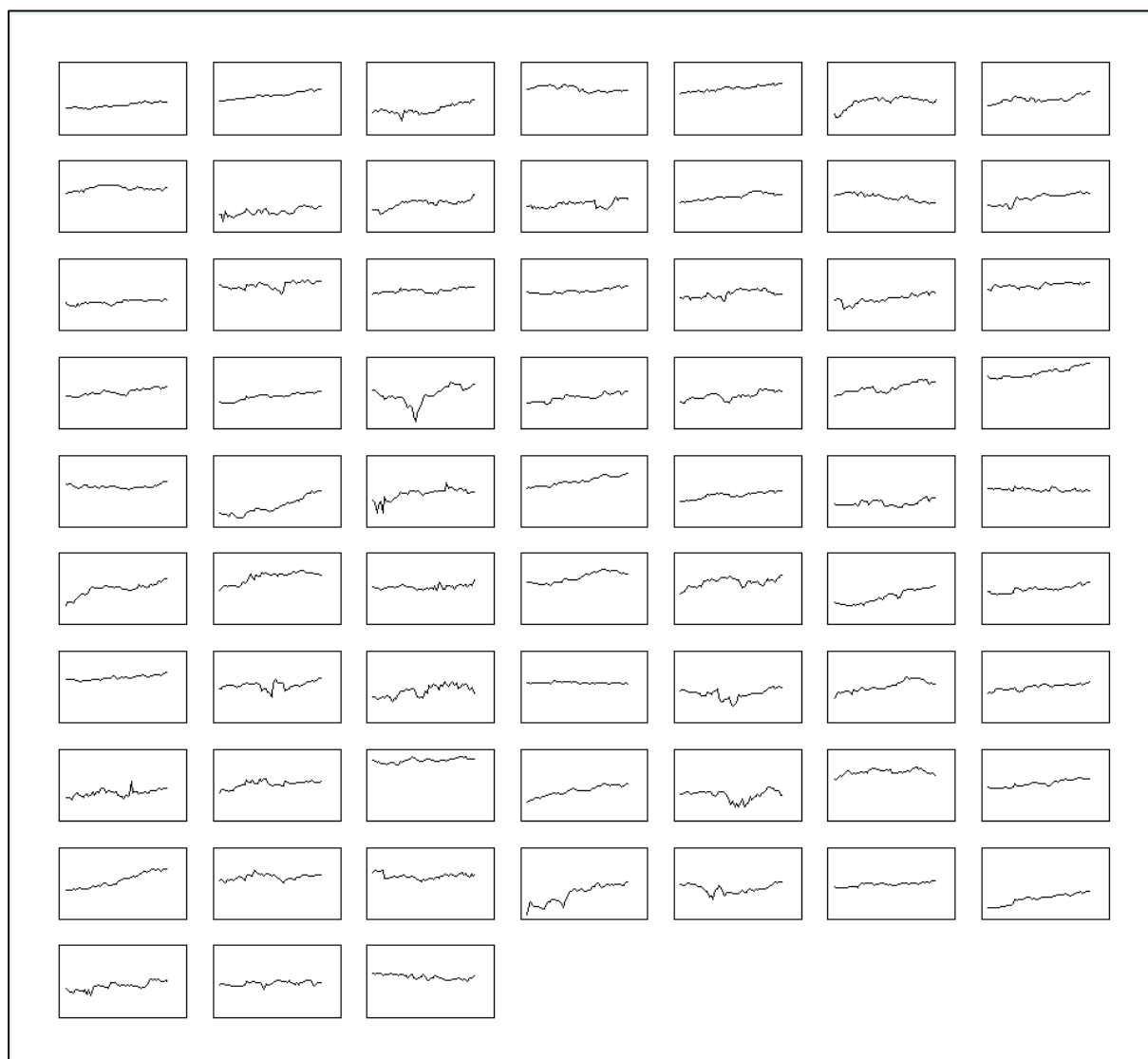
**Figure 2:** Under-five mortality rate (log) over the period 1960-2013



**Notes:** Countries from left to right are: Australia, Austria, Bangladesh, Barbados, Belgium, Benin, Bolivia, Botswana, Brazil, Burkina Faso, Burundi, Canada, Central African Republic, Chile, Colombia, Congo, Rep., Cote d'Ivoire, Denmark, Dominican Republic, Ecuador, Fiji, Finland, France, Ghana, Greece, Guatemala, Honduras, Hungary, Iceland, India, Indonesia, Ireland, Italy, Japan, Kenya, Korea, Rep., Lesotho, Malawi, Malaysia, Mauritania, Mexico, Morocco, Netherlands, Nicaragua, Nigeria, Norway, Peru, Philippines, Portugal, Rwanda, Senegal, Singapore, Spain, Sudan, Swaziland, Sweden, Thailand, Togo, Trinidad and Tobago, Turkey, Uganda, United Kingdom, United States, Uruguay, Venezuela, Zambia.



**Figure 3:** Trade-to-GDP ratio (log) over the period 1960-2013



**Notes:** Countries from left to right are: Australia, Austria, Bangladesh, Barbados, Belgium, Benin, Bolivia, Botswana, Brazil, Burkina Faso, Burundi, Canada, Central African Republic, Chile, Colombia, Congo, Rep., Cote d'Ivoire, Denmark, Dominican Republic, Ecuador, Fiji, Finland, France, Ghana, Greece, Guatemala, Honduras, Hungary, Iceland, India, Indonesia, Ireland, Italy, Japan, Kenya, Korea, Rep., Lesotho, Malawi, Malaysia, Mauritania, Mexico, Morocco, Netherlands, Nicaragua, Nigeria, Norway, Peru, Philippines, Portugal, Rwanda, Senegal, Singapore, Spain, Sudan, Swaziland, Sweden, Thailand, Togo, Trinidad and Tobago, Turkey, Uganda, United Kingdom, United States, Uruguay, Venezuela, Zambia.

## (b) Empirical specification and estimation strategy

As noted earlier, following common practice in panel cointegration studies, we employ a parsimonious model and include only trade openness (TO) and child health (CH) in our empirical model specification. Thus, the baseline model to estimate the long-run effect of trade on health can be represented as follows, where both variables are log-transformed:

$$CH_{it} = \alpha_i + \beta TO_{it} + \varepsilon_{it} \quad (1)$$

with  $i = 1, \dots, N; t = 1, \dots, T$ ,

where the subscripts  $i$  and  $t$  represent country and time periods, respectively.  $CH$  denotes child health and is represented by the under-five mortality rate and  $TO$  denotes trade openness measured as the trade-to-GDP ratio. The coefficient  $\beta$  can be interpreted as the long-run elasticity of under-five mortality with respect to trade openness, indicating the percentage change in mortality due to a one percent change in the trade-to-GDP ratio. Finally,  $\alpha_i$  denotes country-specific intercepts, while  $\varepsilon_{it}$  is the stochastic error term.

Before coming to the estimations, it behooves us to discuss some of the challenges in estimating equation (1) consistently, some of which relate to the time-series properties of the variables of interest. First, we have to recognize that both variables, the under-five mortality rate and the trade-to-GDP ratio exhibit trends over the long time period considered here. The mortality rate is trending downwards while trade openness is trending upwards in most of the countries captured in the analysis. This indicates that both series may be non-stationary, leading to spurious regression in the sense of Granger & Newbold (1974), if the two variables are not cointegrated. Therefore, as a starting point of the analysis, we test for non-stationarity of the variables employing recently developed panel unit root tests. These tests and results will be presented in the next section.

If the variables are found to be non-stationary or, more specifically, integrated of the same order, we can test the variables for cointegration employing panel cointegration tests. Two variables are cointegrated if they share a common stochastic trend, meaning that there is a long-run relationship between them. This implies that the linear combination of two integrated variables must be stationary (Engle & Granger, 1987). In the case  $CH$  and  $TO$  are both integrated of the same order and cointegrated, the parameter estimates are said to be

superconsistent, meaning that the coefficient estimates are consistent and converge to the true parameter values at a faster rate than in standard regressions with stationary variables (Stock, 1987). Therefore, we get estimates for the trade effect on child health that are more accurate under cointegration than what would be possible with conventional methods (see Herzer, 2013). This property of superconsistency does hold even in the presence of temporal or contemporaneous correlation between the (stationary) error term and the explanatory variable(s), implying that the cointegration estimates are not biased due to omitted stationary variables (see Stock, 1987, and Bonham & Cohen, 2001). The fact that a regression of two cointegrated variables has a stationary error term further implies that no relevant non-stationary variables are omitted from equation (1). This is because any omitted non-stationary variables that form part of the cointegrating relationship between trade and child health would enter the error term, leading to non-stationary residuals and a failure to detect cointegration (see Everaert, 2011, and Chintrakarn & Herzer, 2012).

A further advantage of finding cointegration is that cointegration relationships are invariant to model extensions (see e.g. Lütkepohl, 2007), justifying our bivariate model specification. This means that if we are able to confirm cointegration between trade and child health, this relationship also exists in an extended variable space, implying that no additional variables are required to obtain unbiased estimates of the long-run effect of trade on child health (see Herzer, 2013). The estimates of the bivariate cointegration equation will be asymptotically efficient, even if other cointegration relationships are ignored (see Phillips, 1991, and Carporale & Pittis, 1999).

In order to estimate the long-run effect of trade on child health, we employ the group-mean panel-dynamic ordinary least-squares estimator (PDOLS) of Pedroni (2001) that corrects for serial correlation, the potential endogeneity of trade and cross-country heterogeneity. In this case, the coefficient  $\beta$  of equation (1) represents the cross-country average of the individual country effects of trade on child health. It involves estimating separate time-series regressions for each country and then averaging the individual coefficients (as will be described in more detail in the next section).

A final issue that requires attention is that of potential cross-sectional dependence among the variables that may affect the results. Cross-section dependence may arise from various sources, for example common business cycles or global demand shocks in the case of trade or common health shocks in the case of child health. Examples of such shocks that affect child health in several countries at the same time may include major influenza epidemics, the introduction of new vaccines or the diffusion of antibiotics (Leigh et al., 2009). Thus, if variables strongly co-move across countries, this can be an indication of cross-section dependence. As standard panel unit root and cointegration tests can lead to wrong inference in the presence of cross-section dependence, we apply recently introduced tests that account for this issue.

#### **4. EMPIRICAL RESULTS**

In this section, we present the results for the cross-section dependence (CD) test, the panel unit root and cointegration tests as well as the PDOLS estimation results for the long-run effect of trade on child health. In addition, we perform various robustness checks and provide some additional insights into the trade-child health nexus.

##### **(a) Cross-section dependence**

Cross-section dependence in macro-level panel data analysis has received a lot of attention over the past decade. As has been described above, this type of cross-section correlation may arise from local spillover effects between countries or regions or from unobserved common shocks that become part of the error term (see Eberhardt & Teal (2011) for a survey). In many empirical analyses using panel data, it is thus inappropriate to assume that cross-section members are independent, in particular in the analysis of macroeconomic data that have strong inter-economy linkages (Breitung & Pesaran, 2008; Urbain & Westerlund, 2006). As the focus in this study is on the impact of trade openness on child health and trade integration implies increasing interdependencies between countries, it would be unreasonable to assume error cross-section independence.

