Essays on the common currency, real financial market exchange rates and capital flows

Inaugural-Dissertation zur Erlangung des akademischen Grades
eines Doktors der Wirtschafts- und Sozialwissenschaften
der Wirtschafts- und Sozialwissenschaftlichen Fakultät
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Magister Valentyna Ozimkovska
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To my parents and my husband,
whose love and support helped me to work
being far away from all of them

Vorwort

Die vorliegende Arbeit ist während meines Studiums im Ph.D. Programm "Quantitative Economics" der Christian-Albrechts-Universität zu Kiel und während meines Praktikums an dem Institut für Weltwirtschaft an der Universität Kiel entstanden. Mein besonderer Dank gilt meinem Doktorvater Professor Dr. Stefan Reitz. Seine umsichtige Anleitung und hervorragende Betreuung haben entscheidend zum Gelingen dieser Arbeit beigetragen. Herrn Professor Dr. Markus Haas danke ich herzlich für seine Tätigkeit als Zweitgutachter.

Die Kapitel 1 und 2 dieser Dissertation basieren auf meiner eigenen Arbeit. Herr Professor Dr. Stefan Reitz hat mir hilfreiche Kommentare und Empfehlungen während meiner Arbeit an Kapitel 1 und 2 gegeben. Das Kapitel 3 dieser Dissertation ist eine Arbeit, die in Kooperation mit Herrn Professor Dr. Stefan Reitz entstanden ist. Die Grundidee, der Text und die Schätzung des Models des Kapitels 3 wurden in gemeinsamer Arbeit mit Herrn Professor Dr. Stefan Reitz entwickelt. Die Literatur und die Theorie des dritten Kapitels gehen auf mich zurück. Das Kapitel 1 'Volatility of industrial production growth and characteristics of optimal currency areas in EU-12 countries' wird mit Genehmnigung von dem Springer-Verlag Berlin Heidelberg veröffentlicht.

Für fachliche Diskussionen danke ich Frau Maria Gelman, Herrn Dr. Karl Finger und Herrn Sebastian Müller. Darüber hinaus danke ich meinen Kollegen aus dem Ph.D. Programm "Quantitative Economics" für die freundliche Arbeitsatmosphäre.

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1. INTRODUCTION

After the collapse of the Bretton Woods system of fixed exchange rates in 1973, industrialized and developing countries under the governance of the International Monetary Fund (IMF) have been trying to find optimal exchange rate regimes. The IMF has been promoting the floating exchange rate regime and the free movement of capital. At the same time, European countries fixed their exchange rates among each other, creating the European Monetary System and later the European Monetary Union (EMU). The two recent severe crises - the global financial crisis and the euro crisis - have demonstrated that the impact of factors such as a single currency and international capital flows on the health of world economies were not fully studied and understood. After the start of the global financial crisis, investors withdrew capital from foreign countries. This worsened the situation in financial markets and led to deep recessions in most industrialized countries and emerging markets. After the global financial crisis, the IMF changed its view on liberalizations of international capital movements. In 2012, the IMF stated that the management of international capital may be appropriate under some circumstances. For the successful management of international capital flows, it is important to understand how the interaction of exchange rates with asset prices influences investors' behavior.

After the start of the euro crisis in 2011, some countries which planned to join the euro area decided to postpone this important step. Before the creation of the euro zone, the characteristics of optimum currency areas were the main criteria, used to decide if countries can join a monetary union. However, not much research has been done to understand if these decisions, based on the characteristics of the optimum currency area, helped to mitigate the costs related to the adoption of the euro. Moreover, no prior research was able to indicate why some countries of the euro zone could overcome the global financial crisis faster than other countries. Understanding these questions is of great importance for countries which plan to join the euro area. This work sheds new light on the above mentioned issues from policy and theoretical perspectives.

Chapter 1 studies the impact of the introduction of the euro on the volatility of industrial production growth and the characteristics of the optimal currency in the EU-12 countries (Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal and Spain). The literature related to the optimum currency areas and the euro area emerged in two waves. In the early 90s, before the creation of the EMU, researchers studied the potential impacts of the introduction of the euro on real economies and the criteria of optimum currency areas of the EU countries (Emerson, 1992; Masson and Taylor, 1992; Davies and Lyons, 1996; Amiti, 1999). After the creation of the euro area in 1999, more attention was paid to the impact of the membership in the European Monetary System and the EMU on macroeconomic aggregates (Sopraseuth, 2003; European Commission, 2007; Weyerstrass et al., 2011; Jamil et al., 1995).

The contribution of Chapter 1 to the literature is threefold. First, it investigates how the introduction of the euro in the EU-12 countries influenced the short-term volatility of output, measured by the volatility of industrial production growth. Second, this work assesses whether more favorable criteria of optimum currency areas keep the volatility of industrial production growth constant. Finally, it investigates the impact of the global financial crisis on the volatility of industrial production growth and on the characteristics of the optimum currency areas of the EU-12 countries.

Chapter 1 employs the Chow breakpoint test and the Quandt-Andrews test to check for structural breaks in the industrial production volatility obtained from the Autoregressive Moving Average model and Autoregressive-Exponential General Autoregressive Conditional Heteroskedastic model. The results suggest that after the introduction of the euro, the volatility of industrial production growth has not significantly changed in Austria, France, Luxembourg, the Netherlands and Spain. However, the volatility of industrial production growth did increase in Finland, Ireland, Italy, Luxembourg and Portugal after the adoption of the common currency. In Germany and Greece, the volatility of industrial production increased after 2002 and 1997 respectively. This observation cannot be connected directly to the introduction of the euro. After the beginning of the financial crisis, the volatility of industrial production growth increased in all EU-12 countries except France and Greece. Criteria for optimum currency areas fail to explain why the volatility of some EU-12 countries remained unchanged after the introduction of the euro and after the start of the financial crisis. Those countries, where the volatility of industrial production has not changed significantly after the introduction of the euro, had a long history of fixed or pegged exchange rate regimes. This group of countries recovered faster after the financial crisis.

Chapter 2 investigates the relationship between cross-border equity flows and relative international asset prices expressed in the same currency which can be considered as the Real Financial Market Exchange Rate (RFER). This chapter investigates cross-border equity flows between the US and a number of industrialized countries as well as a number of emerging markets. Broadly, current literature does not investigate the impact of exchange rate volatility on equity flows. Hau and Rey (2008a), Fidora et al. (2007), Broner et al. (2013) and Caporale et al. (2015) shed some light on this issue.

The contribution of Chapter 2 to the literature is as follows. First, it investigates how the RFER influence cross-border portfolio flows. Second, I take a deeper insight into investors' behavior by studying disaggregated portfolio flows. Finally, I study international equity flows not only of industrialized markets but also of emerging markets.

Results of the Granger causality test suggest that causality goes from real financial market exchange rate volatility to equity flows. According to the Autoregressive Distributed Lag model, real financial market exchange rate volatility negatively influences purchases of foreign equity. This finding is in line with the portfolio optimization theory. The impact of the RFER volatility on sales of foreign equity is also negative. This result can be explained by the theory of behavioral finance which states that investors are reluctant to realize losses of their portfolios. That is why investors decrease sales of assets when riskiness of the assets increases. The impact of the RFER on net purchases of foreign equity is positive. This result implies that sales of foreign equity decrease more strongly than purchases of foreign equity when riskiness of foreign assets increases.

Chapter 3 is dedicated to the relationship between equity flows and the RFER between Canada and the US. The impact of asset returns on equity flows has been studied since the 1990s. Researchers find a positive impact of returns on equity flows, which is known as the return chasing effect (Bohn and Tesar, 1996; Brennan and Cao, 1997; Froot et al., 2001; Bekaert et al., 2002; Ülkü and Weber, 2014). There is also evidence of a negative impact of returns on equity flows, called the portfolio rebalancing effect (Bohn and Tesar, 1996; Hau and Rey, 2004, 2008a, 2008b; Tille and Van Wincoop, 2010; Evans and Hnatovska, 2014). We contribute to the existing literature by studying the relationship between US-Canada equity flows and relative asset prices expressed in the same currency. Additionally, as in Chapter 2, we explore disaggregated equity flows.

We estimate a number of VAR-GARCH(1,1) models over the period from 01M1997 until 02M2015. Our results suggest that the RFER has a significant impact on purchases and sales of foreign equity as well as on net purchases of foreign equity.

The behavior of Canadian and US investors with respect to changes in relative equity prices differs. Moreover, there are heterogeneous groups of investors within Canada and the US. According to our results, the portfolio rebalancing effect dominates the behavior of Canadian investors, while the return chasing effect prevails among US investors.

2. VOLATILITY OF INDUSTRIAL PRODUCTION GROWTH AND CHARACTERISTICS OF OPTIMAL CURRENCY AREAS IN EU-12 COUNTRIES

Magister Valentyna Ozimkovska

2.1 Introduction

The establishment of the European Monetary Union (EMU) in 1999 drew the attention of researchers to questions, concerning the impact of the euro on the would be euro-zone economies and the theory of optimum currency areas. The current euro-zone crisis, which was triggered by the global financial crisis, induces researchers to rethink these questions. In 2012 NBER Macroeconomic Annual conference, Krugman gave a speech, published under the name 'Revenge of the Optimum Currency Area' (Krugman, 2012). In his discourse, Krugman emphasizes that the importance of the criteria for optimum currency areas was underestimated, when the decision about the introduction of the euro was made. Eichengreen (2014) also analyzes the importance as well as the drawbacks of the traditional theory of optimum currency areas.

The aim of this research is to analyze how the introduction of the euro and the global financial crisis influenced the short-term volatility of output in the EU-12 countries (Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal and Spain). This research also investigates whether the characteristics of optimum currency areas had an impact on the volatility of output and also looks at how these characteristics have developed over time.

More countries are going to join the euro-zone in the future. Therefore, it is important to know how the introduction of the euro can influence the real economy of these countries. Moreover, it is useful to investigate if the characteristics of the traditional theory of optimum currency areas can help to lower the costs of joining a monetary union. Before the creation of the EMU, the characteristics of optimum currency areas were studied in order to assess the feasibility and the benefits of the EMU. Although the theory of optimum currency areas is very convincing and is frequently cited, no attempt was made in the past to investigate empirically if the characteristics of optimum currency areas reduce costs of adopting a common currency. After the global financial crisis, the growth of some countries of the euro-zone recovered relatively fast. However, other countries slid into the euro-zone crisis. That is why it is important to study the impact of the financial crisis on the volatility of industrial production of the EU-12 countries. It is interesting to identify if the countries with better characteristics of optimum currency areas did not experience an increase in the volatility of industrial production and how the financial crisis influenced the characteristics of optimum currency areas. This can shed some light on the question why some countries of the EU-12 countries stayed in recession or stagnation for years after the financial crisis.

Countries create a monetary union to gain benefits from a common currency, but joining a monetary union also involves costs. The countries profit from reduced information costs, eliminated foreign exchange risks and promoted trade. The cost of the single currency is a loss of monetary autonomy and the transmission of shocks among countries. Adjustments of foreign exchange rates prevent transmission of shocks to macroeconomic fundamentals. The loss of the possibility to adjust currency exchange rates is considered as one of the main disadvantages of a monetary union (Goodhart, 2007). Thus, the introduction of the euro could increase the volatility of output in the euro-zone countries, because their exchange rates would no longer be able to adjust in response to asymmetric shocks.

According to the theory of optimum currency areas, countries can join a monetary union when they fulfill some criteria, which help economies to respond to asymmetric shocks. The main criteria of optimum currency areas are capital and labor mobility (Mundell, 1961), product diversification (Kennen, 1969) and openness of an economy (McKinnon, 1963). These criteria help to mitigate costs of adopting a single currency.

The first literature that studies the potential impact of the euro on real economies and the criteria of optimum currency areas of the EU countries emerged in the early 90s, before the creation of the EMU. Under the project of the EMU, the Commission of the European Communities identifies that the loss of the exchange rate as a shock absorber is a potential cost of the EMU. Emerson (1992) argues, however, that within the EMU the amount of exogenous shocks will decrease and that the single currency still can be managed with respect to the world.