Accordingly, we test the data for cross-sectional independence using the CD test proposed by Pesaran (2004). This test is particularly suited for the analysis, as it is applicable to a variety of panel data models, including homogeneous/heterogeneous dynamic and non-

stationary models (see Pesaran, 2004). Moscone & Tosetti (2009) show that the Pesaran (2004) CD test works well in large and small panels where  $N > T$ , as is the case here. The CD test tests the null hypothesis of cross-section independence across all panel members. Rejecting the null hypothesis would serve as an indication that there is error cross-section dependence that needs to be taken into account. The CD test is based on all pair-wise correlations of the ordinary least squares (OLS) residuals from the individual regressions in the panel data model, in our case:

$$CH_{it} = \alpha_i + \beta_i TO_{it} + u_{it} \quad (2)$$

with  $i = 1, \dots, N; t = 1, \dots, T$ ,

where the intercepts,  $\alpha_i$ , and the slope coefficients,  $\beta_i$ , are allowed to vary across the panel members. Under the null hypothesis,  $u_{i,t}$  is assumed to be independent and identically distributed (i.i.d.) over periods and across cross-sectional units, whereas under the alternative, it may be correlated across cross-sections. Thus, we test

$$H_0: \rho_{ij} = \rho_{ji} = \text{cor}(u_{i,t}, u_{j,t}) = 0 \text{ for } i \neq j \quad (3)$$

versus

$$H_1: \rho_{ij} = \rho_{ji} \neq 0 \text{ for some } i \neq j, \quad (4)$$

where  $\rho_{ij}$  is the product moment correlation coefficient of the errors and is given by

$$\rho_{ij} = \rho_{ji} = \frac{\sum_{t=1}^T u_{it} u_{jt}}{(\sum_{t=1}^T u_{it}^2)^{\frac{1}{2}} (\sum_{t=1}^T u_{jt}^2)^{\frac{1}{2}}} \quad (5)$$

The CD test statistic is defined as

$$CD = \sqrt{\frac{2T}{N(N-1)}} (\sum_{i=1}^{N-1} \sum_{j=i+1}^N \widehat{\rho}_{ij}) \rightarrow N(0, 1), \quad (6)$$

where  $\widehat{\rho}_{ij}$  is the sample estimate of the pair-wise correlation of the OLS residuals as given by (4). Pesaran (2004) shows that the CD test statistic is normally distributed under the null hypothesis of no cross-sectional dependence. Equation (6) reveals that the CD test is based

on the average of pair-wise correlation coefficients of the OLS residuals coming from the individual regressions in the panel (de Hoyos & Sarafidis, 2006).

We proceed with the following two steps to perform the CD test for our time-series panel data model. First, we compute the residuals from the heterogeneous parameter model (2) using the Pesaran & Smith (1995) Mean Group (MG) estimator including an intercept to capture fixed effects and a country-specific linear trend to capture time-invariant unobservables.<sup>136</sup> Second, we test the residuals for cross-section independence using the CD test as described above. The CD test results are presented in Table 2.

**Table 2:** Pesaran (2004) test for cross-section dependence

Variable	CD-test	p-value	corr	abs(corr)
MG_residual	13.72	0.000	0.040	0.391

**Note:** Under the null hypothesis of cross-section independence  $CD \sim N(0,1)$

The null hypothesis of cross-section independence can be clearly rejected, indicating that child health and trade openness are highly dependent across countries. The average absolute correlation of the residuals is 0.391, providing further evidence suggesting the presence of cross-sectional dependence. This finding underlines the importance of taking into account cross-section dependence when analyzing the trade-child health nexus and has important implications for the panel unit root and cointegration analysis.

#### (b) Panel unit root tests

Second, we examine the time-series properties of the data and present the estimation results for the panel unit root tests (PURT), which test for non-stationarity of both the under-five mortality rate and the trade-to-GDP ratio for the considered panel over the period 1960-2013. The “first-generation” PURTs have been developed on the assumption of cross-section independence. However, variants of these tests allow for a limited degree of cross-sectional dependence by subtracting cross-sectional means (see Levin, Lin & Chu, 2002). We use the

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<sup>136</sup> See Pesaran & Smith (1995) for a detailed description of this estimator. We use the MG estimator as it is specifically designed for non-stationary variables and allows for heterogeneous slope coefficients across group members, such that it is particularly useful for estimating equation (2). Note, however, that applying the CD test to the residuals from a FE model (see e.g. de Hoyos & Sarafidis, 2006), which does not allow for heterogeneous slope coefficients, led to the same conclusions.

panel unit root test of Im, Pesaran, & Shin (2003) (IPS, hereafter), which is one of the most widely employed PURTs in empirical analyses. It has good finite sample properties and is less restrictive compared to other PURTs such as the Levin, Lin, and Chu (2002) (LLC) test, as it allows for autoregressive coefficients that are heterogeneous across panel units, i.e. heterogeneous short-run dynamics. The results of the LLC test, which assumes that the autoregressive parameter is identical for all cross-section units (i.e. homogenous short-run dynamics), can be misleading in case this assumption is violated (see Breitung & Pesaran, 2008).

The IPS test tests the null hypothesis that all of the individuals of the panel (in our case 66 countries) have a unit root against the alternative hypothesis that some fractions are stationary, and is based on the following augmented Dickey Fuller (ADF) – type regression for each cross-section unit  $i$ :

$$\Delta x_{it} = \gamma_i z_{it} + \rho_i x_{it-1} + \sum_{j=1}^{k_i} \varphi_{ij} \Delta x_{it-j} + \varepsilon_{it} \quad (7)$$

, where  $k_i$  is the lag order and  $z_{it}$  represents deterministic trends such as a constant or a constant combined with an individual time trend and  $x_{it}$  stands for  $CH$  (or  $TO$ ). The IPS tests the null hypothesis of a unit root for all  $i$ , i.e.

$$H_0: \rho_i = 0, \quad i = 1, \dots, N \quad (8)$$

against the alternative that

$$H_1: \rho_i < 0, \quad i = 1, \dots, N_1; \quad \rho_i = 0, \quad i = N_1 + 1, \dots, N, \quad (9)$$

i.e. that some fractions of the panel are stationary, using the standardized t-bar or IPS statistic

$$IPS = \Gamma_{\bar{t}} = \frac{\sqrt{N}[\bar{t}_{NT} - \mu]}{\sqrt{v}}, \quad (10)$$

where  $\bar{t}_{NT}$  is the average of the  $N$  (=66) cross-sectional ADF  $t$ -statistics from equation (7) and  $\mu$  and  $v$  are the mean and variance of the average of the individual  $t$ -statistics, tabulated in Im, Pesaran, & Shin (2003). The IPS statistic is standard normally distributed under  $H_0$  (see Baltagi & Moscone, 2010).

To identify the order of integration of the under-five mortality rate and the trade-to-GDP ratio, we apply the IPS test to the variables in levels and in first differences. As the series in levels show a trending behavior (see Figures 2 and 3), we include a country-specific time trend in this case. If the IPS test is unable to reject the null of non-stationarity for the variables in levels and rejects the unit-root hypothesis for the first differenced variables, we can conclude that the variables are integrated of order 1, i.e.  $I(1)$  and proceed with the cointegration test. The results are presented in Table 3 for both the original variables in levels and first differences as well as for the cross-sectionally demeaned data, which has been suggested to mitigate the impact of cross-section dependence.

**Table 3:** IPS (2003) Panel unit root test

Variables	Deterministic terms	IPS statistic (2 lags)	IPS statistic (3 lags)
Levels			
<i>CH</i>	Constant, trend	-2.7956***	2.0406
<i>TO</i>	Constant, trend	-0.7702	-0.4359
<i>CH (demeaned)</i>	Constant, trend	-2.4163***	-0.2882
<i>TO (demeaned)</i>	Constant, trend	-1.4024	-1.5891
First differences			
$\Delta CH$	Constant	-8.2270***	-8.3141***
$\Delta TO$	Constant	-27.7781***	-21.1438***
$\Delta CH$ (demeaned)	Constant	-4.9153***	-7.9314***
$\Delta TO$ (demeaned)	Constant	-26.1190***	-20.7868***

**Note:** The IPS statistic is distributed as  $N(0, 1)$ . A constant and trend are included for the variables in levels, and only a constant for the variables in first differences. "Demeaned" denotes that cross-section means have been subtracted to mitigate the impact of cross-section dependence. For comparison, we show the results when two or three lags, respectively, are selected to adjust for autocorrelation in the ADF regressions. \*\*\* Significance at the 1% level.

The IPS test fails to reject the unit root null hypothesis in levels for both the under-five mortality rate and the trade-to-GDP ratio when three lags are included to adjust for autocorrelation in the ADF regressions, but rejects the null for the under-five mortality rate if only two lags are included in the ADF regressions. In case of the first-differenced variables,



the IPS test strongly rejects the null of non-stationarity in all of the cases. Therefore, we get somewhat mixed results for the under-five mortality rate, regardless of using the original data or the transformed data after subtracting cross-sectional means. This may be due to two reasons. First, including only two lags does not suffice to adjust for autocorrelation in the ADF regressions or second, subtracting cross-sectional means does not suffice to account for the presence of cross-section dependence, which is a major issue to be considered in our analysis as has been indicated in the last section.

The IPS test allows only for a limited degree of cross-sectional dependence by subtracting cross-sectional means as suggested by Levin, Lin & Chu (2002). However, Strauss & Yigit (2003) show that demeaning across the panel units does not usually eliminate cross-sectional dependence. Thus, if other forms of cross-section dependence are present in the data, these kind of tests can have low power and exhibit substantial size distortions (see e.g. Breitung & Pesaran, 2008). For example, Moscone & Tosetti (2009) examine global correlations in health expenditures across countries and find evidence for spatial correlations between health expenditure levels, which cannot be accounted for via demeaning.

Thus, while the first-generation PURT tests can account for cross-sectional dependence only to a very limited degree, recently developed “second-generation” tests allow for cross-section dependence in a variety of forms and degrees and attempt to overcome the deficiencies of demeaning. A commonly used second-generation PURT is the cross-sectionally augmented IPS (CIPS) test proposed by Pesaran (2007), which allows for cross-section dependencies arising from multiple unobserved factors. The CIPS test allows for cross-section dependence by augmenting the ADF regression (eq. 7) with the cross-section averages of lagged levels and first differences of the individual series. Thus, the CIPS test is based on the cross-sectionally augmented ADF (CADF) regression, which is given by

$$\Delta x_{it} = \gamma_i z_{it} + \rho_i x_{it-1} + \sum_{j=1}^{k_i} \varphi_{ij} \Delta x_{it-j} + \alpha_i \bar{x}_{t-1} + \sum_{j=0}^{k_i} \eta_{ij} \Delta \bar{x}_{t-j} + v_{it} , \quad (11)$$

where  $\bar{x}_t$  is the cross-section mean of  $x_{it}$ , in our case the averages of *CH* and *TO*, respectively, for the sample countries (i.e. the respective variables averaged over the sample countries), and  $\Delta \bar{x}_t$  is the cross-section average of  $\Delta x_{it}$ . which is the differenced value of *CH*

and  $TO$ . The null hypothesis is equivalent to that of the IPS test, i.e. the CIPS test tests the null that each series contains a unit root against the alternative that at least one of the individual series is stationary. Accordingly, the CIPS statistic is the simple average of the individual CADF statistics and is given by

$$CIPS = \frac{1}{N} \sum_{i=1}^{N_i} t_i, \quad (12)$$

where  $t_i$  is the ordinary least squares  $t$ -ratio of the autoregressive coefficient  $\rho_i$  in equation (11). The asymptotic distribution of the CIPS statistic is non-standard and critical values for different values of both  $N$  and  $T$  are tabulated in Tables II (a)-(c) in Pesaran (2007). Baltagi (2008) shows that the CIPS test, which explicitly allows for cross-sectional dependence, performs better in testing the null hypothesis of non-stationarity in the presence of cross-sectional dependence compared to the simpler IPS and other first-generation PURTs. Besides that, simulations by Gengenbach, Palm & Urbain (2004) show that in general, the CIPS test has the best size properties compared to several other second-generation Panel Unit Root Tests. Interestingly, while the CIPS test has been designed for testing the unit root hypothesis when the variable under study has a factor structure, Monte Carlo experiments of Baltagi et al. (2007) reveal that this test is robust also in the presence of other sources of cross-section dependence such as spatial correlations. The results are displayed in Table 4 for both the original variables in levels and first differences, including two or three lags to account for autocorrelation in the ADF regressions.