A number of studies evaluate if the countries of the euro area meet the criteria of optimum currency areas, such as the degree of openness and production diversification. Masson and Taylor (1992) conclude that the countries of the euro area as a group have relatively closed economies with respect to the rest of the world. With respect to each other, the economies of the euro area countries are open. This implies that the introduction of the euro should not substantially influence the volatility of production in the euro-zone, because the euro could be adjusted against other currencies. Davies and Lyons (1996) state that the production of the EU countries is diversified. Amiti (1999) studies the specialization trends in the EU countries. Because of the trade liberalization, some countries started to specialize their production in 1968. In the period 1980-1990, all countries show an increase in the specialization. This tendency to specialize increases the influence of asymmetric shocks on macro variables. Moreover, if industries differ substantially among countries, shocks tend to be even more asymmetric. Thus, the introduction of the euro in such countries should increase the volatility of output.

Later literature focuses on the impact of the membership in the European Monetary System (EMS) and the EMU on macroeconomic aggregates. Sopraseuth (2003) investigates international business cycles of the EMS members. According to his results, France, Denmark, Italy and Portugal experienced a decrease in gross domestic product (GDP) volatility under the fixed exchange rate regime over the period 1Q1987-4Q1998, when compared to the floating exchange rate regime over the period 3Q1971-2Q1979. GDP fluctuation did not change significantly in the Netherlands, Germany, Ireland, Austria, Spain and Belgium. The European Commission (European Commission, 2007) analyses how the volatility of output growth in the euro area has changed over the period from 1970 to 2007. The report calculates standard deviations of the euro area GDP growth rates for rolling windows of 5 years. The data show a significant drop in the volatility of output growth in the period 4Q1996-3Q2006. Weyerstrass et al. (2011) investigate business synchronization and business cycle volatility in the euro area. According to their results, after the introduction of the euro, the business synchronization did not change substantially. Business cycle volatility dropped in most countries. Jamil et al. (1995) explore how reduced exchange rate volatility influenced industrial production of 11 European countries. They conclude that the lower real exchange rate volatility of the euro reduced negative impacts on industrial production.

To my best knowledge, there is no research that examines how the introduction of the euro affected short-term volatility of output in the euro zone countries. Moreover, there is no attempt to evaluate if the fulfillment of the criteria of optimum currency areas mitigates costs related to the introduction of a single currency. This research tries to close this gap.

The contribution of this research to the literature is threefold. First, it investigates the impact of the introduction of the euro in the EU-12 countries on the short-term volatility of output, measured by industrial production. Second, it evaluates the criteria of optimum currency areas for each EU-12 country and assesses if more favorable criteria reduce the volatility of industrial production growth. Finally, it investigates the impact of the global financial crisis of 2007-2008, which could be considered as a symmetric shock, on the volatility of industrial production growth and on the characteristics of optimum currency areas.

The results suggest the following. After the introduction of the euro, the volatility of industrial production increased significantly in Finland, Ireland, Italy and Portugal. The increase in volatility in these countries likely occurred because the transmission of shocks to the industrial production increased. The standard macroeconomic theory, which states that the introduction of a single currency increases the volatility of output, is confirmed for only 4 countries among 12. In contrast to the previous finding, after the adoption of the single currency, the volatility of industrial production has not changed significantly in Austria, France, Luxembourg, the Netherlands and Spain. In Germany and Greece, the increase in the volatility of industrial production occurred in 2002 and 1997 respectively. This observation cannot be connected directly to the introduction of the euro. After the start of the financial crisis, the volatility of industrial production increased in all EU-12 countries, except France and Greece. After the financial crisis, the amount of shocks to the industrial production of the EU-12 countries has not changed significantly. In general, the countries, where the volatility of industrial production has not changed significantly, do not exhibit better characteristics of optimum currency areas than those countries, where the volatility of industrial production has increased. The countries, where the volatility of industrial production has not changed significantly after the introduction of the euro, were previously under fixed or pegged exchange rate regimes and recovered faster after the financial crisis.

The remainder of this chapter is organized as follows. The next section explains how the adoption of a common currency influences the volatility of macro variables and briefly discusses the main criteria for optimum currency areas. Sections 2.3 and 2.4 describe the empirical methodology and the data. Section 2.5 provides the empirical results. The last section concludes.

2.2 Theoretical background

When several countries create a monetary union, they agree to fix their exchange rates and lose their monetary autonomy. As a result, the countries of the monetary union cannot adjust their currencies in response to shocks and the impact of the shocks is transmitted to macro variables. This implies that macro variables react stronger to shocks from abroad. Additionally, the reaction of economies to the shocks of domestic origin changes. In both cases the volatility of macro variables increases.

Let us consider a simple monetary model under floating and fixed exchange rate regimes. The model assumes that the aggregated supply curve is vertical. The demand for real money balances is a function of real national income and prices. Purchasing power parity holds. In the case of an expansionary money shock, economic agents increase their spending and this drives up prices. Under the floating exchange rate regime, the domestic currency depreciates. Thus, the economy reaches a new level of equilibrium with a higher level of prices. Under the fixed exchange rate regime, the foreign reserves decrease and the economy returns to the initial level of equilibrium, causing prices that were pushed up by the shock to fall. The fall in prices is considered as a painful process because it decreases production and increases unemployment (Copeland, 2008). Thus, under the fixed regime, the shock is transmitted into the real sector of the economy.

There are also more sophisticated macroeconomic models, which evaluate the impact of fixed exchange rates or the accession to a monetary union. The Dynamic General Equilibrium Model (Duarte, 2002) assumes that monopolistic competitive firms can apply price discrimination in foreign and domestic markets. Prices are set in the buyer's currency. Thus, the law of one price does not hold. As a result, changes in the nominal exchange rate do not affect relative prices of domestic and imported goods. According to the simulations of this model, output and consumption are slightly more volatile under the fixed exchange rate regime than under the floating exchange rate regime.

A stylized New Keynesian model by Aarle et al. (2008) measures how the accession to the euro area influences a small economy. Simulations of this model show that in the case of a positive domestic demand shock, variables such as output volatility, inflation, fiscal deficits and net export are larger under the post-accession regime than under the pre-accession regime. A positive domestic fiscal shock produces similar results. A positive domestic cost-push shock and negative shock to the euro area interest rate cause stronger fluctuations of output and prices in the post-accession case. The impact of a positive shock to the euro area output is similar to the influence of a demand shock, but its effect is smaller. All considered, domestic and foreign shocks evoke stronger output volatility under the post-accession than under the pre-accession regime.

The theory of optimum currency areas defines criteria which mitigate costs of fixed exchange rates. Capital and labor mobility (Mundell, 1961) and product diversifications (Kennen, 1969) help economies to adjust in response to shocks. Another criterion of the theory of optimal currency areas is the degree of openness of the economy (McKinnon, 1963). Mongelli (2002) assigns to this category financial market integration, similarities in inflation rates, fiscal and political integration.

The remainder of this section explains in detail the role of the capital and labor mobility, product diversification and the openness of the economy, since the aim of this research is to analyze the ability of the above-mentioned criteria to impact the short-term volatility of output in the EU-12 countries. As suggested by Mundell (1961), high production factor mobility reduces the need to adjust real factor prices and the nominal exchange rate in periods of disturbances. Mundell (1961) divides the US and Canada not according to the countries' borders, but according to regions, namely, the East and the West. Each of the regions specializes on the production of one product. Due to the rise in productivity, there is an overproduction in the East and increased demand for products from the West, which creates an inflationary pressure in the West. In such a situation, the movements in the Canadian/US dollar exchange rate cannot restore the equilibrium in both regions. There would be either low unemployment at the expense of inflation or restrained inflation at the expense of unemployment. If the factors of production could freely move between the East and the West, new equilibrium levels would be achieved in both regions. Thus, when regions have a high degree of capital and labor mobility, there is no need to have a flexible exchange rate between their currencies.

According to the theory of Kennen (1969), a country with diversified production will export a wide range of products. When a shock hits one kind of exportable goods, the demand for another kind of exportable goods can increase. Thus, the shocks can offset each other, having no impact on the total level of output. If the production is highly concentrated in one area, the shock is likely to influence the level of output. This theory works, however, only in the normal course of events. Some shocks can influence all exportable goods. An example of such a shock is general inflation, which is a process of rising overall prices in the economy.

McKinnon (1963) argues that, in an economy with a high level of openness, adjustments of the exchange rate are ineffective for controlling the external balance. Moreover, such adjustments are damaging for internal price stability. When a country has a large share of exportable and importable goods in the consumption and the prices of non-tradable goods are constant in terms of the domestic currency, exchange rate movements will directly influence the prices of imports and exports. The prices of tradable goods will also change with respect to non-tradable goods.

Thus, in an economy with a high degree of openness, exchange rates are unlikely to adjust, even if the country has monetary autonomy. That is why fixing exchange rates in economies with a high degree of openness should not influence the volatility of production.

2.3 Empirical methodology

2.3.1 Tests for change in volatility

Several econometric tests can be employed to examine if the volatility of industrial production growth has changed after the introduction of the euro and after the start of the financial crisis. First, the basic F-test of equality of variances checks if the variance of industrial production of the EU-12 countries differ across sub periods:

$$F = \frac{S_i}{S_{i+1}} \tag{2.1}$$

where S_i is variance of sub sample i (Hays, 1994).

The measured variance can, however, change due to the changes in the mean as well as due to the changes in volatility. As I am interested in determining the changes in the volatility of industrial production growth, I apply the Chow breakpoint test to the transformed residuals from the Autoregressive Moving Average (ARMA (p,q)) model and to the conditional volatility obtained from the Autoregressive Exponential General Autoregressive Conditional Heteroskedastic (AR(p)-EGARCH(1,1)) model. The Chow test is appropriate for this research, because its aim is to test the hypotheses of the structural break at specific dates (the introduction of the euro and the start of the financial crisis). For the purpose of this test, the data can be divided into reasonably large sub samples. I apply the Chow test based on the Wald statistic, as it does not assume that the disturbance variance is the same in the regressions across both subsamples. In contrast to the Chow test based on the Wald statistic, the Chow test based on the F-statistic, for example, needs this assumption.

I estimate the ARMA (p,q) model of industrial production growth for each EU-12 country. For the diagnostic of the model the following tests are applied. The Breusch-Godfrey Serial Correlation LM test checks if the residuals are serially correlated. The Breusch-Pagan-Godfrey test checks residuals for heteroscedasticity. The lag order of the ARMA (p,q) models are chosen so that the residuals of the models are not serially correlated. Additionally, the Akaike Information Criteria are used to identify if some other lags of AR or MA terms should be included into the models.

Following the procedure by McConnell and Perez-Quiros (2000), the residuals

($\hat{\varepsilon_t}$) from the estimated ARMA(p,q) model are transformed into the following form:

$$\bar{\varepsilon}_t = \sqrt{\frac{\pi}{2}}|\hat{\varepsilon}_t| \tag{2.2}$$

McConnell and Perez-Quiros (2000) argue that $\bar{\varepsilon}_t$ are unbiased estimators of the standard deviation of the errors ε_t under the assumption of a normal distribution.

Next, using the Chow test, I test for a structural break in the equation:

$$\bar{\varepsilon}_t = c + u_t \tag{2.3}$$

where c is the estimator of the standard deviation and u_t are residuals.

The Chow test is calculated as follows. Suppose that $\hat{\Theta}_1$ and $\hat{\Theta}_2$ are two consistent and asymptotically normally distributed estimators based on two independent subsamples. $\mathbf{V}_1$ and $\mathbf{V}_2$ are asymptotic covariance matrices. $\hat{\Theta}_1 - \hat{\Theta}_2$ has the zero mean and an asymptotic covariance matrix $\mathbf{V}_1 - \mathbf{V}_2$ under the null hypothesis that the true parameters are the same. Thus, the Wald statistic

$$W = (\hat{\Theta}_1 - \hat{\Theta}_2)'(\mathbf{V}_1 - \mathbf{V}_2)^{-1}(\hat{\Theta}_1 - \hat{\Theta}_2) \tag{2.4}$$

has a limiting chi-squared distribution with k degrees of freedom, where k is the number of parameters in the equation (Greene, 2002).

In the next step, I check if the skewness and kurtosis of the residuals from the ARMA (p,q) models changed after the introduction of the euro and after the start of the financial crisis. Increased skewness and kurtosis would indicate that the transmission of shocks to the industrial production growth in the EU-12 countries increased. The distribution of residuals is skewed when there are large, infrequent and typically negative shocks. The distribution shows excess kurtosis when large positive or negative shocks are more frequent compared to the normal distribution (Blanchard and Simon, 2001). I check if the skewness and excess kurtosis are significant as well as if they significantly differ in the sub periods after the introduction of the euro and after the start of the financial crisis.

In addition to the procedure of McConnell and Perez-Quiros (2000), I obtain the conditional volatility of industrial production growth from the AR(p)-EGARCH(1,1) model. The advantage of the EGARCH model is that it captures most stylized facts of volatility such as excess kurtosis and volatility clustering. The EGARCH model does not impose non-negative constraints on the parameters and reduces the effect of outliers on the estimated results (Jamil et al., 1995). The Chow breakpoint test is also applied to the conditional volatility obtained from the AR(p)-EGARCH(1,1) model.

Finally, the Quandt-Andrews test for unknown breakpoints checks if the volatility of industrial production growth has changed during a period other than the one assumed in the analysis (Andrews, 1993; Andrews et al., 1994). This procedure is useful, since agents can form their expectations before the defined date or can react with lags. Furthermore, there is no consensus on the date, which should mark the beginning of the financial crisis. The Quandt-Andrews test calculates the Chow test statistics at every observation between two dates τ_1 and τ_2. The calculated k Chow test statistics are summarized in three ways. The maximum statistic is the maximum of individual Chow F-statistics:

$$Max\ F = max_{\tau_1 \leq \tau \leq \tau_2}(F(\tau)) \tag{2.5}$$

The Exponential statistics has the following form:

$$Exp\ F = ln\{\frac{1}{k}\sum_{\tau=\tau_1}^{\tau_2} exp(\frac{1}{2}F(\tau))\} \tag{2.6}$$

The Average statistic is the average of the individual F-statistics:

$$Ave\ F = \frac{1}{k}\sum^{\tau_2} F(\tau) \tag{2.7}$$

2.3.2 Measurement of criteria of optimum currency areas

In order to evaluate the criteria of optimum currency areas within the EU-12 countries, I study the degree of capital mobility, openness of the economy and the production diversification of these countries. The empirical part of this research does not cover labor mobility, because labor mobility can compensate for shocks only over the medium or long-run horizon. In the EU, workers face language, cultural and educational differences. This imposes restrictions on the ability of workers to change their place of residency and employment. Because this chapter analyzes monthly volatility, it would be inappropriate to assume that labor mobility can help economies to respond to shocks over a short-term period.

After July 1990, capital movements between the member states of the EMS were liberalized. Spain, Greece, Ireland and Portugal had transitional agreements that were designed to last several years (Council Directive, 1988). The EU-12 countries abolished restrictions on capital movements by January of 1999. Despite the absence of legal restrictions on capital movements, it is useful to check if capital mobility differs across the EU-12 countries. Lower capital mobility in some countries could indicate that their capital movements do not compensate for asymmetric shocks which are transmitted into the industrial production.

There is no widely accepted approach how to measure capital mobility. Montiel (1994) describes existing empirical methods and their limitations. Not all of these methods can be applied to countries that are members of a monetary union, for example, the test of monetary autonomy. The approach which also can be used for countries, that are members of a monetary union, considers the magnitude of capital flows expressed as a percentage of GDP. When a country is highly integrated into the global financial market, its residents are able to lend and borrow from residents of other countries thereby increasing capital flows (Golub, 1990). Despite the fact that the equalization of the financial asset prices reduces the incentives for capital movements, agents reallocate their portfolios in response to the change in the global financial prices. This also generates capital flows (Montiel, 1994). This approach measures the integration to the global financial market. As the economies of a monetary union are a part of the global economy, this approach captures also the integration in the monetary union. Moreover, the capital mobility between the countries of the monetary union and the countries of the rest of the world can also help economies to adjust in response to shocks. That is why the magnitude of capital flows expressed as a percentage of GDP can be used in this chapter to measure capital mobility of the EU-12 countries.

As this chapter studies short-term volatility of output, the measurement of capital mobility includes only those capital flows that can adjust in the short-term. Such capital flows are portfolio investment assets and liabilities and other investment assets and liabilities. Capital flows in derivatives are excluded from the analysis because the size of capital flows in derivatives is small comparing to the size of other capital flows and the data on these flows are incomplete. Thus, the ratio which measures capital mobility is as follows:

$$CapitalMobility = \frac{PIA + PIL + OIA + OIL}{GDP} \tag{2.8}$$

where PIA is portfolio investment assets, PIL is portfolio investment liabilities, OIA is other investment assets, OIL is other investment liabilities, and GDP is gross domestic product.

The most applied ratio, which measures the degree of the openness of an economy, is the trade intensity ratio:

$$TradeIntensityRatio = \frac{X + M}{GDP} \tag{2.9}$$

where X and M are exports and imports respectively, GDP is the gross domestic product.

In the theory of optimum currency areas, McKinnon (1963) defines the degree of openness of the economy as the ratio of tradable to non-tradable goods. Tradable goods are those that can enter into foreign trade. Non-tradable goods cannot enter into foreign trade because they cannot be transported. Thus, the trade intensity ratio is an appropriate measure of the degree of openness as defined by McKinnon (1963).

The GINI coefficient is a measure of inequality of a distribution. This method can be used to measure the degree of industry diversification. Helg et al. (1995) and Amiti (1999) use the GINI coefficient to study specialization trends of industries within the EU. In order to measure the degree of the production diversification in the EU-12 countries, the GINI coefficient (Deaton, 1997) is calculated as follows:

$$G = \frac{N+1}{N-1} - \frac{2}{N(N-1)u}\left(\sum_{i=1}^{N} P_i X_i\right) \tag{2.10}$$

where N is the number of observations, X_i is the production of sector i, u is the mean industry production, P_i corresponds to the rank of industry i, which are indexed in non-decreasing order. Higher values of $GINI$ coefficients indicate a higher degree of specializations. Thus, countries with low values of $GINI$ coefficient have a high degree of production diversification.

In this chapter, I try to assess if the countries, where the change in volatility of industrial production is not significant, have better characteristics of optimum currency areas. For this purpose, I employ Spearman's rank correlations of Chow statistics and levels of characteristics of optimum currency areas. The Chow statistic indicates the likelihood of the structural break in volatility of industrial production. The lower the Chow statistic is the more likely it is that volatility of industrial production remained unchanged after the introduction of the euro. Therefore, there should be positive correlation between levels of characteristics of optimum currency areas and the likelihood that the volatility of industrial production remains unchanged for the EU-12 countries.

The Spearman's rank correlation (ρ) for two variables for a sample size of n is calculated in the following way:

$$\rho = 1 - \frac{6\sum d_i^2}{n(n^2-1)} \tag{2.11}$$

where d_i is a difference between ranks of two variables (Myers et al., 2010).

2.4 Data

In January 1999, the euro was introduced in Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, the Netherlands, Portugal and Spain. Greece adopted the euro in January 2001. I study the volatility of industrial production of the EU-12 countries, mentioned above, because since the introduction of the euro in these countries, significant time has passed. It allows comparing the periods before and after the introduction of the euro. I use industrial production growth of all Organization for Economic Cooperation and Development (OECD) countries as a proxy for the global industrial production growth.

The period from 06M1993 until 06M2013 is the most suitable for this research. In the middle of 1993 most countries of the EMS abandoned the fixed exchange rate mechanism and their currencies could fluctuate within the band of +/- 15 %, which de facto represented a floating exchange rate regime. The exception was the Dutch guilder, which stayed pegged within the range of +/- 2.5%. Austria joined the EMS in 1995 and continued its hard currency policy, fixing the Austrian schilling to the German mark. Even though the exchange rates of Austria and the Netherlands were not allowed to fluctuate, I keep these countries in the sample. It is interesting to see if the introduction of the euro had a different impact on the volatility of industrial production of the countries, where the exchange rate was more strictly fixed relative to those currencies that were allowed to fluctuate within the range of +/- 15 %.

The start of the liquidity crisis in the middle of 2007 can be considered as the beginning of the global financial crisis. This time period can also signal the change in the volatility of the industrial production. There is, however, no consensus regarding the starting date of the global financial crisis. The Quandt-Andrews test helps to verify if the structural break happened at some other time period. The comparison of the sub-periods 01M1993-12M1998 (12M2000 for Greece), 01M1999 (01M2001 for Greece)-06M2007 and 07M2007-06M2013 can reveal how the introduction of the euro and the start of the financial crisis affected the short-term volatility of output.

Industrial production growth can be used to evaluate short-term volatility. The data on industrial production are available on a monthly basis and provide a higher number of observations than the data on GDP. It represents, however, only around 20% of the aggregated GDP in the EU-12 countries. As investors make their decisions based on the short-term data, it is important to study how the introduction of the euro influenced the volatility of industrial production. GDP data, available on quarterly basis, can be used to study only longer-term volatility. Industrial production is also used by Baxter and Stockman (1989), Flood and Rose (1995) and Kim (2000). Following the procedure by Rose and Spiegel (2012), I check if there is a connection between the short-term volatility of industrial production and recession in the EU-12 economies. Rose and Spiegel use time series such as GDP, values of main national stock indexes and credit ratings of economies.

In order to evaluate the criteria of optimum currency areas in the EU-12 countries, I measure the degree of capital mobility, the openness of the economy and production diversification. Due to the lack of data, some ratios are calculated over time periods shorter than from 06M1993 to 06M2013. In particular, the data on portfolio investment assets and portfolio investment liabilities for Belgium and Greece are available over the period 1Q1999-2Q2013. The data on production across sectors (Table A.1) for EU-12 countries except Ireland and Portugal are available over the period from 1993 until 2008. The data on production across sectors (Table A.1) for Ireland and Portugal are available over the periods 1999-2008 and 1993-2006 respectively. The following time series are not available for Luxembourg: portfolio investment assets, portfolio liabilities, other investment assets and other investment liabilities.

Table 2.1 summarizes the time series applied in this research, their characteristics and sources. As not all data are seasonally adjusted, I adjust time series with X-12 procedure when necessary. The X-12 procedure is based on the moving seasonality ratio. The moving seasonality ratio is a measure of the average change in the irregular component divided by the average change in the seasonal series for the entire series. The irregular component is estimated by dividing the seasonal component into detrended series.

2.5 Empirical results

2.5.1 Volatility of the industrial production growth

This section describes the results of tests which check if the volatility of industrial production growth has changed after the introduction of the euro and after the start of the financial crisis. Table 2.2 displays the standard deviation of the industrial production growth in three sub periods: 06M1993-12M1998, 01M1999-06M2007 and 07M2007-06M2013. The F-test in Table 2.2 indicates if the variance of industrial production growth changed after the adoption of the euro and after the financial crisis.

According to Table 2.2, Italy has the lowest level of standard deviation of industrial production growth before the introduction of the euro. Belgium and France have the lowest levels of standard deviation of industrial production growth after the introduction of the euro and after the start of the financial crisis respectively.

Tab. 2.1: Description of the time series applied in this research

Time series	Units of measurement	Frequency	Seasonal adjustments	Source
Production of total industry of EU-12 countries (applied in differences)	Index	Monthly	SA	Industry and Services statistic, OECD statistic database
Portfolio investment assets, portfolio liabilities	US dollar	Quarterly	NA	Balance of Payment statistic, IFS Statistic database
Other investment assets, other portfolio liabilities	US dollar	Quarterly	NA	Balance of Payment statistic, IFS Statistic database
International trade exports	US dollar	Quarterly	SA	International Trade and Balance of Payment statistic, OECD statistic database
International trade imports	US dollar	Quarterly	SA	International Trade and Balance of Payment statistic, OECD statistic database
Historical GDP (expenditure approach)	US dollar	Quarterly	SA	National Account statistic, OECD statistic database
Production across sectors*	Euro	Yearly	NA	Industry and Services statistic, OECD statistic database
National stock market indexes**	Index	Quarterly	NA	Obtained from the Datastream database
Credit rating of EU-12 countries	Indicator	Quarterly	NA	Oxford Economics database, obtained from the Datasream database

Note: SA-time series are seasonally adjusted, NA-time series are not seasonally adjusted.
*Tables A.1 and A.2 of Appendix A exhibits the list of sectors.
** Stock market indexes used in this chapter are Austria ATX, Belgium 20, Finland OMX Helsinki 25, France CAC 40, Greece FTSE Athex Large Capital, Germany DAX 30 Performance, Ireland ISEQ, Italy Mibtel, Luxembourg Luxx, the Netherlands AEX Index, Portugal PSI-20, Spain IBEX 35.