**Table 4:** CIPS (Pesaran, 2007) panel unit root test

Variables	Deterministic terms	CIPS statistic (2 lags)	CIPS statistic (3 lags)
Levels			
<i>CH</i>	Constant, trend	1.210	5.044
<i>TO</i>	Constant, trend	0.404	-0.438
First differences			
$\Delta CH$	Constant	-3.401***	-3.250***
$\Delta TO$	Constant	-3.987***	-3.419***

**Note:** The CIPS test refers to the cross-sectionally augmented IPS test (Pesaran, 2007) and is based on the cross-sectionally augmented ADF (CADF) regression. A constant and trend are included for the variables in levels, and only a constant for the variables in first differences. The relevant five- (one-) percent critical value for the CIPS statistic is -2.58 (-2.68) with an intercept and a linear time trend, and -2.10 (-2.20) with an intercept only. For comparison, we show the results when two or three lags, respectively, are selected to adjust for autocorrelation in the ADF regressions. \*\*\* Significance at the 1% level.

In this case, the results are unambiguous and the CIPS test fails to reject the unit root null hypothesis in levels for both the under-five mortality rate and the trade-to-GDP ratio in all cases, no matter how many lags are included to adjust for autocorrelation in the ADF regressions. Therefore, we can conclude that both variables are non-stationary in levels. Since the unit-root hypothesis can be rejected for the first-differenced variables, it can be concluded that the two variables are integrated of the same order, i.e.  $I(1)$ , which is the necessary condition for cointegration in a bivariate context. This finding also shows the importance of adequately accounting for the existence of cross-sectional dependency relations when testing for unit roots in a panel context. Given the above findings, we will proceed with the panel cointegration analysis and test if the two integrated series are also cointegrated, which is the necessary condition for a long-run relationship between trade and child health.

### (c) Panel cointegration tests

Since the panel unit root tests indicate that the variables are both integrated of order one, we employ the heterogeneous panel cointegration tests advanced by Pedroni (1999, 2004) to test for cointegration between trade and child health. These residual-based tests allow for endogenous regressors as well as for parameter heterogeneity in the panel, including heterogeneity in the long-run cointegrating vectors and the dynamics, by permitting

heterogeneous slope coefficients, fixed effects and individual specific time trends (Neal, 2014). This is an advantage over homogenous panel cointegration tests, because it is unrealistic to assume that the cointegrating vectors are identical across all members of the panel (see Pedroni, 2004). This is an important issue to consider here, as the long-run relationship between trade and child health will most likely be country-specific and contingent on country-specific factors such as the ability of a country to adopt foreign technologies and the ability of a country's population to acquire and process transferred health-relevant knowledge. Therefore, the benefits from trade with respect to child health will be country-specific and, consequently, the long-run effect of trade on health cannot be expected to be the same for all countries. These tests are essentially an extension of the Engle & Granger (1987) two-step (time-series) cointegration tests applied to panel data, where we first estimate the hypothesized cointegrating relationship and in the second step, test the residuals from this regression for stationarity. In our case, in the first step, we estimate

$$CH_{it} = \alpha_i + \delta_i t + \beta_i TO_{it} + \varepsilon_{it} , \quad (13)$$

where the parameters  $\alpha_i$  and  $\delta_i$  capture country-specific effects and deterministic time trends and  $\varepsilon_{it}$  denotes the estimated residuals that represent deviations from the long-run relationship. In the second step, we test the residuals from above for stationarity based on the following equation:

$$\hat{\varepsilon}_{it} = \rho_i \hat{\varepsilon}_{it-1} + \sum_{k=1}^K \varphi_{ij} \Delta \hat{\varepsilon}_{it-j} + \vartheta_{it} , \quad (14)$$

where  $k=1, \dots, K$  is the number of lags included in the ADF regressions. Pedroni (1999, 2004) provides seven test statistics to test the null hypothesis of no cointegration, i.e.  $H_0: \rho_i = 1$ , which differ with respect to the alternative hypothesis. These tests can be classified as either “within”-dimension (*panel*) or “between” dimension (*group mean*) tests, which are all based on the residuals from Eq. (13) and are variants of the ADF and Phillips & Perron (1988) PP tests for single time-series. The basic idea of both classes of test statistics is to first estimate the cointegration relationship separately for each country of the panel and then pool the resulting residuals when constructing the cointegration test.

The first type of tests based on the within dimension approach include four statistics, the parametric variance ratio (*panel v*)-statistic, a non-parametric PP type  $\rho$ -statistic (*panel  $\rho$* ), a non-parametric PP type panel *t*-statistic (*panel PP*), and an ADF type *t*-statistic (*panel ADF*). These statistics essentially pool the autoregressive coefficients across different members of the panel for the unit root tests on the estimated residuals (i.e. along the "within-dimension"), constraining the autoregressive parameters to be homogeneous across countries, i.e.  $\rho_i = \rho$ . Therefore, the alternative hypothesis for these tests is  $H_1: \rho_i = \rho < 1$  for all  $i$ . Basically, these first type of statistics are constructed by taking the ratio of the sum of the numerators and denominators of the analogous conventional time-series statistics across the individual members of the panel (see Pedroni, 1999).<sup>137</sup>

The second class of statistics is based on pooling the residuals along the "between-dimension" and averages the individually estimated autoregressive coefficients for each member of the panel, thus allowing the autoregressive coefficients to be heterogeneous across countries. Therefore, the group-means approach is less restrictive as it does not require a common value for the unit root coefficient under the alternative hypothesis (see Herzer & Nunnenkamp, 2015). Accordingly, the alternative hypothesis for these tests is  $H_1: \rho_i < 1$  for all  $i$ . The group-mean panel cointegration statistics include three statistics: the group  $\rho$ , group PP and group ADF statistic. Basically, these are simply the group mean variants of the conventional individual time-series statistics. The standardized panel and group-mean statistics both are asymptotically normally distributed and are given by

$$K = \frac{\varphi - \mu\sqrt{N}}{\sqrt{v}} \rightarrow N(0, 1) \quad , \quad (15)$$

where  $\varphi$  is the respective panel or group mean statistic, and  $\mu$  and  $v$  are the expected mean and variance of the corresponding statistic as tabulated in Pedroni (1999).

The relative power of each test statistic is not entirely clear, however, Pedroni (1999) showed that the panel ADF and group mean ADF statistics have somewhat better small sample properties than the other statistics, and are more reliable when  $T < 100$ , which is the case here. Besides that, Harris & Sollis (2003) find that the ADF statistics perform comparatively better in case the errors follow an autoregressive process. Wagner &

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<sup>137</sup> For a detailed explanation and formal representation of the test statistics, see Pedroni (1999).

Hlouskova (2010) confirm these results and find that, amongst the single equation tests for the null hypothesis of no cointegration, the two tests of Pedroni applying the ADF principle perform best. Moreover, they find that the tests of Pedroni also outperform the system tests developed by Larsson et al. (2001) and Breitung (2005). For completeness, we report the results for all seven test statistics of the Pedroni (1999, 2004) heterogeneous panel cointegration tests in Table 5.

**Table 5:** Results for Pedroni (1999, 2004) panel cointegration tests

Test statistic	Constant	Constant & trend
Panel $\nu$ – statistic	5.246***	4.257***
Panel $\rho$ – statistic	-5.695***	-6.761***
Panel PP – statistic	-5.695***	-7.587***
Panel ADF – statistic	-4.789***	-6.326***
Group $\rho$ – statistic	-5.826***	-4.417***
Group PP – statistic	-6.813***	-6.677***
Group ADF – statistic	-6.329***	-6.211***

**Note:** Variables have been time-demeaned to capture common time effects among the panel countries. In the first column, only a constant is included while the results in the second column additionally include a linear time trend. All test statistics are distributed  $N(0,1)$  under a null of no cointegration. The number of lags used in the ADF regressions was determined by the Akaike information criterion with a maximum of three lags. \*\*\* indicates a rejection of the null hypothesis of no cointegration at the 1% level.

In Column 1 of Table 5, only a country-specific effect is included in the cointegrating relationship, while in Column 2 we additionally include a deterministic time trend. Furthermore, both variables have been time-demeaned to capture common time effects among the panel countries. The number of lags included in the ADF regressions was determined by the Akaike information criterion with a maximum of three lags. Under the alternative hypothesis, the panel  $\nu$  -statistic goes to positive infinity, while the other statistics diverge to negative infinity (Pedroni, 1999). The results reveal that in all cases the null of no cointegration is rejected at the 1% significance level, indicating that trade and child health exhibit a long-run cointegration relationship.

We take this finding as a first indication that the two series are cointegrated. One problem with the residual-based Pedroni cointegration tests is that they only allow for a limited

degree of cross-sectional dependence in the form of common time effects among panel members, for example due to common shocks or spillovers among countries at the same time. However, they cannot account for more sophisticated forms of cross-section dependence, for example correlations that differ between pairs of individual time series. Another issue with residual-based panel cointegration tests such as the one above is that they restrict the long-run elasticities to be equal to the short-run elasticities. If this restriction is invalid, these kinds of cointegration tests may suffer from low power (see, e.g. Westerlund 2007, and Solberger, 2011).

To confirm the result of cointegration between trade and child health for the panel countries, we additionally test for cointegration between the trade-to-GDP ratio and the under-five mortality rate using recently developed error-correction based cointegration tests. These tests are based on structural rather than residual dynamics and do not impose any common-factor restrictions (Westerlund, 2007). Moreover, simulation results of Westerlund (2007) show that they have high power relative to residual-based panel cointegration tests such as the ones of Pedroni (1999, 2004). The Westerlund (2007) error-correction-based tests examine whether there is error correction among the variables, allowing for a large degree of heterogeneity, both in the long-run cointegrating relationship and in the short-run dynamics, and dependence within as well as across the panel members. More specifically, they test the null hypothesis of no cointegration by inferring whether the error-correction term in a conditional panel error-correction model is equal to zero (Persyn & Westerlund, 2008). In these tests, if the null hypothesis of no error correction is rejected, the null of no cointegration is also rejected.