Tab. 2.2: Standard deviation of the industrial production growth and the results of the F-test for equality in variances

Country	Standard deviation 06M1993-12M1998	Standard deviation 01M1999-06M2007	Standard deviation 07M2007-06M2013	F-statistic (p value) 06M1993-12M1998/ 01M1999-06M2007	Change in variance after the introduction of the euro	F-statistics (p value) 01M1999-06M2007/ 07M2007-06M2013	Change in variance after the financial crisis
Austria	1.30	1.28	1.89	1.03 (0.92)	Equal	2.17 (0.00)	Increased
Belgium	1.75	1.15	1.69	2.31 (0.00)	Decreased	2.17 (0.00)	Increased
Finland	1.08	2.20	2.82	4.15 (0.00)	Increased	1.64 (0.03)	Increased
France	1.19	1.37	1.51	1.32 (0.21)	Equal	1.22 (0.38)	Equal
Germany	0.99	1.24	1.97	0.58 (0.04)	Increased	2.51 (0.01)	Increased
Greece	2.19	2.74	3.27	1.56 (0.04)	Increased	1.43 (0.11)	Equal
Ireland	1.16	5.22	5.22	20.27 (0.00)	Increased	1.00 (0.99)	Equal
Italy	0.98	1.27	1.79	1.70 (0.02)	Increased	1.99 (0.00)	Increased
Luxembourg	3.56	3.03	4.08	1.38 (0.16)	Equal	1.81 (0.01)	Increased
Netherlands	1.77	1.84	3.29	1.07 (0.74)	Equal	3.21 (0.00)	Increased
Portugal	2.58	2.95	3.36	1.31 (0.22)	Equal	1.30 (0.24)	Equal
Spain	1.48	1.59	1.70	1.16 (0.51)	Equal	1.13 (0.58)	Equal

Luxembourg has the highest level of standard deviation of industrial production growth during all three sub periods. The reason of this can be that the greatest part of the economy of Luxembourg consists of finance, insurance, real estate and business services which are more volatile than other sectors of the economy.

The F-test suggests that after 01M1999 the variance of industrial production growth increased in Finland, Germany, Greece, Ireland and Italy. It is interesting that after the introduction of the single currency, the variance of industrial production decreased in Belgium. The reduced real volatility of the euro could also have a stabilizing effect on the economy of Belgium as it is shown by Jamil et al. (1995). In the remaining countries, the variance of industrial production growth has not changed. According to the results of the F-test, the start of the financial crisis influenced the variance of the following seven countries within the sample: Austria, Belgium, Finland, Germany, Italy, Luxembourg and the Netherlands. The variance in these countries increased. In the rest of the countries, the variance has not changed.

Because the change in the measured variance can be caused by the change in the mean as well as by the volatility changes, I proceed with a number of tests for structural breaks in the volatility of industrial production growth of the EU-12 countries. First, I estimate a univariate ARMA (p,q) model for each of the EU-12 countries across two subsamples: 06M1993-12M1998 and 01M1999-06M2013. According to the results of the diagnostic tests, all coefficients in the estimated equations are significant. The results of the tests suggest that the residuals are homoscedastic and errors are serially uncorrelated.

Tab. 2.3: The results of the Chow structural break test for the univariate ARMA (p,q) model

Country	Test for structural break in variance, Chow statistic (p value) 01M1999	Change in variance after the introduction of the euro	Test for structural break in variance, Chow statistic (p value) 07M2007	Change in variance after the financial crisis
Austria	0.07 (0.79)	Equal	10.40 (0.00)***	Increased
Belgium	1.80 (0.18)	Equal	4.95 (0.03)**	Increased
Finland	14.83 (0.00)***	Increased	0.17 (0.68)	Equal
France	1.23 (0.27)	Equal	0.42 (0.52)	Equal
Germany	5.85 (0.01)**	Increased	6.44(0.01)***	Increased
Greece	1.83 (0.18)	Equal	1.17 (0.28)	Equal
Ireland	34.17 (0.00)***	Increased	0.49 (0.48)	Equal
Italy	1.79 (0.18)	Equal	4.53 (0.03)**	Increased
Luxembourg	0.74 (0.39)	Equal	13.66 (0.00)***	Increased
Netherlands	1.72 (0.19)	Equal	13.66 (0.00)***	Increased
Portugal	2.89 (0.09)*	Increased	1.46 (0.23)	Equal
Spain	0.00 (0.98)	Equal	0.43 (0.51)	Equal

Table 2.3 reports the Chow statistic which is applied to the transformed residuals from the ARMA (p,q) models. The Chow statistic suggests that from those countries, whose variance changed according to the F-test, Finland, Germany and Ireland have a structural break in the volatility of industrial production growth after the introduction of the euro. The null hypothesis of no structural break in volatility can be rejected at the 10% significance level for Portugal. The variance of industrial production growth of Portugal has not, however, changed after 10M1999 according to the F-test.

According to the Chow statistic, the volatility of industrial production growth of Austria, Germany, Italy, Luxembourg and the Netherlands increased after the start of the financial crisis. Also, the F-test shows increased variance in these countries after 07M2007. The results of the F-test also suggest that the variance of industrial production growth increased in Finland. The Chow test does not show a structural break in the volatility for Finland after the start of the financial crisis.

As the change in the volatility of industrial production growth after the introduction of the euro can be caused by other factors, such as global development, I include the industrial production growth of all OECD countries in the ARMA (p,q) models. The industrial production of the OECD countries is an approximation for the global industrial production growth. This variable captures global factors that could influence the volatility of the industrial production of the EU-12 countries.

The industrial production growth of the OECD countries and its lagged values are significant at least at the 5% significance level for all countries except Luxembourg. Thus, it is a useful control variable. For Luxembourg, neither OECD industrial production growth nor its lagged values are significant over the period 06M1993-06M2007. The results of the Chow test applied to the transformed residuals from the ARMA (p,q) model with a control variable are reported in Table 2.4.

First, I analyze the period 06M1993-06M2007. For Finland, Ireland and Portugal both results from the univariate ARMA(p,q) model and the results from the ARMA(p,q) model with OECD control variable show a structural break in volatility in 01M1999. After including the OECD variable into the regression, the Chow test does not identify any structural breaks for Germany in 01M1999. Additionally, it shows a structural break in the variance for Belgium and for Greece (at the 10% significance level).

Tab. 2.4: The results of the Chow structural break test for the ARMA (p,q) model, where OECD industrial production model and/or its lagged values are included as an independent variable

Country	Test for structural break in variance Chow statistic (p value) 01M1999	Change in variance after the introduction of the euro	Test for structural break in variance Chow statistic (p value) 07M2007	Change in variance after the financial crisis
Austria	0.67 (0.41)	Equal	14.94 (0.00)***	Increased
Belgium	16.09 (0.00)***	Decreased	7.35 (0.01)***	Increased
Finland	15.94 (0.00)***	Increased	0.33 (0.57)	Equal
France	0.25 (0.62)	Equal	0.33 (0.57)	Equal
Germany	2.02 (0.16)	Equal	14.57 (0.00)***	Increased
Greece	3.63 (0.06)*	Increased	0.46 (0.50)	Equal
Ireland	30.06 (0.00)***	Increased	0.19 (0.66)	Equal
Italy	0.021 (0.89)	Equal	10.43 (0.00)***	Increased
Luxembourg	-	-	1.33 (0.25)	Equal
Netherlands	0.64 (0.43)	Equal	13.46 (0.00)***	Increased
Portugal	4.04 (0.05)**	Increased	0.06 (0.81)	Equal
Spain	0.00 (0.98)	Equal	3.47 (0.06)*	Increased

According to the results of the Chow test, applied to the residuals of the ARMA(p,q) models with the control variable, there is a structural break in volatility of industrial production growth in Austria, Germany, Italy and the Netherlands after the start of the financial crisis. The Chow test, applied to the univariate ARMA(p,q) model, shows similar results. Additionally, the former methodology shows a structural break in the volatility for Belgium and Spain (at the 10% significance level) and does not confirm the structural break in the volatility for Luxembourg. In general, the results of the Chow test, applied to the univariate ARMA(p,q) model, are confirmed by the results from the ARMA (p,q) model with the control variable. Some differences, however, exist.

Further on, I carry out the Chow test for a structural break in the conditional variance obtained from the AR(p)-EGARCH(1,1) models. Table 2.5 represents the results. AR(p)-EGARCH(1,1) is regressed for every country and contains p autoregressive terms and OECD industrial production growth as an explanatory variable. All explanatory variables are significant at least at the 5% significance level. According to the ARCH LM test and the correlogram of squared residuals, there is no evidence of heteroscedasticity in the models and errors are serially uncorrelated.

The Chow test shows a structural break in the conditional variance in 01M1999 for Belgium, Finland, Ireland and Portugal. These results are consistent with the results of the Chow test, applied to the ARMA(p,q) models with the OECD variable. Additionally, the results of the Chow test suggest that there is a structural break in the conditional variance in 01M1999 for Italy. More countries experienced an increase in the volatility after the start of the financial crisis according to the results obtained from the AR(p)-EGARCH(1,1) models than according to the results obtained from the ARMA(p,q) models with the OECD variable. In addition to Austria, Belgium, Germany, Italy, the Netherlands and Spain, the results from the AR(p)-EGARCH(1,1) model indicate a structural break in the conditional variance of the industrial production growth in Finland, Ireland and Portugal.

Tab. 2.5: The results of the Chow structural break test for the AR(p)-EGARCH (1,1) model

Country	Test for structural break in conditional variance Chow Statistic (p value) 01M1999	Change in conditional variance after the introduction of the euro	Test for structural break in conditional variance Chow Statistic (p value) 07M2007	Change in conditional variance after the financial crises
Austria	1.40 (0.24)	Equal	17.76 (0.00)***	Increased
Belgium	47.72 (0.00)***	Decreased	21.14 (0.00)***	Increased
Finland	37.28 (0.00)***	Increased	6.78 (0.01)***	Increased
France	0.79 (0.38)	Equal	0.01 (0.94)	Equal
Germany	0.86 (0.35)	Equal	99.14 (0.00)***	Increased
Greece	0.06 (0.81)	Equal	0.31 (0.31)	Equal
Ireland	3.43 (0.06)*	Increased	7.73 (0.01)***	Increased
Italy	39.92 (0.00)***	Increased	12.66 (0.00)***	Increased
Luxembourg	0.86 (0.35)	Equal	0.05 (0.83)	Equal
Netherlands	2.65 (0.10)	Equal	431.55 (0.00)***	Increased
Portugal	58.62 (0.00)***	Increased	31.37 (0.00)***	Increased
Spain	1.01 (0.31)	Equal	33.34 (0.00)***	Increased

The Quandt-Andrews test for unknown structural breakpoint verifies if the volatility of industrial production growth of the EU-12 countries changed at the dates other than 01M1999 or 07M2007. I apply the Quandt-Andrews test to the conditional variances, obtained from the AR(p)-EGARCH(1,1) models, over the sub periods 06M1993-06M2007 and 01M1999-06M2013. In the first sub-period, the Quandt-Andrews test shows a structural break in the conditional variance for Belgium, Finland, Ireland, Italy and Portugal. The Chow test for a known breakpoint suggests the same results for these countries. Additionally, the Quandt-Andrews test suggests that there is a structural break in the conditional variance over the period 06M1993-06M2007 for Greece and Germany. Over the period 01M1999-06M2013, the Quandt-Andrews test does not identify any countries with a structural break in the conditional variance in addition to the ones identified by the Chow test.