The four Westerlund (2007) tests are panel extensions of those proposed in the context of a single time series by Banerjee et al. (1998). Each test is able to accommodate individual-specific short-run dynamics (including serially correlated error terms), non-strictly exogenous regressors, individual-specific fixed effects and time trends, individual-specific slope parameters, and cross-sectional dependencies in the error term (Westerlund, 2007). All of the tests are based on the conditional error-correction model, in our case:

$$\Delta CH_{it} = \delta'_i d_t + \alpha_i(CH_{it-1} - \beta'_i TO_{it-1}) + \sum_{j=1}^{p_i} \alpha_{ij} \Delta CH_{it-j} + \sum_{j=0}^{p_i} \gamma_{ij} \Delta TO_{it-j} + e_{it}, \quad (16)$$

where  $d_t = (1, t)'$  holds the deterministic components (i.e. a constant or a constant and a linear time trend), and  $\alpha_i$  determines the speed at which the system reverts back to the long-run equilibrium relationship between the variables,  $CH_{it-1} - \beta_i' TO_{it-1}$ , after a sudden shock. Therefore, if  $\alpha_i < 0$ , then there is error correction, which implies that child health and trade are cointegrated, whereas if  $\alpha_i = 0$ , error correction will be absent and there is no cointegration. Westerlund (2007) follows this idea and proposes four panel cointegration tests, all testing the null hypothesis of no cointegration, i.e.  $H_0: \alpha_i = 0$  for all  $i$ .

In order to estimate the error correction parameter without having to rely on a prespecified  $\beta_i$ , equation (16) can be reparameterized as

$$\Delta CH_{it} = \delta_i' d_t + \alpha_i CH_{it-1} + \lambda_i' TO_{it-1} + \sum_{j=1}^{p_i} \alpha_{ij} \Delta CH_{it-j} + \sum_{j=0}^{p_i} \gamma_{ij} \Delta TO_{it-j} + e_{it}, \quad (17)$$

where the parameter  $\alpha_i$  is unaffected by imposing an arbitrary  $\beta_i$ , such that the least squares estimate of the error correction parameter can be used to test for cointegration, whose distribution is free of nuisance parameters (Westerlund, 2007).<sup>138</sup> The alternative hypothesis depends on what is assumed about the homogeneity of  $\alpha_i$ . The “group-mean” tests test the null of no cointegration against the alternative hypothesis that there is cointegration for at least one cross-sectional unit, i.e.  $H_0^g: \alpha_i < 0$  for at least one  $i$ . The “panel” statistics pool the information regarding the error correction along the cross-sectional dimension of the panel and test the null of no cointegration against the alternative of cointegration for the panel as a whole, i.e.  $H_0^p: \alpha_i = \alpha < 0$  for all  $i$  (see Persyn & Westerlund, 2008). All test statistics are based on the least squares estimate of  $\alpha_i$  of equation (17) and the associated  $t$ -ratio, and the asymptotic results of Westerlund (2007) reveal that the tests have limiting normal distributions. The group-mean statistics are given by

$$G_\tau = \frac{1}{N} \sum_{i=1}^N \frac{\hat{\alpha}_i}{SE(\hat{\alpha}_i)}, \quad G_\alpha = \frac{1}{N} \sum_{i=1}^N \frac{T\hat{\alpha}_i}{\hat{\alpha}_i(1)}, \quad (18)$$

where  $SE(\hat{\alpha}_i)$  is the conventional standard error of  $\hat{\alpha}_i$ , and  $\hat{\alpha}_i(1)$  is based on the usual Newey & West (1994) long-run variance estimators.<sup>139</sup> The respective panel statistics are given by

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<sup>138</sup> Nuisance parameters are regressors that do not form part of the true data generating process but could potentially introduce endogeneity and serial correlation (Pedroni, 2000, 2001).

<sup>139</sup> For a detailed explanation and formal representation of the test statistics, see Persyn & Westerlund (2008).



$$P_{\tau} = \frac{\hat{\alpha}}{SE(\hat{\alpha})}, \quad P_{\alpha} = T\hat{\alpha}, \quad (19)$$

where  $\hat{\alpha}$  is the estimated common error-correction parameter and  $SE(\hat{\alpha})$  is the corresponding standard error, revealing that for these tests  $\alpha_i$  is assumed to be equal for all  $i$ , i.e.  $\alpha_i = \alpha$ .

To account for cross-sectional dependence, we employ the bootstrap approach of Westerlund (2007), which is superior to the subtraction of cross-sectional means and makes inference possible even under very general forms of cross-section dependence (Westerlund, 2007). The bootstrap method resembles that used by Chang (2004) for unit root tests in panels with arbitrary cross-sectional dependency (Persyn & Westerlund, 2008). The bootstrapped error-correction statistics are constructed as above, but are now based on the bootstrap samples of  $CH_{it}$  and  $TO_{it}$ , letting each panel be driven by a general linear process that may be different across cross-sectional units.<sup>140</sup> Simulation results of Westerlund (2007) show that the bootstrapped tests are very effective in eliminating the effects of cross-sectional dependence, while the  $G_{\tau}$  and  $P_{\tau}$  statistics appear to be quite robust to cross-sectional correlations even without using the bootstrapped versions of the tests. The results of the Westerlund (2007) panel cointegration tests are depicted in Table 6. As the results may be sensitive to the choice of the width of the Bartlett kernel used in the semiparametric estimation of the long-run variances, we report the results using three different kernel windows. Note that Newey & West (1994) recommend to choose the bandwidth according to the rule  $4\left(\frac{T}{100}\right)^{2/9}$ , which in our case is roughly 3.

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<sup>140</sup> For more details on the bootstrap method, see Chang (2004) and Westerlund (2007).

**Table 6:** Results for Westerlund (2007) panel cointegration tests

Kernel window	Test statistic	Constant & trend (only lags)	Constant & trend (lags & leads)
2	$G_{\tau}$	-3.628*** (0.000)	-3.628*** (0.000)
	$G_{\alpha}$	-8.953*** (0.000)	-8.917*** (0.000)
	$P_{\tau}$	-27.314***(0.000)	-26.837***(0.000)
	$P_{\alpha}$	-7.688*** (0.000)	-7.270*** (0.000)
3	$G_{\tau}$	-3.628*** (0.000)	-3.753*** (0.000)
	$G_{\alpha}$	-9.695*** (0.000)	-9.646*** (0.000)
	$P_{\tau}$	-27.539***(0.000)	-27.139***(0.000)
	$P_{\alpha}$	-8.512*** (0.000)	-8.102*** (0.005)
4	$G_{\tau}$	-3.628*** (0.000)	-3.753*** (0.000)
	$G_{\alpha}$	-10.476***(0.005)	-10.394***(0.000)
	$P_{\tau}$	-27.747***(0.000)	-27.412***(0.000)
	$P_{\alpha}$	-9.347** (0.015)	-8.941*** (0.010)

**Note:** Bootstrapped p-values (based on 200 replications) in parentheses. As both series are clearly trending, a constant and a linear time trend are included in the cointegration relationship. In the first (results) column, only lags are included in the error-correction equations, while in the second column, both lags and leads are included, to relax the strict exogeneity assumption. To avoid overparametrization and the resulting loss of power, only one lag (and lead) is included in the tests. \*\*\* (\*\*) indicates a rejection of the null hypothesis of no cointegration at the 1% (5%) level.

As the results in Table 6 reveal, all test statistics strongly reject the null hypothesis of no cointegration between trade and child health, speaking in favor of a long-run cointegrating relationship between trade and child health and confirming the results of the Pedroni cointegration tests. As both series are clearly trending, a constant and a linear time trend have been included in the cointegration relationship. In the first (results) column, only lags have been included in the error-correction equations, assuming the strict exogeneity of trade. As can be seen, all test statistics reject the null hypothesis of no cointegration, regardless of the kernel window chosen. We can relax the strict exogeneity assumption of trade in the basic model by making the error correction model in equation (17) conditional not only on the lags but also on the leads of the first differenced  $TO$  variable. Westerlund (2007) shows that this procedure is generally able to appropriately correct for non-strictly exogenous regressors. In this case, we are assuming that trade is only weakly exogenous

with respect to child health. As the results show, allowing for weak exogeneity by including both lags and leads of the first differenced trade variable does not change the results, suggesting that the findings are not driven by a violation of the strict exogeneity assumption of trade with respect to child health.

Taken together with the Pedroni panel cointegration test results, which do not require any correction to account for the absence of strict exogeneity, we can conclude that the finding of cointegration between trade and child health is not driven by the potential endogeneity of trade. Overall, the panel cointegration tests indicate that the two integrated variables cointegrate, which is the necessary condition for the existence of a “non-spurious” long-run relationship between trade and child health. After confirming a cointegration relationship between the variables, the long-run parameters can be estimated. To estimate the long-run coefficients of the cointegration relationship between trade and child health, we employ the between-dimension group-mean panel dynamic OLS (PDOLS) estimator of Pedroni (2001). The results are presented in the next section.

#### (d) Estimation of the long-run parameters

We employ the PDOLS estimator of Pedroni (2001) to estimate the long-run effect of trade on child health. The PDOLS estimator is superconsistent under cointegration and robust to the omission of other potential explanatory variables that do not form part of the cointegrating relationship (Herzer, 2013). It further has the advantage that it accounts for both the possible endogeneity of trade and cross-country heterogeneity in the effects of trade on child health. Therefore, it overcomes the problem of assuming a homogeneous long-run coefficient across countries as is the case for the within-dimension approach, but allows for heterogeneous slope coefficients in the estimation of the long-run relationship between trade and child health. This means that the slope coefficients (see  $\beta_i$  in eq. 20) are allowed to differ across cross-section units, i.e. the long-run effect of trade on health is assumed to be not homogenous but heterogeneous, which is a significant advantage of the PDOLS estimator. Besides that, the between-dimension estimators suffer from much lower small sample size distortions compared to the within-dimension estimators. The PDOLS estimator involves estimating separate country-specific DOLS regressions and averaging the

individual coefficients, such that the point estimates can be interpreted as the mean value of the cointegrating vectors (see Herzer, 2013).

The PDOLS estimator is an extension of the individual time-series dynamic OLS (DOLS) estimator and its estimation involves two steps. We first estimate the country-specific DOLS regressions while using heteroskedasticity- and autocorrelation-consistent (HAC) standard errors, and in the second step average the long-run coefficients and associated  $t$ -statistics over the entire panel, i.e. along the between-dimension (see Pedroni, 2001). The DOLS regression for each country in our case is given by

$$CH_{it} = \alpha_i + \beta_i TO_{it} + \sum_{j=-p_i}^{p_i} \varphi_{ij} \Delta TO_{it-j} + \mu_{it} , \quad (20)$$

where  $\varphi_{ij}$  are the coefficients of lead and lag differences of trade, accounting for possible serial correlation and endogeneity of trade, thus yielding unbiased estimates, and  $\beta_i$  are the country-specific slope coefficients. The between-dimension group-mean PDOLS estimator can then be calculated as

$$\beta_{PDOLS} = \frac{1}{N} \sum_{i=1}^{N_i} \hat{\beta}_i , \quad (21)$$

where

$$t_{\beta_{PDOLS}} = \frac{1}{\sqrt{N}} \sum_{i=1}^{N_i} \hat{t}_{\beta_i} \quad (22)$$

is the corresponding  $t$ -statistic, and  $\hat{\beta}_i$  is the conventional (time-series) DOLS estimator applied to country  $i$  as in equation (20). Thus, the PDOLS long-run coefficient estimate is simply the average of the country-specific DOLS estimates, and the corresponding  $t$ -statistic is sum of the individual  $t$ -statistics divided by the root of the number of cross-sectional units, in our case 66.<sup>141</sup> The long-run variance of the residuals in equation (20) is computed through the Newey & West (1987) method, where the maximum lag for the Bartlett kernel is selected according to  $4\left(\frac{T}{100}\right)^{2/9}$  (see Newey & West, 1994), which in our case is roughly 3.