The Quandt-Andrews test shows that the maximum Chow breakpoint test statistics are in 05M2002 in Germany and in 06M1997 in Greece. This means that 05M2002 and 06M1997 are the most likely breakpoint locations for Germany and Greece respectively. The volatility of industrial production growth in Greece could have increased as a result of the monetary policy, the aim of which was to fulfill the Maastricht criteria. In particular, starting from 1995, the Central Bank of Greece tried to limit the depreciation of drachma with respect to the European Currency Unit (ECU) to 3%. The Central Bank also aimed to reach a monetary expansion of 7-9% growth in M3 and to lower the inflation to 8%. These aims were reached by 1997. The increase in the volatility of industrial production growth of Germany after 05M2002 can be related to the burst of the Dot-com bubble. The DAX-30 index has declined by 68% from its peak in 03M2000 to its lowest level in 03M2003. It is possible that the turmoil on the financial market affected the real economy after the collapse of the bubble.

To summarize, the volatility of industrial production growth has not changed significantly after the introduction of the euro in Austria, France, Luxembourg, the Netherlands and Spain. The results of the tests for a structural break suggest that in Greece the volatility increased as a result of the fulfillment of the Maastricht agreement in 06M1997, but did not change after the introduction of the euro. In Germany, the volatility increased in 05M2002, probably due to the Dot-com crisis. After the introduction of the euro, the change in the volatility of Finland, Ireland, Greece and Portugal likely happened because of the transmission of shocks. The residuals from the multivariate ARMA (p,q) model for these countries display increased kurtosis or skewness. The skewness of residuals changed from positive to negative after 01M1999. Belgium is the only country of the EU-12, where the volatility of industrial production growth decreased after the adoption of the euro. This can happen if the benefits of adopting a single currency exceed the costs.

In general, the analysis of how the introduction of the euro influenced the short-term volatility of industrial production reveals results different from the results of the analysis performed on GDP volatility. For example, Sopraseuth (2003), European Commission (2007) and Weyerstrass et al. (2011) find that the volatility of GDP has decreased or stayed unchanged after the adoption of the euro. The different results can be explained by the fact that GDP data are available on quarterly basis and, therefore, have a lower number of observations than industrial production. Furthermore, for some EU countries, GDP is calculated by using lower than quarterly data frequency from which the quarterly values are extrapolated. This leads to data smoothing and can lower output volatility.

The beginning of the financial crisis affected the volatility of the industrial production growth of almost all EU-12 countries. The evidence suggests that in all EU-12 countries except France and Greece, the volatility of industrial production growth increased after the start of the financial crisis.

The kurtosis of residuals from the multivariate ARMA (p,q) model increased for Belgium and the Netherlands. The change of skewness of the residuals from negative to positive happened only for Spain. These are somewhat surprising results as they suggest that the change in the volatility of industrial production growth was not caused by shocks. I would expect, however, that the start of the financial crisis increased the frequency and magnitude of shocks in the analyzed economies.

In less than a decade after the introduction of the euro, the euro-zone countries were hit by the global financial crisis. The growth of economies of some euro-zone countries recovered. However, several countries stayed in years of recession or stagnation. Because high short-term volatility implies higher uncertainty and risk, there may be a connection between the fact that in some countries the volatility of industrial production increased after the introduction of the euro and the fact that some countries have not recovered after the global financial crisis.

Rose and Spiegel (2012) use the differences of post- and pre-crisis levels of GDP, country credit rating from institutional investors and country's main stock indexes to determine if the economy of a specific country recovered after the financial crisis. In order to combine the three factors: levels of GDP, countries' credit ratings from institutional investors and countries' main stock indexes, I extract a common component from these variables. Following the procedure of Rose and Spiegel (2012), the method of principal components is applied to these factors for the EU-12 countries for the time period between 01Q2014 and 02Q1998.

The method of principal components forms a linear combination of the following variables: the differences of post- and pre-crisis levels of GDP, countries' credit ratings from institutional investors and countries' main stock indexes (see Table 2.6). The principal components are obtained by computing eigenvalues of $(X'X)$, where X is the matrix of these variables (see Johnson and Wichern (1992) for details). This procedure creates one measure instead of three variables. The differences of post- and pre-crisis levels of the principal components show if the countries have recovered after the financial crisis.

If the difference of post- and pre-crisis levels of the principal components is negative, it means that the common component of the factors: levels of GDP, countries' credit ratings from institutional investors and countries' main stock indexes is lower in the post-crisis period than in the pre-crisis period. Thus, the countries with negative differences of post- and pre-crisis levels of the principal component have not reached their pre-crisis level of GDP, country credit rating from institutional investors and country's main stock indexes. This means that these countries have not recovered after the crisis. A positive difference in the principal component indicates that the economies reached their pre-crisis level in 01Q2014 and have recovered after the crisis.

Table 2.6 shows that countries with negative principal components are Finland, Greece, Ireland, Italy, Portugal and Spain. This means that, in general, GDP, credit ratings and stock indexes of these countries have not reached the pre-crisis levels. Thus, it can be assumed that the economies of these countries still have not recovered after the financial crisis. The striking fact is that among the countries that have not recovered after the financial crisis all but Spain experienced an increase in volatility after the introduction of the euro.

2.5.2 Capital mobility

The aim of the following three subchapters is to assess if the countries, where the change in the volatility of industrial production after the introduction of the euro and after the start of the financial crisis is insignificant, have better characteristics of optimum currency areas than those countries where the volatility of industrial production growth has significantly increased. Because the data for production diversification of the EU-12 countries are available only on a yearly basis prior to 2007, it is not feasible to carry out formal econometric techniques. To accomplish this task, I calculate the average values for characteristics of optimum currency areas over the three subsamples and compare if the countries, where the change in the industrial production volatility is not significant, have more favorable levels of

Tab. 2.6: Verification of countries whose economies have not recovered after the financial crisis

Country	Difference in cumulative GDP growth between periods 04Q2000-01Q2014 and 04Q2000-02Q1998	Absolute difference in credit rating between 01Q2014 and 02Q1998	Relative difference of the national stock index between 01Q2014 and 02Q2008	Difference in principal components between 01Q2014 and 02Q1998	Increase in the volatility industrial production after 1999
Austria	8.80	-0.33	0.34	1.22	
Belgium	6.04	-1.33	0.23	0.85	
Finland	-21.97	0,00	-0.02	-0.13	Increased
France	6.31	-1.33	0.12	0.64	
Germany	15.5	0,00	0.82	2.21	
Greece	0,00	-11.33	-0.42	-1.19	Increased in 1997
Ireland	-20.37	-7.67	0.29	-0.73	Increased
Italy	-35.28	-4.67	-0.73	-2.32	Increased
Luxembourg	3.40	0,00	0.34	1.13	
Netherlands	-12.63	-0.33	0.11	0.28	
Portugal	-27.53	-8.67	0.39	-0.91	Increased
Spain	-27.9	-8.33	0.28	-1.05	

capital mobility, openness and production diversification. Additionally, I calculate Spearman's rank correlations of Chow statistics and levels of characteristics of optimum currency areas. Table 2.7 does not include Luxembourg, because the data necessary to calculate capital mobility for Luxembourg are not available. The analysis does not consider Austria and the Netherlands, because the exchange rates of these countries were not allowed to fluctuate within the broad range of +/- 15%. Tables 2.7, 2.8 and 2.9 show the values for the characteristics of optimum currency areas of these countries for the sake of clarity. The analysis considers Belgium in the same way as the countries with unchanged volatilities, because the volatility of Belgium decreased after the introduction of the euro and such changes are favorable for the economy.

Table 2.7 presents the level of capital mobility for the EU-12 countries over the three sub-periods: 3Q1993-4Q1998, 1Q1999-2Q2007, 3Q2007-2Q2013. The countries are arranged in ascending order according to the level of capital mobility. The shaded area indicates the countries where the change in the volatility of industrial production has not been found to be significant after the introduction of the euro or after the start of the financial crisis.

The theory of optimum currency areas assumes that countries with unchanged volatility have a higher level of capital mobility, because capital flows should adjust

Tab. 2.7: Capital mobility

3Q1993-4Q1998		1Q1999-2Q2007		3Q2007-2Q2013	
Spain	0.027	Italy	0.045	Italy	0.061
Italy	0.031	Greece	0.055	Spain	0.075
France	0.035	Spain	0.061	Germany	0.086
Germany	0.036	Germany	0.065	Austria	0.101
Austria	*0.039*	Portugal	0.072	Portugal	0.111
Portugal	0.041	France	0.093	France	0.119
Finland	0.042	Finland	0.114	Greece	0.171
Netherlands	*0.081*	*Austria*	*0.116*	Netherlands	0.227
Ireland	0.192	*Netherlands*	*0.163*	Belgium	0.283
Belgium	NA	Belgium	0.176	Finland	0.296
Greece	NA	Ireland	0.756	Ireland	0.763

instead of exchange rates in case of shocks. According to Table 2.7, the countries where volatility of industrial production has not significantly changed after the introduction of the euro, do not have the highest level of capital mobility. Spain, for example, has one of the lowest levels of capital mobility. Belgium, where the volatility of industrial production has decreased, has the highest level of capital mobility after Ireland. Ireland, being the country with the highest level of capital mobility, has experienced an increase in the volatility of industrial production. Thus, the high level of capital mobility does not assure that shocks in an economy will be compensated after the introduction of a single currency. Indeed, Krugman (2012) argues that the introduction of the single currency in the euro zone made investors believe that the cross-border risks were eliminated. This caused a large movement of capital from the core countries like Germany and the Netherlands to Spain, Greece and other periphery countries. As a result, the economies of the latter countries grew at a high rate inducing higher inflation. Therefore, the increased capital mobility after the introduction of the euro could be considered as an asymmetric shock in itself. For example, the level of capital mobility of Ireland increased tremendously from 0.192 before the introduction of the euro to 0.756 after the introduction of the euro (Table 2.7). Accordingly, the standard deviation of industrial production of Ireland also increased from 1.16 before the adoption of the common currency to 5.22 after the adoption of the single currency.

After the start of the financial crisis, France and Greece, countries whose volatility has not changed significantly, had approximately an average level of capital mobility after 07M2007. Belgium, Finland, Ireland and the Netherlands, countries with a higher level of capital mobility, experienced a significant increase in the volatility of industrial production. The finding that increased capital flows did not adjust in response to shocks during the financial crisis can be explained by the fact that high capital flows could be a result of retrenchments of capital from foreign countries by domestic investors after the start of the financial crisis.

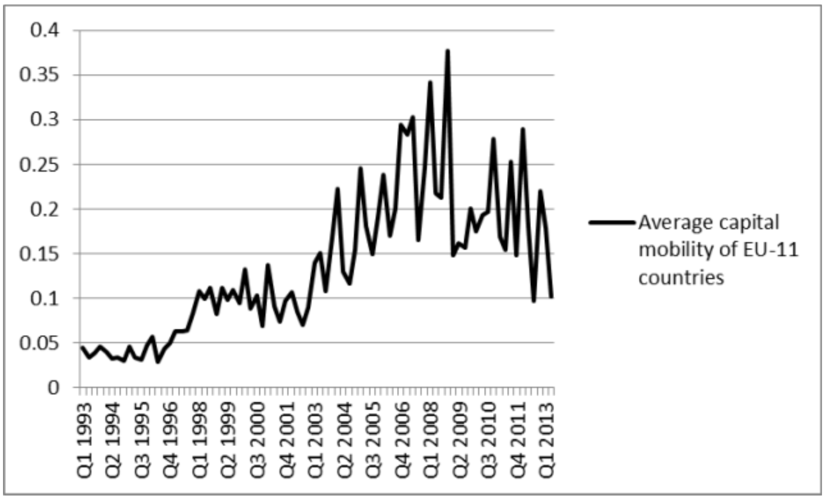

Fig. 2.1: Average capital mobility of EU-11 countries (Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Portugal and Spain) from 1Q1999 until 1Q2013

Figure 2.1 shows the average level of capital mobility of the EU-11 countries over the period 1Q1993-1Q2013. It is possible to infer from the figure that the growth rate of capital mobility in the EU-11 countries increased after 1999. During the period 3Q1993-4Q1998, the yearly growth rate of average capital mobility in the EU-11 countries was 10.58%. During the period 06Q1993-2Q2007, the yearly growth rate of average capital mobility in the EU-11 countries increased to 12.41%. The introduction of the euro, however, was not the only reason why the capital mobility increased. Broner et al. (2013) state that in the 2000s gross capital flows increased in all high and upper-middle income countries because of globalization. After the start of the financial crisis in 3Q2007 until 4Q2008, the annualized growth rate of average capital mobility was 15.87%. In 4Q2008, the level of average capital mobility reached its peak at 0.38 followed by the sharp decrease of -60.88% in 1Q2009. As it was stated earlier, the increase of capital flows during the earliest phase of the financial crisis was not a result of adjustments of capital flows in response to shocks. On the contrary, a high level of capital flows due to retrenchments of capital can in itself represent the source of shocks.

2.5.3 Openness of economy

Table 2.8 shows levels of openness of the economies of the EU-12 countries over three sub-periods 03Q1993-04Q1998, 01Q1999-02Q2007 and 03Q2007-02Q2013. The countries are organized in ascending order according to the level of openness. The level of openness is most important in the sub-period before the introduction of the euro, because, as the theory suggests, if a country has an open economy, it would not adjust its exchange rate in response to shocks even if it had a floating exchange rate regime. Thus, this country can fix its exchange rate without incurring great costs. This means that in countries with open economies, the volatility of industrial production growth would not increase after the adoption of the euro.

In general, it is not possible to conclude that countries whose change in volatility is insignificant have higher levels of openness in the sub-period 03Q1993-04Q1998 than countries whose volatility of industrial production increased significantly. The exception is Belgium, which has the highest level of openness and displays a decrease in the volatility of industrial production after the introduction of the euro. The case of Belgium is in line with the theory. Spain, where the volatility has not changed significantly, has one of the lowest levels of openness. France, Germany and Luxembourg also have lower levels of openness than some countries with increased volatility.

Tab. 2.8: Openness of the economy of EU-12 countries

3Q1993-4Q1998		1Q1999-2Q2007		3Q2007-2Q2013	
Greece	0.018	Greece	0.021	Greece	0.034
Spain	0.021	Spain	0.028	Spain	0.042
Italy	0.024	Portugal	0.032	Portugal	0.049
Portugal	0.025	Italy	0.032	Italy	0.051
France	0.031	France	0.038	France	0.053
Germany	0.034	Germany	0.047	Germany	0.074
Austria	*0.045*	Finland	0.056	Finland	0.075
Finland	0.048	*Austria*	*0.062*	Austria	0.093
Netherlands	*0.067*	Ireland	0.087	Ireland	0.094
Luxembourg	0.067	Luxembourg	0.088	Luxembourg	0.119
Ireland	0.079	*Netherlands*	*0.091*	Netherlands	0.157
Belgium	0.097	Belgium	0.131	Belgium	0.201

During the financial crisis, France had a level of openness lower than average. Greece had the lowest level of openness among all countries within the sample. The data suggest that the high level of openness did not assure that countries would keep unchanged levels of volatility of industrial production after the introduction of the euro and after the beginning of the financial crisis.

Figure 2.2 shows how the level of openness of the EU-12 countries developed from 1993 to 2013. As the trade intensity ratio suggests, the yearly rate of growth of the level of openness increased from 5.25% during the period 3Q1993-4Q1998 to 7.14% during the period 1Q1999-2Q2007. After the beginning of the financial crisis, the average level of openness decreased sharply (by 26%) but has recovered

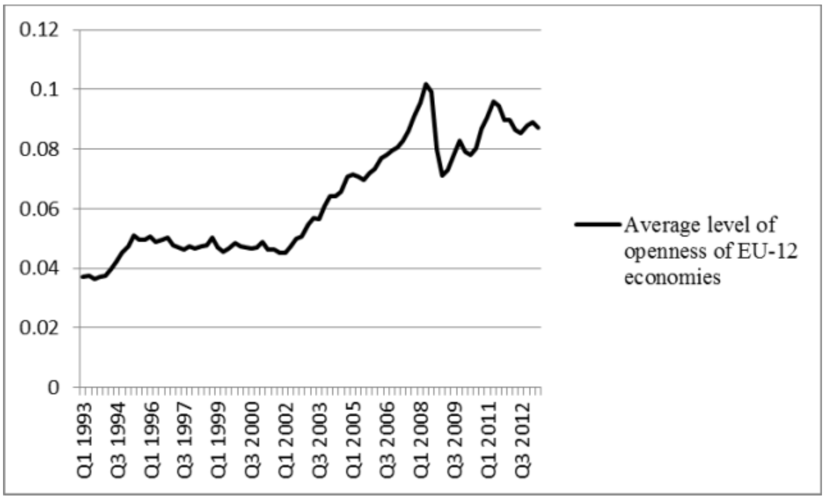

Fig. 2.2: Average level of openness of EU-12 economies

almost to the pre-crisis level by 1Q2011. On one hand, if the financial crisis is considered as a symmetric shock for the EU-12 countries, the reduced openness of the EU-12 economies should not have negative consequences because the euro can be adjusted with respect to the rest of the world. On the other hand, if the financial crisis affected the EU-12 economies in different ways, the country with a low level of openness could adjust its exchange rates at a lower cost. The countries that adopted the euro do not have such a possibility. The question concerning how the financial crisis affected the countries of the euro zone has to be studied in more detail.

2.5.4 Production diversification

According to the theory of optimum currency areas, production diversification mitigates negative consequences of a single currency, because shocks can offset each other in a diversified economy. Therefore, the introduction of a single currency in a diversified economy should not substantially affect the volatility of industrial production growth. The level of production diversification is most important in the period after the adoption of a single currency. Table 2.9 shows the level of production diversification of the EU-12 countries, which is measured by the GINI coefficient over three sub-periods 1993-1998, 1999-2006 and 2007-2008. The countries in the table are organized in ascending order according to the value of GINI coefficient. Lower levels of GINI coefficients correspond to higher levels of production diversifications. The countries with more diversified economies are at the top of the table. The results are contradictory again. In the sub-period 1999-2006, Portugal had the highest level of production diversification, but its production volatility has increased significantly. Spain had also a high level of production diversification and the change in its volatility is insignificant. The countries where the change in industrial production is insignificant, namely, France, Belgium, Germany and Luxembourg, did not have the highest level of production diversification. Also, during the financial crisis, France and Greece, countries whose volatility has not changed significantly, had a lower than average level of production diversification. The evidence suggests that a high level of production diversification does not assure that the volatility of industrial production growth stays unchanged after the introduction of the euro.

Figure 2.3 shows that the production specialization of the EU-12 countries has been increasing over the entire period from 1993 to 2009. From 1993 until 1998, the production specialization increased by 2.3 %. The introduction of the euro seems to influence production specializations in the EU-12 countries, since production specialization increased by 5% between 1999 and 2007. This is 2.7 % more than in the pre-euro period. During the financial crisis, the production specialization increased by 6.1% between 2007 and 2009, which is more than during the previous 10 years. As the data for the industrial production across sectors for the periods after 2009 are not available for all EU-12 countries, the dashed line in Figure 3 depicts the level of production specializations of Austria, Belgium, Finland, France, Germany and Italy from 1993 until 2011. The figure shows that after reaching the peak in 2009, the level of specialization decreased to the pre-financial crisis level by 2011. Thus, the financial crisis decreased production diversification of the EU-12 countries, reducing the possibility that shocks would offset each other in the EU-12 economies.

As the characteristics of optimum currency areas fail to explain why some of the EU-12 countries have not experienced an increase in volatility after the introduction of the euro, I try to take a closer look at the history of the exchange rate regimes of the EU-12 countries. As it was previously stated, the Austrian Central Bank did not change the hard currency policy after joining the EMS and the Austrian schilling was still tied to the German mark at that time. The Netherlands also had to keep the exchange rate of the Dutch guilder within the narrow band of +/- 2.25% after 1993. The volatility of industrial production of Austria and the Netherlands did not change because the exchange rates of these countries could not fluctuate within a wide range before 1999. Therefore, the introduction of the euro did not have a big impact on the economies of both Austria and the Netherlands.

Even though the exchange rates of Belgium and Luxembourg were allowed to fluctuate within the band of +/- 15% after 1993, these countries have been previously pegging their exchange rates. The exchange rate of Belgium was pegged to the German mark and the exchange rate of Luxembourg was fixed to the Belgian currency. Also, the exchange rate of the French franc vis-à-vis the German mark stayed mostly within the band of +/- 3 % since January 1987 (Obstfeld and Rogoff, 1995). It appears that those countries, which fixed or pegged their exchange rates to the German mark, have not experienced a significant increase in the volatility of industrial production growth after the introduction of the euro.

Tab. 2.9: Production diversification of EU-12 countries from 1993 until 2008

1993-1998		1999-2006		2007-2008	
Portugal	0.449	Portugal	0.481	Italy	0.517
Spain	0.474	Spain	0.502	Austria	0.518
Italy	0.485	Italy	0.509	Finaland	0.525
Finaland	0.495	Finland	0.517	Spain	0.53
Austria	*0.51*	*Austria*	*0.523*	Germany	0.552
France	0.528	France	0.557	Netherlands	0.573
Belgium	0.536	Germany	0.562	France	0.578
Netherlands	*0.538*	Belgium	0.565	Belgium	0.588
Germany	0.542	Ireland	0.575	Ireland	0.602
Greece	0.59	*Netherlands*	*0.575*	Greece	0.627
Luxembourg	0.725	Greece	0.613	Luxembourg	0.829
Ireland	NA	Luxembourg	0.792	Portugal	NA

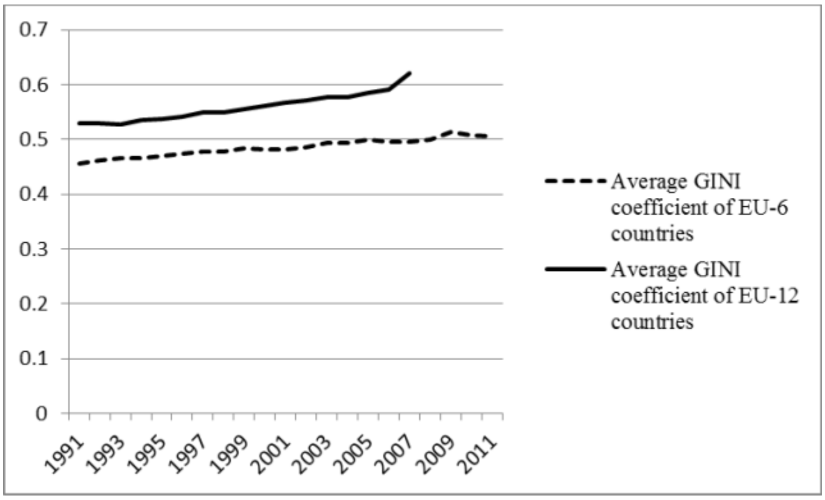

Fig. 2.3: Production specialization of EU countries
Note: EU-6 countries include Austria, Belgium, Finland, France, Germany and Italy.

Germany, being the biggest economy in the euro zone, played a dominant role in the monetary policy of EMS and EMU. The German mark was an anchoring currency for several euro-zone countries. The role of Germany could possibly explain why the volatility of German industrial production has not changed after the introduction of the euro.

In contrast to the currencies of other countries, where volatility of industrial production has not changed, Spanish currency was not pegged or fixed to the German mark. The Spanish peseta was allowed to fluctuate within the range of +/-15%. The characteristics of optimum currency areas of Spain were in general worse than in countries with increased volatility of industrial production growth. That is why it is puzzling that the volatility of Spanish industrial production growth has not changed significantly after the introduction of the euro.