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<sup>141</sup> See Pedroni (2001) for a more detailed representation of the group-mean method to calculate the averaged coefficients and associated  $t$ -statistics.

The estimation results for the group-mean PDOLS estimate of the impact of international trade on child health is depicted in Table 7. In the first two columns, we used the raw (untransformed) data for the estimation. The first column shows the results when the simple average of the individual coefficient estimates is used to construct the panel estimate as in equation (21). For comparison, in the second column we also show the results when we use a different averaging method. In this case, the individual beta coefficients are weighted by the size of their standard errors, such that betas that are more precisely estimated (i.e. have lower standard errors) have more influence over the mean group average. The results using the raw data point to a highly significant and very strong long-run effect of trade on child mortality. However, the cross-section dependence (CD) test rejects the null of cross-section independence for the raw data, indicating that the coefficient estimates are likely to be biased due to cross-sectional dependence.

In order to account for cross-sectional dependence in the form of common time effects among members of the panel, in columns 3 and 4, we apply the PDOLS procedure to time-demeaned data, which is equivalent to subtracting cross-sectional averages from the original variables (see Herzer, 2013). The estimation results reveal a highly significant negative long-run impact of trade openness on child mortality, and the PDOLS estimate implies that an increase in the trade-to-GDP ratio of 1% decreases the under-five mortality rate by about 0.47%, on average. The results for the simple and the weighted mean are very similar and substantially smaller compared to the results using the untransformed data. The CD test shows that, in case of the demeaned data, the null hypothesis of cross-section independence cannot be rejected, such that the results in the last two columns should not be biased due to the presence of cross-section dependence. To test the sensitivity of the estimation results, we perform some robustness checks in the next section.

**Table 7:** PDOLS estimates of the long-run effect of trade on child mortality

Independent variable	PDOLS	PDOLS	PDOLS	PDOLS
	(raw data, simple mean)	(raw data, weighted mean)	(demeaned data, simple mean)	(demeaned data, weighted mean)
<i>TO</i>	-1.581*** (-69.77)	-1.233*** (-69.77)	-0.4672*** (-24.78)	-0.4731*** (-24.78)
Countries	66	66	66	66
Observations	3102	3102	3102	3102
CD test	74.56***	74.56***	-0.77	-0.77

**Note:** The dependent variable is *CH*. *t*-statistics are in parenthesis. The DOLS regressions were estimated with three leads and lags. Under the null hypothesis of cross-section independence  $CD \sim N(0,1)$ . “Demeaned data” indicates that the data has been demeaned over the cross-sectional dimension. Simple mean” is the simple average of the country-specific DOLS estimates. “Weighted mean” indicates that the individual beta coefficients are weighted by the size of their standard errors. \*\*\* Significance at the 1% level.

#### (e) Robustness checks

As has been mentioned above, the PDOLS estimator of Pedroni (2001) is robust to a variety of estimation problems, including omitted variables, slope heterogeneity, the potential endogeneity of trade, and cross-country heterogeneity in the effect of trade. Although the CD test does not indicate any problems with cross-country dependence, we additionally employ the common correlated effects mean-group estimator (CCEMG) of Pesaran (2006) to test the robustness of the long-run estimation results. The CCEMG estimator is robust to cross-section dependence arising from multiple unobserved common factors (regardless of if they are stationary or non-stationary) and allows the response to these factors to differ across panel members (see Herzer, 2013, and Kapetanios et al., 2011). These factors may be associated, for example, with local spillover effects or global shocks such as the recent financial crisis (see Chudik et al., 2011). The CCEMG estimator augments the group-specific regressions with the cross-section averages of the dependent variable (here *CH*) and the explanatory variable(s) (here *TO*). In our case, the cross-sectionally augmented cointegrating regression is given by

$$CH_{it} = \alpha_i + \beta_i TO_{it} + b_{i0} \overline{CH}_t + b_{i1} \overline{TO}_t + u_{it}, \quad (23)$$

where the cross-section averages serve as proxies for the unobserved common factors. Similar to the PDOLS estimator, the relationship is estimated for each panel member separately and the estimated coefficients are averaged across countries, such that cross-country heterogeneity is accounted for. The results are presented in Table 8, where each country-specific regression is additionally augmented with a linear trend term. In column 1, we report the simple (unweighted) average, while in column 2 we report a weighted (outlier-robust) estimate of the long-run effect, where less weight is given to outlier observations while computing the averages (see Eberhardt, 2012). As can be seen, outliers do not significantly affect the results and both coefficient estimates again point to a negative long-run effect of trade on child mortality, although the effect is substantially smaller in this case. The CD test also shows that the estimator was successful in accounting for cross-section dependence. However, one problem with the CCEMG estimator is that it is based on the assumption of exogeneity of regressors and therefore does not account for the possible endogeneity of trade, which may bias the results. As the PDOLS estimation additionally accounts for endogeneity and the CD test does not point to any problems with cross-section dependence for the transformed data, we should lend more credence to the PDOLS estimation results.

So far, we have looked at approaches allowing for parameter heterogeneity across panel members. A different approach to estimate the long-run panel cointegration parameters lies in pooling the data over the cross-section units, implicitly assuming that the long-run parameters are homogenous across countries. If the individual slope coefficients are indeed homogeneous, this procedure leads to efficiency gains compared to the estimators used so far (see Herzer & Nunnenkamp, 2015). However, if this is not the case, the pooled estimators may yield inconsistent results. Nevertheless, Baltagi & Griffin (1997) show that, in some circumstances, the efficiency gains from pooling may still offset the biases due to slope heterogeneity.

**Table 8:** Alternative estimates of the long-run effect of trade on child mortality

Independent variable	CCEMG	CCEMG	“within-dimension”	“within-dimension”
	(unweighted average)	(weighted “outlier-robust” average)	DOLS (raw data)	DOLS (demeaned data)
<i>TO</i>	-0.1273*** (-3.04)	-0.1285*** (-3.20)	-0.5363*** (-8.84)	-0.3579*** (-10.72)
Countries	66	66	66	66
Observations	3564	3564	3102	3102
CD test	-1.11	-1.11	49.16***	12.77***

**Note:** The dependent variable is *CH*. *t*-statistics are in parenthesis. The DOLS regressions were estimated with three leads and lags. Under the null hypothesis of cross-section independence  $CD \sim N(0,1)$ . “Demeaned data” indicates that the data has been demeaned over the cross-sectional dimension. For the CCEMG estimator, the “unweighted average” is the simple average, while the “weighted average” puts less weight on outliers (see Eberhardt (2012) for details). \*\*\* Significance at the 1% level.

To see if the results change when using the pooled estimation approach, we employ the (within-dimension) dynamic OLS estimator of Kao & Chiang (2000), which has been shown to outperform other pooled estimators suited for the estimation of the cointegrating relationship, for example the fully-modified OLS (FMOLS) estimator of Pedroni (2000) (see Wagner & Hlouskova, 2010).<sup>142</sup> The DOLS estimator is superconsistent and asymptotically unbiased and uses a parametric approach to correct for endogeneity and serial correlation (see Herzer & Nunnenkamp, 2015). More specifically, it augments the cointegrating regression with leads and lags of the first differences of the regressors, such that we obtain the following regression equation

$$CH_{it} = \alpha_i + \beta TO_{it} + \sum_{j=-k}^k \theta_{it} \Delta TO_{it} + \varepsilon_{it}, \quad (24)$$

where  $\theta_{it}$  are the coefficients of the lead and lag differences. As in the case of the PDOLS estimation, we show both the results for the raw data and the transformed data that has been demeaned over the cross-section dimension, to account for cross-sectional dependence in the form of common time effects among panel members. The within-dimension DOLS estimates of the long-run child health elasticity with respect to trade are

<sup>142</sup> Note that the simple OLS estimator of equation (1) is asymptotically biased and its distribution depends upon nuisance parameters, which could introduce endogeneity and serial correlation (Pedroni, 2000, 2001). It is therefore not considered as an alternative estimator for the problem at hand.



displayed in the last two columns of Table 8 and confirm the previous result of a significant negative long-run effect of trade on child mortality. As the CD test indicates, however, the coefficient estimates for both the raw and the demeaned data may be biased due to cross-section dependence. Moreover, we lose the ability to account for cross-country heterogeneity, which seems to be an important factor in the trade-child health relationship as previously shown, and thus lend more credence to the PDOLS results. Therefore, we continue the robustness analysis using the PDOLS estimator and demeaned data, using the simple mean as in the original model of Pedroni (2001).

In the following, we test the robustness of our results to the employment of alternative measures of trade openness and child health. As an alternative measure for child health, we use the infant mortality rate (per 1,000 live births), which corresponds to the number of infants dying before reaching one year of age, per 1,000 live births in a given year. As for the under-five mortality rate, data comes from WDI, based on estimates developed by the UN Inter-agency Group for Child Mortality Estimation (UNICEF, WHO, World Bank, UN DESA Population Division) using nationally representative data. As can be seen in Table 9, the PDOLS estimation results for the long-run effect of trade on child health is almost identical, when the infant mortality rate (in logs) is used as dependent variable. As an alternative to our WDI-based measure of trade openness in current prices, which is available for the 1960-2013 period, we could use the OPENK variable from the Penn World Tables 7.1, which measures the trade-to-GDP ratio at constant prices and is available for a larger set of countries but only from 1960-2010 (see Heston et al., 2012). As can be seen in the third column of Table 9, the significant negative long-run effect of trade on child mortality remains when using this alternative trade openness measure (in logs). However, the CD test does reject the null of cross-section independence, at least at the ten percent level of significance, suggesting that the coefficient estimates may be biased due to cross-section dependence.

The focus of the present study is on the economic component of globalization as the benefits of globalization are expected to flow mainly from trade (see FAO, 2003). Additionally, as globalization is not only an economic phenomenon and trade openness measures may not fully capture other aspects of globalization or openness of a country, for example flows of people or ideas, a multivariate approach to measuring globalization is used. In Column 4 of

Table 9, we report the results when the KOF index of globalization (in logs) is used instead of our trade openness measure. Complete data is available for a sample of 104 countries over the period 1970-2012. The KOF index is a more comprehensive measure of globalization that measures three dimensions (economic, political and social) and combines them into one index. Economic globalization includes information on actual flows such as trade and foreign direct investment (FDI), and data on restrictions such as import barriers and taxes on international trade. Political globalization includes information on membership in international organizations and international treaties. The social component of the globalization index includes data on personal contact, information flows and cultural proximity (see Dreher, 2006).<sup>143</sup> As the results show, this more comprehensive measure of openness has a significant negative long-run impact on child mortality, supporting the view that general openness and integration into the world economy is beneficial for child health. Besides that, this result implies that our finding of a positive long-run impact of openness on child health carries over to this substantially larger set of countries. Globalization generally affects child health through the same pathways as trade openness, while the effect of improved access to health-relevant information may be better captured by the globalization index, which includes data on the social component of openness. This result is in line with findings of other related studies pointing to beneficial effects of globalization for economic growth (see e.g. Dreher, 2006), for absolute poverty (see Bergh & Nilsson, 2014) and life expectancy (see Bergh & Nilsson, 2010), and for gender equality (see Potrafke & Ursprung, 2012).