Tab. 2.10: Spearman's rank correlation coefficient between Chow statistics and levels of characteristics of optimum currency areas for EU-12 countries

Characteristics of Optimum Currency Areas (OCA)	Chow statistics for the introduction of the euro and OCA (3Q1993-4Q1998)	Chow statistics for the introduction of the euro and OCA (1Q1999-2Q2007)	Chow statistics for the start of the the financial crisis and OCA (1Q1999-2Q2007)	Chow statistics for the start of the financial crisis and OCA (3Q2007-2Q2013)
Capital mobility	-0.895*** (-5.322)	-0.209 (-0.641)	-0.164 (-0.498)	0.227 (-0.700)
Openness of the economy	-0.210 (-0.679)	-0.028 (-0.088)	-0.524** (-1.948)	-0.524** (-1.948)
Production diversification	0.027 (0.082)	0.056 (0.177)	0.434 (1.522)	0.136 (0.413)

Additionally to presented Tables 2.7, 2.8 and 2.9, I calculate Spearman's rank correlations of Chow statistics and levels of characteristics of optimum currency areas. The EU-12 countries are ranked according to the average values of the characteristics of optimum currency areas which are exhibited in Tables 2.7, 2.8 and 2.9. The lower rank is assigned to the lower level of characteristics of optimum currency areas. The EU-12 countries are ranked according to the value of the Chow test applied to the univariate ARMA(p,q) model (Table 2.3). In the cases of capital mobility and openness, lower ranks are assigned to higher levels of Chow statistics. In the case of production diversification, lower ranks are assigned to lower levels of Chow statistics because lower levels of GINI-coefficient correspond to higher production diversification of the EU-12 countries. According to the theory, there should be positive rank correlation in all these cases. Table 2.10 exhibits the Spearman's rank correlations of Chow statistics and levels of characteristics of optimum currency areas. The Spearman's rank correlations between the Chow statistics and the levels of production diversification are positive over all periods. The Spearman's rank correlations between the Chow statistics and the levels of capital mobility are also positive over the period 3Q2007-2Q2013. These positive values of the rank correlations are, however, insignificant. The rest of Spearman's rank correlations are negative. Some of them are significant. Spearman's rank correlations confirm the conclusion based on Tables 2.7, 2.8 and 2.9 that more favorable characteristics of optimum currency areas do not help countries to mitigate the transmission of shocks after the introduction of a common currency and after the start of the financial crisis.

2.6 Conclusions

This chapter contributes to the literature by studying the following issues. The first question is how the introduction of the euro and the global financial crisis influenced the volatility of industrial production growth of the EU-12 countries. The second question is whether favorable criteria of optimum currency areas helped the countries to keep the level of volatility of industrial production growth constant. The third question is how the characteristics of optimum currency areas changed after the introduction of the euro and after the start of the financial crisis.

The results of this research show that after the introduction of the euro, the volatility of industrial production increased in Finland, Ireland, Italy and Portugal. The standard macroeconomic theory, which states that the introduction of a single currency increases the volatility of output, is confirmed for only 4 countries from 12. In most of the EU-12 countries, however, the volatility of industrial production did not change significantly. After the introduction of the euro, the change in the volatility of industrial production has not been found to be significant in Austria, France, Luxembourg, the Netherlands and Spain. Belgium is the only country where the volatility of industrial production decreased after the introduction of the euro. The volatility of industrial production in Greece increased in 1997, when the country fulfilled the Maastricht agreement and its currency began to fluctuate within a narrower range. In Germany, the volatility of industrial production increased in 2002. This outcome can be connected to the burst of the Dot-com bubble and not to the introduction of the euro. The unchanged volatility of Austria and the Netherlands can be explained by the fact that the currencies of these countries were not allowed to fluctuate after 1993 within the wider band of +/- 15%.

The fact that changes in the volatility of industrial production are not significant after the introduction of the euro in France, Germany, Luxembourg and Spain and decreased volatility in Belgium contradicts the standard macroeconomic theory. This means that the latter countries bear lower costs of joining a monetary union. I try to assess if the countries, where the volatility of industrial production has not increased significantly, have more favorable characteristics of the optimum currency areas than those countries, where the volatility of industrial production has remained unchanged. As the data show, better characteristics of optimum currency areas cannot explain the fact that the volatility of industrial production has not changed significantly in some countries after the introduction of the euro. To explain this puzzle, I analyze the exchange rate regimes of those countries, where the change in the volatility of industrial production is not significant. The interesting fact is that even though the currencies of Belgium, France and Luxembourg were allowed to fluctuate within the range of +/-15% after 1993, these countries fixed or pegged their exchange rates *de facto* or *de jure* before joining the EMS. The fact that the volatility of Spanish industrial production has not changed after the introduction of the euro remains puzzling. The results also reveal that the countries, where the volatility of industrial production has increased significantly after the introduction of the euro, have not recovered after the financial crisis.

France and Greece have not shown any increase in the volatility of industrial production growth after the start of the financial crisis. In the rest of the EU-12 countries, the volatility of industrial production growth increased significantly after the start of the financial crisis. Thus, the financial crisis could be considered as a symmetric shock for most economies of the EU-12 countries. Furthermore, the countries, where the volatility of industrial production remained unchanged after the financial crisis, do not display more favorable characteristics of optimum currency areas than the countries with an increased volatility of industrial production. The financial crisis had an impact not only on the volatility of industrial production, but also on the characteristics of the optimum currency areas. During the financial crisis, capital mobility, the openness of the economy and the production diversification of EU-12 countries decreased.

The analysis of skewness and kurtosis of the residuals from the multivariate ARMA (p,q) models reveals that after the introduction of the euro, the transmission of shocks to the industrial production of the EU-12 countries increased. This confirms the macroeconomic theory that when countries adopt a single currency, the transmission of shocks to the real economy of these countries increases. After the financial crisis, the amount of shocks to the industrial production of the EU-12 countries remained unchanged. Thus, the financial crisis that can be considered as a large shock has not influenced the amount or the magnitude of shocks to the industrial production of the EU-12 countries in the period following the crisis.

The implication of this research is that the introduction of the euro increased the volatility of industrial production growth in the countries that were unable to recover after the financial crisis. The countries that have not experienced any increase in the volatility of industrial production pegged or fixed their exchange rates before joining the EMS. This group of countries seemed to recover after the financial crisis. More favorable characteristics of optimum currency areas do not explain the fact that the volatility of industrial production growth has not changed neither after the introduction of the euro nor after the financial crisis. The financial crisis decreased the level of characteristics of optimum currency areas, lowering the ability of the EU-12 countries to adjust in response to asymmetric shocks.

Appendix A

Tab. A.1: Sector coverage of the production in industry of EU-12 countries from 1993 until 2009

C01T05	Agriculture, hunting, forestry and fishing
C10T14	Mining and quarrying
C15T37	Manufacturing
C15T16	Food products, beverages and tobacco
C17T19	Textiles, textile products, leather and footwear
C20	Wood and products of wood and cork
C21T22	Pulp, paper, paper products, printing and publishing
C23T25	Chemical, rubber, plastics and fuel products
C26	Other non-metallic mineral products
C27T28	Basic metals and fabricated metal products
C29T33	Machinery and equipment
C34T35	Transport equipment
C36T37	Manufacturing not elsewhere classified and recycling
C40T41	Electricity, gas and water supply
C45	Construction
C50T55	Wholesale and retail trade - restaurants and hotels
C60T64	Transport, storage and communications
C65T74	Finance, insurance, real estate and business services
C75T99	Community, social and personal services

Tab. A.2: Sector coverage of the production in industry of Austria, Belgium, Finland, France, Germany and Italy from 1993 to 2011

D01T03 Agriculture, forestry and fishing
D05T09 Mining and quarrying
D10T12 Food products, beverages and tobacco
D13T15 Textiles, wearing apparel, leather and related prodcuts
D16T18 Wood and paper products and printing
D19T23 Chemical, rubber, plastics, fuel products and other non-metallic mineral products
D24T25 Basic metals and fabricated metal products, except machinery and equipment
D26T28 Machinery and equipment
D29T30 Transport equipment
D31T33 Furniture; other manufacturing; repair and installation of machinery and equipment
D35 Electricity, gas, steam and air conditioning supply
D36T39 Water supply; sewerage, waste management and remediation activities
D45T47 Wholesale and retail trade, repair of motor vehicles and motorcycles
D49T53 Transportation and storage
D55T56 Accommodation and food service activities
D58T63 Information and communication
D64T66 Financial insurance activities
D68T82 Real estate, renting and business activities
D84T99 Community, social and personal services
D01T03 Agriculture, forestry and fishing
D05T09 Mining and quarrying

3. REAL FINANCIAL MARKET EXCHANGE RATE VOLATILITY AND PORTFOLIO FLOWS

Magister Valentyna Ozimkovska

3.1 Introduction

The collapse of the Bretton Woods fixed exchange rate system in 1973 had two main consequences for major economies. Firstly, volatile exchange rates induced more uncertainty. Secondly, countries could lift capital restrictions because they introduced the floating exchange rate regime. As a result, since the 1970s, the growth of capital flows has exceeded the growth of gross domestic product (GDP). In particular, gross cross-border transactions in bonds and equities for the United States (US) were equivalent to 4% of GDP in 1975. In the early 1990s, this share increased to 100% of GDP and had grown to 245% of GDP by 2000 (Hau and Rey, 2006). Despite the fact that risk is one of the main factors which influences investments, the relationship between exchange rate uncertainty and portfolio flows has not been broadly investigated. The aim of this chapter is to shed more light on this question.

Studying the impact of exchange rate uncertainty on portfolio flows is of great importance because international portfolio flows can have positive as well as negative impacts on financial sectors and real economies. Cross-border portfolio flows foster efficient allocation of resources by channeling capital to more productive companies. They connect the capital markets of different countries and make international risk sharing possible. However, rapid capital movements can induce substantial economic costs. For example, capital surges cause real estate booms, banking crises, debt defaults, inflation and currency crises. Sudden capital stops are correlated with currency depreciations, slower economic growth and higher interest rates (Forbes and Warnock, 2012). From the investors' perspective, it is useful to understand what influences portfolio flows since movements of capital affect returns of investors' portfolios. From the policy makers' perspective, it is vital to understand movements of portfolio flows in order to reduce the vulnerability of financial systems and to mitigate negative outcomes of financial crises.

The contribution of this research to the literature is threefold. First, I study the relationship between volatility of Real Financial Market Exchange Rates (RFER) and portfolio flows. Recent research finds long-run relationships between RFER and capital flows (Ghosh and Reitz, 2013; Gelman et al., 2015). However, the impact of RFER volatility on capital flows has not yet been studied. Second, I analyze disaggregated portfolio flows, which enable us to better understand investors' behavior. Finally, in contrast to Caporale et al. (2015), my analysis includes not only industrialized countries, but also emerging markets in which the US has the highest share of portfolio investments. I am thus able to compare investors' decisions related to portfolio allocations of equities of developed countries and emerging markets.

The focus of this chapter is on monthly bilateral cross-border portfolio flows between the US and its main investment partners over the period from 01M2000 to 07M2014. The data which stems from the Treasury International Capital System (TIC) provide disaggregated equity flows. These data enable me to analyze how RFER uncertainty influences investors' decisions concerning purchases and sales of foreign equity. I control in the analysis for returns, interest rates, global volatility and industrial production, as these factors also influence equity flows.

My results show strong evidence that RFER volatility Granger causes cross-border purchases and sales of equities for the industrialized countries and emerging markets. According to the results, the impact of RFER volatility on purchases of foreign equity is negative, which is consistent with the portfolio optimization theory. I also find a negative relationship between RFER volatility and sales of foreign equity. This finding contradicts the portfolio optimization theory, but can be explained by the theory of behavioral finance, which suggests that investors are inclined not to sell more risky assets in their portfolios in order to not realize losses. Furthermore, I find that when sales of foreign assets decrease more than purchases of foreign assets as a response to higher RFER volatility, the impact of RFER volatility on net purchases is positive. Such evidence I find in the data.

The impact of other factors on equity flows is consistent with my results related to RFER volatility as well as with other studies. An important finding is that equity flows seem to react more strongly to RFER volatility than to the Volatility Index (VIX), which is widely used in research as a proxy for riskiness of financial markets. Therefore, further research may also incorporate RFER volatility as an estimate of uncertainty of foreign financial markets for domestic investors. Another important implication of this research is that RFER volatility can be used by policy makers as a warning signal for large capital movements which could harm financial and economic stability. That is why the role of RFER volatility as a warning signal for possible future instability of financial systems require further studies.

The remainder of the chapter is organized as follows. The next section presents current literature on exchange rate volatility and capital flows. Section 3.3 outlines the theoretical background for the empirical research. Section 3.4 and Section 3.5 describe the data and the empirical results. The last section concludes the chapter.

3.2 Related literature

After abandoning the Bretton Woods system, floating exchange rates introduced additional uncertainty for international trade and investments. The macroeconomic effect on trade of floating exchange rate risk was widely analyzed theoretically and empirically (see McKenzie (1999) and Auboin and Ruta (2013) for comprehensive reviews). Some studies are dedicated to the effect of exchange rate volatility on foreign direct investments (Goldberg and Kolstad, 1994; Görg and Wakelin, 2002; Kiyota and Urata, 2004). Not much research has been done on exchange rate uncertainty and portfolio flows.