In summary, the results displayed in Table 9 reveal that the favorable and significant long-run relationship between openness and child health is not due to the specific measures employed in the analysis.<sup>144</sup> In summary, it can be concluded that our finding of a favorable long-run effect of openness on child health is robust to the presence of arbitrary cross-section dependence, potential outliers, the selection of the sample and time period, the estimation method employed, and to different measures of openness and child health.

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<sup>143</sup> For a more detailed representation of the globalization index and its different components, see Dreher, 2006, updated in Dreher, Gaston & Martens, 2008.

<sup>144</sup> Note that we tested all variables for unit roots and cointegration before we applied the PDOLS estimator, confirming that all series are integrated of order 1,  $I(1)$ , and cointegrated.

**Table 9:** PDOLS estimates using alternative child health and openness measures

	PDOLS (Dep. Var: under- five mortality rate)	PDOLS (Dep. Var: infant mortality rate)	PDOLS (Dep. Var: under- five mortality rate)	PDOLS (Dep. Var: under- five mortality rate)
<i>TO</i>	-0.4672*** (-24.78)	-0.4792*** (-25.15)		
OPENK			-0.3544*** (-28.11)	
KOF index of globalization				-0.3931*** (-30.38)
Countries	66	66	92	104
Observations	3102	3102	4048	3744
CD test	-0.77	-0.70	1.93*	-0.69

**Note:** *t*-statistics are in parenthesis. The DOLS regressions were estimated with three leads and lags. Under the null hypothesis of cross-section independence  $CD \sim N(0,1)$ . Demeaned data has been used in all cases. See text for details on the variables. All variables are in logs, such that the coefficient corresponds to the long-run elasticity of child health with respect to openness. \*\*\*(\*) Significance at the 1%(10%) level.

#### (f) Individual country and sub-sample estimates

The results so far indicate that trade has, on average, a beneficial long-run effect on child health, as indicated by a reduction of the under-five mortality rate. One aim of our panel cointegration analysis was to account for cross-country heterogeneity in the impact of trade on child health by employing the between-dimension group-mean panel dynamic OLS (PDOLS) estimator of Pedroni (2001). In this section, we present the individual country DOLS estimates underlying the mean-group estimates presented in Table 7. Besides that, we try to assess whether countries with specific characteristics benefit more from trade in terms of improvements in child health (see Herzer, 2013). The individual country DOLS estimates, using the same specification as in column 3 of Table 7 (demeaned data, simple mean) are presented in Table 10.

Although, in general, the individual country DOLS estimates should be interpreted with caution given the relatively small number of observations for each county (see Herzer, 2013),

the results reveal that there is considerable heterogeneity in the effect of trade on child health across countries. The coefficient ranges from -3.490 for Austria to 3.763 for Singapore, and although the effect of trade on child mortality is negative and highly significant in most of the sample countries, in some of them the effect is insignificant or even positive. Overall, the results point to relatively large cross-country differences in the impact of trade, which underlines the importance of accounting for cross-country heterogeneity in the estimation of the trade effect on child health. The detrimental effect of trade for health in some of the countries, especially developed ones, may be explained by the facilitated transfer of infectious disease or unhealthy consumer goods and practices across borders (see Owen & Wu, 2007, and Hawkes, 2006).

Because of the small number of observations for the individual country estimates and possibly multifaceted reasons for the differential impacts, we refrain from speculating about why we observe the specific signs and magnitudes with respect to the trade effect in each individual country (see also Herzer, 2013). Instead, in the following we focus on the PDOLS estimates for specific regional country groups and assess whether countries with specific characteristics such as a beneficial policy and institutional environment benefit more from trade in terms of long-term improvements in child health.

**Table 10:** Individual country DOLS estimates

Country	ln(TO)	t-stat	Country	ln(TO)	t-stat
Australia	-0.583***	-2.382	Japan	0.551***	3.180
Austria	-3.490***	-3.985	Kenya	-1.527***	-10.410
Bangladesh	-0.685***	-6.987	Korea, Rep.	-1.202***	-2.515
Barbados	-0.101	-0.994	Lesotho	0.212	0.572
Belgium	-0.121	-0.153	Malawi	-0.890***	-3.882
Benin	-0.001	-0.007	Malaysia	-1.040***	-7.871
Bolivia	-0.042	-0.235	Mauritania	-0.534**	-2.038
Botswana	-1.557***	-11.060	Mexico	-0.597***	-8.852
Brazil	-1.512*	-1.841	Morocco	0.271	0.482
Burkina Faso	-0.195	-0.539	Netherlands	-0.496	-1.551
Burundi	-0.590*	-1.655	Nicaragua	0.713***	3.746
Canada	-0.797***	-3.094	Nigeria	1.128***	5.496
Central African Rep.	-0.977***	-30.680	Norway	0.352***	2.740
Chile	-2.031***	-8.122	Peru	-0.294	-1.361
Colombia	0.843***	2.709	Philippines	0.374**	2.008
Congo, Rep.	-0.256	-0.337	Portugal	0.910	0.495
Cote d'Ivoire	-1.976***	-6.468	Rwanda	-1.554**	-2.079
Denmark	0.634**	2.093	Senegal	-0.127	-0.633
Dominican Rep.	-0.105***	-2.522	Singapore	3.763***	4.267
Ecuador	-1.147***	-7.357	Spain	-1.202***	-19.030
Fiji	-1.155***	-4.738	Sudan	-0.619***	-4.225
Finland	-1.142**	-1.969	Swaziland	-2.509***	-5.097
France	-0.273	-0.907	Sweden	-0.324	-1.313
Ghana	0.066	0.729	Thailand	-0.562***	-22.180
Greece	-1.988***	-3.053	Togo	-0.776***	-4.994
Guatemala	-0.408**	-2.028	Trinidad & Tobago	-0.878***	-2.463
Honduras	-0.695***	-4.714	Turkey	-0.425***	-5.763
Hungary	-0.854***	-5.394	Uganda	-0.861***	-6.767
Iceland	0.649***	6.512	United Kingdom	0.165	1.016
India	0.097*	1.715	United States	0.257*	1.944
Indonesia	0.136	1.153	Uruguay	-0.244	-1.057
Ireland	-0.721***	-5.942	Venezuela, RB	-0.057	-1.375
Italy	-0.587	-0.447	Zambia	-1.252***	-9.089

**Note:** The dependent variable is *CH*. The DOLS regressions were estimated with three leads and lags. Demeaned data has been used in all cases. See text for details on the variables.. \*\*\* (\*\*) (\*) Significance at the 1% (5%) (10%) level.

First, we test the sensitivity of our group-mean PDOLS results to the exclusion of specific geographical regions, to assess whether there are any differences in the strength of the trade effect on child health due to geographic location. Countries from the following regions are captured in the analysis, based on the country classification as suggested by the World Bank: East Asia & Pacific, Europe & Central Asia, Latin America & the Caribbean, Middle East & North Africa, North America, South Asia, and Sub-Saharan Africa. The results are presented in Table 11, where we exclude one region at a time from the PDOLS estimation.

**Table 11:** Regional differences in the PDOLS estimates

	ln(TO)	No. of countries	Observations
Full sample	-0.4672*** (-24.78)	66	3102
East Asia & Pacific excl.	-0.6000*** (-23.58)	57	2679
Europe & Central Asia excl.	-0.4350*** (-22.45)	49	2303
Latin America & the Caribbean excl.	-0.4351*** (-24.02)	51	2397
Middle East & North Africa excl.	-0.4525*** (-24.91)	64	3008
North America excl.	-0.4889*** (-25.32)	64	3008
South Asia excl.	-0.4942*** (-25.02)	64	3008
Sub-Saharan Africa excl.	-0.2361*** (-12.58)	47	2209

**Note:** The dependent variable is *CH*. *t*-statistics are in parenthesis. The DOLS regressions were estimated with three leads and lags. Demeaned data has been used to account for cross-sectional dependence the cross-sectional dimension. \*\*\* Significance at the 1% level.

As can be seen, the significance and strengths of the long-run effect of trade on the child mortality is similar in most of the cases and comparable to the effect for the full sample. The group-mean PDOLS estimate is greatest in case of the exclusion of countries from the region East Asia & Pacific and smallest when Sub-Saharan African countries are excluded from the

sample. This indicates that the trade effect on child health is comparably strong in Sub-Saharan African countries and weaker in countries from the region East Asia & Pacific. This result suggests that the cross-country differences discussed above may to some extent be attributed to the belonging of countries to a specific geographical region. It is difficult to say why exactly these specific regions benefit more or less from trade in terms of gains in child health.

Nevertheless, in the following we try to shed some more light on the specific factors that could potentially affect the strength of the trade-child health relationship in different country groups. First, we notice that all of the Sub-Saharan African countries included in the sample belong to the group of developing countries. It may be expected that developing countries benefit more from an opening up the economy in terms of child health due to various reasons. If we focus on the links between trade and child health (see Section 2), some factors could explain this. Child's dietary intake is to a great extent determined by household food security. Many households in developing countries rely on the consumption of basic food staples for a great part of food consumption. Besides that, many of the developing countries are food insecure in the sense that they lack access to enough food. Trade may serve to smooth out excess demand or excess supply situations in domestic markets, thereby stabilizing national food supplies and increasing household food security and child's dietary intake (see Runge et al., 2003). Trade also makes available a greater variety of foods, which has been found to contribute to better nutrition (see e.g. Arimond & Ruel, 2004). Moreover, closer integration with the world facilitates the transmission of health-related knowledge as well as access to health-improving measures developed in richer countries, which most developing countries otherwise would not have access to (see Cutler et al., 2006, and Deaton, 2004). To assess whether developing countries indeed benefit more from trade with respect to child health, we exclude developed countries from the sample. The PDOLS results for the sample of developing countries is displayed in the first row of Table 12. As can be seen, the long-run effect of trade on child health is somewhat bigger in this sample, suggesting that developing countries benefit more from an opening up of the economy for trade in terms of improvements in child health.

**Table 12:** PDOLS estimates for specific country sub-samples

	ln(TO)	No. of countries	Observations
Developing countries	-0.5289*** (-25.08)	46	2162
Countries with strong “Voice and accountability”	-0.4827*** (-22.12)	39	1833
Countries with high “Political Stability and an Absence of Violence”	-0.5528*** (-22.45)	37	1739
Countries with high “Government Effectiveness”	-0.5408*** (-21.23)	35	1645
Countries with good “Regulatory Quality”	-0.5275*** (-21.13)	39	1833
Countries with strong “Rule of Law”	-0.4839*** (-17.80)	35	1645
Countries with strong “Control of Corruption”	-0.4721*** (-14.04)	64	3008

**Note:** The dependent variable is *CH*. *t*-statistics are in parenthesis. The DOLS regressions were estimated with three leads and lags. Demeaned data has been used to account for cross-sectional dependence the cross-sectional dimension. \*\*\* Significance at the 1% level.

Next, we try to assess if the policy and institutional environment influences the ability of countries to benefit from trade and consequently the effect of trade on child health. Recently, a number of studies pointed to the potential importance of governance for health and nutrition (see e.g. Halleröd et al., 2013; Haddad, 2012). Besides that, the growth effects of trade have been found to be partly depending on policy complementarities that help a country take advantage of international competition and trade (see Dollar and Kraay, 2004; Chang et al., 2009). For this purpose, we divide the sample countries according to countries with “bad” and “good” governance based on the Worldwide Governance Indicators provided by Kaufmann, Kraay, & Mastruzzi (2010) and repeat the PDOLS estimation for those countries with a high value of the corresponding governance indicator. The composite measures of governance are in units of a standard normal distribution and range from -2.5 to 2.5, with higher values corresponding to better governance. We categorize the countries with a value of above zero as belonging to the countries with good governance. The analysis is performed for all of the six governance indicators in the following areas: Voice and



Accountability, Political Stability and Absence of Violence, Government Effectiveness, Regulatory Quality, Rule of Law, and Control of Corruption. Voice and accountability relates to the presence of democratic institutions and the extent of political rights and civil liberties. Political instability refers to politically-motivated violence in the form of civil and social unrest, armed conflicts and terrorism. Government effectiveness captures perceptions about the quality of public services as well as the quality of policy formation and implementation. Related to this, regulatory quality refers to the ability of the government to implement sound policies and regulations that promote private sector development. The rule of law represents the extent to which agents have confidence in the rules of society, for example in the judicial system and the quality of contract enforcement. Lastly, control of corruption captures perceptions of the extent to which public power is exercised for private gain.<sup>145</sup>

The results, depicted in Table 12, show that in nearly each of the cases, the magnitude of the trade impact on child mortality is significantly greater in countries with a high quality of governance, except for the case of countries with a strong control of corruption, where the effect is, however, very similar to the full sample results. The most important elements of governance strengthening the benefits from trade in terms of child health can be subsumed under the headings “effective democratic institutions” and “high political stability”. There may be several reasons for this finding. In democracies, specific policies may facilitate the process of adjustment, improve the functioning of markets, and minimize potentially adverse impacts of trade liberalization policies (Ames et al., 2001). For example, democratic governments are more likely to care for the protection and effective realization of human rights and the well-being of their citizens, and may therefore put more emphasis on the equal distribution of the benefits from trade (Haddad & Oshaug, 1998). Democracies may also be more willing to promote equal rights and status of men and women as well as access to education, in turn increasing the ability to absorb foreign knowledge and acquire new technologies (see Coe et al., 2009). Similarly, high political stability and the absence of violence is likely to have a favorable effect on the strength of the trade-child health relationship. The presence of political violence may worsen the possibilities of a country to take advantage of trade openness, for example by disrupting transport, trade and markets

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<sup>145</sup> The data and a detailed description of the methodology underlying the construction of each of the governance indicators is available at [www.govindicators.org](http://www.govindicators.org).

and thus access to important child health inputs, which may partly be delivered through trade. Moreover, health-care facilities may be destroyed and access to medical supplies impaired due to conflicts (Green, 1994), weakening the health-improving effect of increased trade and transfers of medical supplies and drugs, for example vaccines, medical treatments, pharmaceuticals. These results are in line with Cornia (2001), who argues that the positive health effects associated with globalization may be dependent on complementary policies such as the creation of democratic institutions that ensure that markets are non-exclusionary and safety nets are in place.

From the additional analyses, we can conclude that the cross-country heterogeneity in the trade effect on child health can partly be explained by the belonging of a country to a specific geographical region and by the quality of governance in the country, potentially improving the ability of a country to take advantage of trade.

## **5. CONCLUSION AND POLICY RECOMMENDATIONS**

Globally, interest in the issue of how to improve child health has increased dramatically in recent years. Reducing the under-five mortality rate by two-thirds until 2015 has also been included as one of the United Nations Millennium Development Goals (MDGs). Health professionals so far tended to focus on health-specific interventions to tackle the preventable direct causes of ill health, such as immunization, insecticide-treated mosquito nets, rehydration treatment for diarrhea, and nutrition supplements (UNICEF et al., 2014). This partly explains why the health sector has traditionally avoided to focus on trade-health issues and to get involved in trade debates as stated by MacDonald & Horton (2009). However, as countries are increasingly integrated with the world, health is also affected increasingly by factors beyond the health system, including trade (see Smith, Lee, & Drager, 2009).

We conceptualized the linkages between trade and child health based on the UNICEF (1990) conceptual model on the causes of child malnutrition, which combines the elements of dietary intake and child health. As discussed in some detail in Section 2, trade may affect child's dietary intake, caring resources and behaviors for both mothers and children, as well as the health environment quality and access to healthcare services. With respect to child's

dietary intake, trade may lead to a higher and more stable domestic food supply, make available a greater variety of foods, and increase food access, all factors potentially contributing to better household food security and nutrition. Regarding care for mothers and children, closer integration with the world facilitates the transmission of health-related knowledge, for example about appropriate caring and feeding practices (see e.g. Babinard & Pinstруп-Andersen, 2001). Finally yet importantly, health-improving measures and new medical technologies developed in richer countries, such as improvements in water supply, the use of antibiotics and the widespread immunization of children, can be transmitted through trade to the rest of the world very quickly, leading to improvements in the health environment quality (see Cutler et al., 2006). Due to these important mechanisms, we hypothesized that trade leads to long-run improvements in child health.

Unfortunately, empirical evidence on the trade effects on health is scarce. In this study, we tried to provide a remedy to this fact and assessed the impact of trade on child health, based on a cross-country panel data set covering 66 countries for the period 1960-2013. To account for the time-series properties of the data and potential cross-country heterogeneity in the impact of trade, the study employed heterogeneous panel cointegration techniques that are robust to omitted variables and endogeneity, to identify the long-run cointegrating relationship between trade and child health. The results revealed that trade and child health are cointegrated and that trade works to reduce the under-five mortality rate significantly in the long-run. The results were robust to the methodology and openness indicator employed as well as to the presence of cross-sectional dependence and changes in the sample composition. Additional analyses suggested that the trade-child health relationship tends to be stronger in countries with a favorable policy and institutional environment.

From a policy perspective, some recommendations can be derived from the empirical results. First, our findings point to the importance of a country's openness and market integration for improvements in health. Openness to international trade should therefore constitute a fundamental component of a policy mix to enhance child health, and trade liberalization in the sense of progressive reductions in the levels of protection and the elimination of policies that distort trade can be an effective instrument for this purpose. It should be seen as a complement but not as a substitute for domestic health and education

policies aimed at improving health-relevant knowledge and child health and reducing child mortality. Our results further suggest that a stable political environment as well as good governance and the presence of democratic institutions should be seen as a necessary part of an enabling environment for improvements in child health.

We believe that the findings of the current study can provide the basis for future research aiming at improving our understanding of the determinants of child health and mortality. First, as indicated by our country-specific DOLS estimates, in some countries trade has failed to lead to improvements in child health, which calls for regional and country case studies to complement our panel data investigations. These kind of studies may also provide deeper insights into the issue of why and in which circumstances trade has not had the desired effects in terms of improvements in child health. Second, we only assessed the effects of a country's own trade policy stance. Although most gains from multilateral liberalization are expected to come from the countries' own liberalization efforts (Ingco, 1997), it would be interesting to assess how developed countries' trade policies affect health in developing countries. It has been argued, for example, that the health-improving effects of integration could be improved, if protectionism in the developed countries is further reduced (see e.g. Cornia, 2001).

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## APPENDIX

**Table A.1.** List of countries used in baseline regressions (66)

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Australia	Denmark	Kenya	Singapore
Austria	Dominican Republic	Korea, Rep.	Spain
Bangladesh	Ecuador	Lesotho	Sudan
Barbados	Fiji	Malawi	Swaziland
Belgium	Finland	Malaysia	Sweden
Benin	France	Mauritania	Thailand
Bolivia	Ghana	Mexico	Togo
Botswana	Greece	Morocco	Trinidad & Tobago
Brazil	Guatemala	Netherlands	Turkey
Burkina Faso	Honduras	Nicaragua	Uganda
Burundi	Hungary	Nigeria	United Kingdom
Canada	Iceland	Norway	United States
Central African Republic	India	Peru	Uruguay
Chile	Indonesia	Philippines	Venezuela, RB
Colombia	Ireland	Portugal	Zambia
Congo, Rep.	Italy	Rwanda	
Cote d'Ivoire	Japan	Senegal	

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**Table A.2.** Summary statistics

Country	Mean log(CH)	Mean log(TO)	Country	Mean log(CH)	Mean log(TO)
Australia	2.36	3.49	Japan	2.12	3.10
Austria	2.48	4.21	Kenya	4.74	4.07
Bangladesh	4.91	3.20	Korea, Rep.	2.62	3.97
Barbados	3.25	4.67	Lesotho	4.82	4.82
Belgium	2.42	4.72	Malawi	5.39	4.14
Benin	5.21	3.74	Malaysia	3.11	4.82
Bolivia	4.83	3.93	Mauritania	4.97	4.47
Botswana	4.37	4.57	Mexico	3.92	3.43
Brazil	4.12	2.89	Morocco	4.53	3.97
Burkina Faso	5.39	3.48	Netherlands	2.23	4.66
Burundi	5.18	3.44	Nicaragua	4.34	4.12
Canada	2.39	3.97	Nigeria	5.36	3.71
Central African Republic	5.24	3.91	Norway	2.14	4.29
Chile	3.30	3.85	Peru	4.35	3.51
Colombia	3.80	3.44	Philippines	4.09	4.04
Congo, Rep.	4.73	4.67	Portugal	2.94	4.00
Cote d'Ivoire	5.14	4.28	Rwanda	5.10	3.42
Denmark	2.21	4.25	Senegal	5.11	4.07
Dominican Republic	4.21	4.04	Singapore	2.27	5.79
Ecuador	4.19	3.67	Spain	2.59	3.58
Fiji	3.59	4.66	Sudan	4.84	3.27
Finland	2.04	4.03	Swaziland	4.78	4.94
France	2.27	3.71	Sweden	1.96	4.11
Ghana	4.93	3.83	Thailand	3.78	4.18
Greece	2.76	3.65	Togo	5.06	4.43
Guatemala	4.49	3.77	Trinidad & Tobago	3.59	4.50
Honduras	4.24	4.34	Turkey	4.41	3.22
Hungary	3.01	5.44	Uganda	5.07	3.59
Iceland	1.99	4.30	United Kingdom	2.40	3.90
India	4.88	2.85	United States	2.58	2.86
Indonesia	4.49	3.76	Uruguay	3.35	3.64
Ireland	2.42	4.69	Venezuela, RB	3.54	3.85
Italy	2.51	3.67	Zambia	5.08	4.31



## V. GENERAL CONCLUSION

### (a) Summary of findings

Globally, interest in food and nutrition security and health has increased dramatically. Although it is generally acknowledged that “non-nutrition” factors such as macroeconomic structural developments and policies can have profound effects, empirical evidence on this issue is scarce. The main aim of the thesis is to throw more light on the impact of macroeconomic policies and trade and other macro-level drivers on food and nutrition security and child health. The study made an important contribution to the existing literature on the linkages between globalization, trade openness and economic growth and between trade and poverty, which did not explicitly explore the implications for food and nutrition security, and previous cross-country studies that examined cross-country variation in malnutrition rates (of children), however, without considering policy effects.

The second chapter identified the key determinants of child’s nutritional status for a large sample consisting of a maximum of 113 developing countries over the period 1985-2007 and gained insight into the impact of trade on malnutrition, measured as underweight and stunting rates. We extended previous work on the determinants of child malnutrition in various directions and employed advanced econometric methods dealing with several estimation problems to arrive at consistent and efficient estimates.

As regards the theoretical underpinnings, we extended the widely accepted UNICEF (1990) conceptual framework for the causes of child malnutrition and introduced trade policy as part of the political environment. We recognized that trade may have various effects on child malnutrition, with the pathways of influence working through the underlying determinants of child malnutrition, that is food security, care for mothers and children and the health environment quality and access to health services. The results revealed that trade openness works to reduce both child stunting and underweight significantly. The results were robust to the methodology and openness indicator employed as well as to changes in the sample composition and the employment of additional control variables potentially affecting child malnutrition or the openness – malnutrition relationship.

We also conceptualized the main linkages between trade and malnutrition and identified the transmission channels through which trade policy affects child malnutrition. We found that trade openness improves nutrition security *inter alia* by increasing the availability and diversity of food in a country. The results also indicated that the openness of a country improves child's nutritional status through the care for mothers and children transmission channel. This may partly be explained by the fact that closer integration with the world facilitates the transmission of health-related knowledge. Besides that, we found evidence suggesting that trade affects nutritional status through its effect on the health environment and the availability of healthcare services, for example through a facilitation of technology spillovers as well as increased trade and transfers of medical supplies and drugs. Through all these pathways trade openness eventually positively affects nutrition security, which leads us to conclude that the benefits of trade openness outweigh the costs when the objective is to attain improvements in nutrition security. The employment of alternative globalization and openness indicators confirmed the results that protectionist measures such as tariffs are in general detrimental and economic openness is beneficial for child's nutritional status.

Besides the favorable effect of trade, we found that improvements in income lead to significant reductions in both child stunting and underweight, confirming previous studies on this issue (see e.g. Smith & Haddad, 2000; Headey, 2013). The presence of democratic institutions leads to improvements in both stunting and underweight, but significantly so only in the case of underweight. Furthermore, the results revealed that macroeconomic instability as well as political instability (or the presence of violent conflicts) negatively affects child's nutritional status through all of the underlying determinants. The baseline model results also showed that the financial development and access to credit have a favorable impact on nutritional status. Additional results showed that the degree of urbanization, the level of infrastructure development and the availability of foreign direct investments tend to improve nutrition security, while high population growth adversely affects child's nutritional status.

Focusing on the underlying determinants, our results support the findings of earlier studies on the issue and speak to the importance of food availability, female education and women's relative status, and the health environment quality for child's nutritional status. Taking a

closer look at household food security, one of the most important underlying determinants of child's nutritional status, we find that, besides national food availability, food access as well as dietary diversity and diet-quality related aspects of food security play a role for child's nutritional status. Additional results revealed that high fertility rates lead to a deterioration of child's nutritional status, while access to health services improves it. This confirms that both the general health environment quality and access to healthcare services simultaneously affect child's nutritional status in a favorable manner.

The third chapter took a broader perspective and focused on the overall level of food security of the population as indicated by average dietary energy consumption, which is also one of the main determinants of child's nutritional status. One immediate advantage over child malnutrition studies is the greater availability of national food security data, which is not limited by the availability of household survey data and leads to a significantly greater sample size and the possibility to employ more advanced econometric methods dealing with the potential complexity of the dynamic relationships. These circumstances enable a more convincing assessment of the key determinants of food security and of whether food security is responsive to trade policy. We provided a systematic quantitative assessment of the impact of these important macroeconomic structural factors and policies on overall food security levels and assessed the combined effects of various factors on the food economy and the overall state of food security while putting special emphasis on the impact of trade openness.

Food security- in terms of research and policy- generally receives less attention than poverty, and only very few studies explicitly explore the impact of trade policy on food security. In the present study, we tried to provide a remedy to this fact and identified the key country-level determinants of food security based on a large panel data set consisting of a total of 151 countries over the period 1980-2007. We found that trade openness does, on average, have a statistically significant positive net impact on food security, which leads us to conclude that the benefits of trade outweigh the costs when the objective is to attain national level food security. The beneficial effects of openness to trade hold true for dietary energy supply adequacy as well as for dietary diversity and diet quality-related aspects of food security. Besides that, economic and agricultural development, a beneficial domestic policy

environment as well as the availability of domestic resources for agricultural production impact positively on food security. On the contrary, violent conflicts and natural disasters, a high rural population share, high population growth and inflation negatively affect food security. The causal relationship running from trade openness to food security was robust to different sample compositions, to the inclusion of variables capturing specific agro-climatic constraints (e.g. weather-related) and regional/country characteristics, as well as the inclusion of a range of additional variables. Most geographical regions have been found to exert significantly higher food security levels compared to Sub-Saharan Africa. Employing alternative globalization and trade reform indicators confirmed the results that protectionist measures are in general detrimental and economic openness is beneficial for food security. These findings speak to the importance of essential macroeconomic structural factors in determining food security, which previous research has not thoroughly examined.

The fourth chapter of the thesis aimed at contributing to the empirical evidence base needed to identify the causes of child mortality and assessed the impact of trade on child health, based on a cross-country panel data set of 66 countries for the period 1960-2013. Taking note of the fact that “trade aspects need to be considered in the context of improving diet, nutrition and the prevention of chronic diseases (WHO, 2003, p. 28)” we provided a systematic quantitative analysis of the impact of trade on child health and mortality. We accounted for the fact that trade may not be strictly exogenous, as trade can be both a cause and a consequence of increased population health, as better health is generally associated with higher productivity and thus potentially more trade. Secondly, the effect of trade on life expectancy may vary across countries that have different structural country characteristics and policy environments, potentially affecting the functionality of markets and the ability of market participants to respond to induced changes in prices and incentives. In order to consistently and efficiently estimate the long-run-effect of trade on child health, we employed recently developed heterogeneous panel cointegration techniques that are robust to a variety of estimation problems such as cross-country heterogeneity, non-stationarity of the data, omitted variables and endogeneity. The results revealed that trade and child health are cointegrated and that trade works to reduce the under-five mortality rate significantly in the long-run. The results were robust to the methodology and openness indicator employed as well as to the presence of cross-sectional dependence and changes in the sample

composition. Additional analyses suggested that the trade-child health relationship tends to be stronger in countries with a favorable policy and institutional environment.

#### (b) Policy implications

From a policy perspective, some recommendations can be derived from the empirical results. First, our findings point to the importance of a country's openness and market integration for food and nutrition security as well as for child health. At the global level, international trade can link production and consumption of food and hence may play an important role in securing enhanced food security, as it permits global production to take place in those regions most suited to it and enables food to flow from countries with abundant food supplies to ones with insufficient supplies. Conversely, if this mechanism is disrupted by trade barriers, it may have negative consequences for food and nutrition security. Besides that, we identified various other channels through which trade ultimately affects FNS and health. Openness to international trade should therefore constitute a fundamental component of a policy mix to enhance FNS and health, and trade liberalization in the sense of progressive reductions in the levels of protection and the elimination of policies that distort trade can be an effective instrument for this purpose.

Trade policies should be seen as a complement but not as a substitute for domestic development policies aimed at reducing overall food insecurity and malnutrition, for example, investments in the domestic agricultural sector, domestic health and education policies as well as complementary policies to ensure that farmers benefit from liberalization (e.g. addressing production and transport constraints) and vulnerable groups are protected. For example, promoting efficient information flows and improving access to important production inputs may help farmers to respond to changing market conditions. In this respect, the formation of smallholder cooperatives may be useful for risk sharing and improved bargaining power. These farmer groups may also function as important catalysts for the adoption of new technologies through promoting efficient information flows and reducing transaction costs (see e.g. Fischer & Qaim, 2012). Although arguments for protection can be made on both economic and non-economic grounds with respect to the issue of food security, trade barriers are costly and are often fiscally unsustainable and,

besides that, are usually neither the most direct nor the most efficient measures to use (FAO, 2000). Furthermore, as there are generally both poor people who buy and sell food, price distorting measures to help one constituency by definition harms the other (Brooks & Matthews, 2015).

The findings of a detrimental effect of macroeconomic and political instability support claims of the international community that a peaceful, stable political, social and economic environment is a precondition for the achievement of food and nutrition security (see e.g. Thomson & Metz, 1999). This suggests that a stable macroeconomic and political environment should be seen as a necessary part of an enabling environment for improvements in food and nutrition security. In light of the fact that conflicts can also lead to reductions in trade, there may be additional adverse indirect effects of violent conflicts on food and nutrition security. These results suggest that it should be beneficial to integrate conflict analysis and indicators into traditional food security early warning systems. Furthermore, public investment in infrastructure development can help to improve access to food and the other nutrition inputs. A stable macroeconomic environment along with investments in rural infrastructure leading to a reduction in transaction costs may then help producers to withstand foreign competition and expand into export markets. Besides that, the development of the financial sector with the aim to improve the delivery of financial services and to increase access to credit should form part of the policy mix for improving nutrition security. Financial development has the potential to facilitate the population's access to important inputs into child's nutritional status.

The adverse effects of natural disasters on food security suggest that governments should pay close attention to early warning systems in order to dampen the effects of droughts and other climatological phenomena on food security for the affected population. Public sector investments should aim at helping farmers to adapt to climate change, which lead to more frequent and extreme weather events. In this context, the improvement of water management and irrigation systems as well as the cultivation of drought resistant varieties of staple foods should play a central role for securing food production in arid areas. Trade liberalization can also help to stabilize food supplies during periods of intense pressures for domestic agricultural production caused, for example, by droughts or floods. In this respect,

trade openness and the stabilizing role of trade will become even more important in the future for many developing countries, in which climate change is expected to lead to an increase in domestic production shocks.

General economic and agricultural development is critical for enhanced food and nutrition security, such that policies strengthening the agriculture sector and helping to increase agricultural productivity and expand food production, for example the dissemination of new technologies and provision of credit and inputs such as machinery, fertilizers and seeds, should be an element of any domestic food security strategy. At the same time, however, these strategies have to be sustainable. A promising way in this direction is the promotion of sustainable agricultural intensification as a broader effort to ensure food security while protecting the natural resource base (see Marble & Fritschel, 2014). However, the focus should not be restricted to the agriculture sector. Indeed, sustainable food security may not be achieved by only focusing on agriculture at the expense of other sectors and agriculture and the rural economy itself is greatly influenced by macro-level policies and outcomes in the rest of the economy (Timmer, 2000). Beyond that, therefore the establishment of effective institutions in order to protect and improve the natural resource base, for example agricultural and arable land, will be helpful for sustainable domestic food production. Domestic stabilization policies that are able to reduce inflation and output volatility can also be critical to sustainable long-term food security. In this respect, countries should refrain from adopting protectionist measures (e.g. export restrictions) in the face of high food prices, as it may reduce global food supplies, and therefore contribute to rising prices and price volatility. Storage policies should generally be a better option for developing countries to stabilize domestic food prices (see e.g. Gouel & Jean, 2012).

With respect to child health, we confirmed that, as countries are increasingly integrated with the world, health is also affected increasingly by trade. As discussed in some detail, trade may affect child's dietary intake, caring resources and behaviors for both mothers and children, as well as the health environment quality and access to healthcare services. Our results further suggest that a stable political environment as well as good governance and the presence of democratic institutions should be seen as a necessary part of an enabling environment for improvements in child health. This finding further justifies the evolving

interest in governance and confirms recent studies pointing to the potential importance of governance for health and nutrition (see e.g. Halleröd et al., 2013; Haddad, 2012).



## Curriculum Vitae

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