Despite the fact that capital flows have increased tremendously since the 1970s, the theoretical model which connects exchange rates, stock prices and capital flows was developed for the first time by Hau and Rey in 2006. The model is based on empirical findings which show that order flows and exchange rate movements are strongly correlated (Lyons, 2001; Evans and Lyons, 1999, 2002a, 2002b; Hau et al., 2002; Killeen et al., 2006).

Among the above mentioned papers, the research of Killeen et al. (2006) is of some interest to this study because it is the first attempt to investigate the relationship between order flows and exchange rate volatility. Killeen et al. (2006) state that shocks to order flows increase exchange rate volatility because under the flexible exchange rate regime the elasticity of speculative demand is low. Investors' unwillingness to be exposed to order flow shocks induces the portfolio-balance effect on exchange rates, increasing exchange rate fluctuations.

In the above mentioned theoretical model of Hau and Rey (2006), exchange rates, stock prices and capital flows are jointly determined under incomplete foreign exchange risk trading. The equilibrium model establishes two links. The first link relates to the correlation structure of exchange rates and equity returns. The second link is between exchange rate returns and net portfolio flows which are positively correlated according to the model. Additionally, the model shows that portfolio flows can generate considerable exchange rate volatility. Although the researchers admit that international investors take into account volatility of exchange rates, they state that a negative correlation between exchange rate returns and foreign stock market returns reduces volatility of returns expressed in domestic currency. That is why the model of Hau and Rey (2006) does not predict that portfolio flows react to changes in exchange rate volatility.

In their later work, Hau and Rey (2008a) examine a panel data set of investment positions at the stock level for international equity funds located around the globe. They document that changes in both total equity risk and foreign exchange rate risk induce investors to rebalance their portfolios. This has an impact on international portfolio flows. This empirical finding contradicts the assumption made in the earlier paper (Hau and Rey, 2006) that exchange rate gains are offset by foreign asset losses and vice versa.

Fidora et al. (2007) also show that changes in exchange rate volatility influence the structure of international investors' portfolios. In contrast to Hau and Rey (2006), they show that from a domestic investors' perspective, real exchange rate volatility puts additional risk on foreign securities holdings. Assuming that investors are risk averse, the mean-variance optimization suggests that real exchange rate volatility induces a bias toward domestic financial assets. The investigation of 40 investor countries and 120 destination countries supports this hypothesis.

Broner et al. (2013) study the behavior of gross international capital flows during currency crises, which are associated with increased exchange rate risk. They investigate net purchases of domestic assets by non-residents and net purchases of foreign assets by domestic investors for 103 countries over the period from 1970 until 2009. Their results suggest that net purchases of domestic assets and net purchases of foreign assets decline during currency crises.

The first attempt to test the impact of exchange rate uncertainty on aggregated net international portfolio flows is done by Caporale et al. (2015). They find exchange rate uncertainty has a negative effect on net equity flows in the euro area, the United Kingdom (UK) and Sweden and a positive effect in Australia. The effect of exchange rate risk on net bond flows is negative in Australia, the UK, Japan, the euro area and Sweden. In Canada, the exchange rate uncertainty has a positive impact on bond flows.

3.3 Theoretical Background

3.3.1 Portfolio optimization theory

Suppose that an investor holds in her portfolio a share w of domestic assets D and a share $(1-w)$ of foreign assets F. The investor chooses the optimal weights for the domestic and foreign assets by maximizing the Sharpe Ratio (S_p) of the portfolio:

$$max_{w_i} S_p = \frac{E(R_p) - r_f}{\sigma_p} \tag{3.1}$$

where $E(R_p)$ is the expected return of the portfolio, r_f is the risk free return and σ_p is the standard deviation of the portfolio.

The optimal weight of the domestic assets is

$$w = \frac{(E(R_D) - r_f)\sigma_F^2 - (E(R_F) - r_f)\sigma_D\sigma_F\rho_{D,F}}{(E(R_D) - r_f)\sigma_F^2 + (E(R_F) - r_f)\sigma_D^2 - (E(R_D) - r_f + E(R_F) - r_f)\sigma_D\sigma_F\rho_{D,F}} \tag{3.2}$$

where $E(R_D)$ and $E(R_F)$ are expected returns of the domestic and foreign assets respectively, r_f is the risk free return, σ_D and σ_F are standard deviations of the domestic and foreign assets respectively and $\rho_{D,F}$ is the correlation between the domestic and foreign assets (Baker and Filbeck, 2013, p. 31).

By holding foreign assets in the portfolio, the investor is exposed to foreign exchange risk. Returns on the foreign assets, expressed in the domestic currency, consist of returns on the foreign assets, expressed in the foreign currency and returns on the foreign exchange. Therefore, returns on the foreign assets expressed in the domestic currency are as follows:

$$R_F = (1 + R_E)(1 + R_A) - 1 = R_E + R_A + R_E R_A \tag{3.3}$$

where R_A and R_E are returns on foreign assets and foreign exchange respectively. Assuming that the term $R_E R_A$ approaches zero, the variance of the foreign assets, expressed in the domestic currency, is as follows:

$$\sigma_F^2 = \sigma_E^2 + \sigma_A^2 + 2\rho_{A,F} \tag{3.4}$$

where σ_F^2, σ_A^2 and σ_E^2 are variances of the foreign assets expressed in domestic currency, foreign assets expressed in foreign currency and foreign exchange respectively; $\rho_{A,F}$ is the covariance between the foreign assets and exchange rate.

The combination of Equations 3.2 and 3.4 shows that when the volatility of exchange rates increases, the weight of the domestic assets (w) increases. It means that the investor has to decrease the share of the foreign assets in the portfolio. By rebalancing her portfolio, the investor influences international stock flows.

Suppose that a domestic investor has a fixed amount of funds, which she allocates between foreign and domestic assets according to Equation 3.2. At the time t, the portfolio (P) of the investor can be expressed by the following equation:

$$P = D_t + F_t \tag{3.5}$$

where D and F are domestic and foreign assets. The weight of the domestic asset w_t and the weight of the foreign asset $(1 - w_t)$ at the time t are equal to:

$$w_t = D_t/P \tag{3.6}$$

$$(1 - w_t) = F_t/P \tag{3.7}$$

It follows from Equation 3.7 that the amount of the foreign assets which the investor will hold in her portfolio in the next period depends on the chosen weight w_{t+1} as suggested by Equation 3.2. That is why the amount of foreign assets in the investor's portfolio at the time $t + 1$ is equal to:

$$F_{t+1} = (1 - w_{t+1})P \tag{3.8}$$

If $w_{t+1} < w_t$, the investor has to purchase additional foreign assets to increase the share of foreign assets in her portfolio:

$$F_{t+1} = F_t + Purchase_F \tag{3.9}$$

where $Purchase_F$ is the amount of the foreign assets purchased. Combining Equations 3.8 and 3.9, I obtain

$$Purchase_F = P(w_t - w_{t+1}) \tag{3.10}$$

It is possible to infer from Equations 3.2, 3.4 and 3.10 that the relative risk of foreign assets and exchange rate risk vis-à-vis domestic assets influences purchases or sales of foreign stocks by the investor. If the foreign asset risk and exchange rate risk decrease vis-à-vis domestic asset risk, the weight of domestic assets in the investor's portfolio decreases. Therefore, the investor rebalances her portfolio by purchasing additional shares of the foreign assets. This has an impact on the portfolio flow from the foreign country into the domestic country. The concept of the RFER allows estimating the riskiness of foreign assets and exchange rates with respect to domestic assets.

3.3.2 Concept of the Real Financial Market Exchange Rate

RFER is calculated based on the prices of financial assets, similarly to how the real exchange rate is determined by the prices of goods. It is a ratio of two countries' asset prices expressed in one currency. While the real exchange rate, based on goods prices, is derived from the law of one price in the market for goods, the RFER follows from the law of one price in financial markets (Lamont and Thaler, 2003). In this chapter, the RFER is calculated in the following way:

$$RFER = S_{d/f}\frac{P_f}{P_d} \tag{3.11}$$

where $S_{d/f}$ is a nominal exchange rate expressed as a domestic price of foreign currency, P_d and P_f are prices of domestic and foreign financial assets respectively.

The concept of RFER has been recently developed by Gelman et al. (2015). They argue that the RFER shows the relative attractiveness of one country's financial assets as compared to another country's financial assets. The RFER provides a measure of the price competitiveness of financial assets of the foreign country compared to those of the domestic country, because prices of financial assets are determined based on future cash flows. A temporary change in RFER may signal mispricing of one country's assets with respect to another country's assets. Recent research shows a long term link between effective RFER and capital flows (Ghosh and Reitz, 2013; Gelman et al., 2015). Higher RFER volatility implies more uncertainty about relative future profitability of foreign assets. That is why when RFER volatility changes, investors are likely to rebalance their portfolios directly influencing portfolio flows.

3.3.3 Variables

Proxies for monthly RFER volatility are calculated based on realized daily RFER returns. The advantage of this method is that it treats volatility as an observable variable which can be modeled directly. In contrast to the realized volatility, such approaches as the family of (Generalized) Autoregressive Conditional Heteroscedasticity models, proposed by Engle (1982) and Bollerslev (1986), treat volatility as a latent variable which has to be estimated. Baum et al. (2004), Klaassen (2004) and Caglayan and Di (2010) also employ daily exchange rate movements to proxy for monthly exchange rate volatility in order to assess the impact of exchange rate volatility on trade. They argue that this approach yields a more representative measure of volatility.

In this chapter, RFER volatility is measured by employing the approach of Menkhoff et al. (2012):

$$Vol_t = \frac{1}{T}\sum_{\tau \in T} |r_\tau| \tag{3.12}$$

where Vol_t is RFER volatility in month t, $|r_\tau|$ is absolute daily return on RFER on day τ and T is the total number of trading days in month t. This measure is analogous to the realized volatility method (see, for example, Andersen et al. (2001)). The only difference is that it uses absolute returns instead of squared returns in order to minimize the impact of outliers. As in Menkhoff et al. (2012), I employ RFER volatility innovation in the empirical estimation. Volatility innovations are the residuals of the first order Autoregressive Process of Vol_t from Equation 3.12.

In my empirical estimation, I control for other factors that affect portfolio flows. In general, researchers divide determinants of capital flows into pull and push factors. Pull factors are of domestic origin, while push factors are of external origin. Calvo et al. (1993), Fernandez-Arias (1996) and Chuhan et al. (1998) argue that push factors are more important than pull factors in driving capital flows. Calvo et al. (1993) find, however, that domestic factors are also important for capital flows. Griffin et al. (2004) state that both pull and push factors drive cross-border capital flows.

The theoretical and empirical research suggests that the main factors which influence capital flows are growth, interest rates and global risk. Domestic productivity affects growth generating lending booms and busts. This influences capital flows (Aguiar and Gopinath, 2007; Broner et al., 2013). There is evidence that low interest rates in the US lead to higher capital outflows to foreign countries (Calvo et al., 1993; Fernandez-Arias, 1996; Taylor and Sarno, 1997; Chuhan et al., 1998). Forbes and Warnock (2012) and Fratzscher (2012) find that the global risk influences portfolio flow movements. They proxy the global risk using the VIX calculated by the Chicago Board Option Exchange. The VIX measures implied volatility based on prices for a range of options on the S&P 500 index. In my estimation, I control for the factors which are found to have a significant impact on movements of capital flows.

In addition to the above mentioned factors, I include financial market returns in the empirical model. It is possible to infer from Equation 3.2 that the weight of foreign assets depends on returns on the foreign asset. Thus, returns on financial assets are likely to influence portfolio flows. Fratzscher (2012) confirms empirically that positive equity returns lead to more capital inflows into economies.

Despite the fact that both domestic and foreign factors can influence cross-border portfolio flows, I include into a regression such factors as growth, interest rates and financial market returns only for foreign countries. Growth, interest rates and market returns on domestic and foreign countries are substantially correlated. This can induce the problem of multicollinearity in the empirical estimation.

3.4 Data

I examine the impact of RFER volatility on bilateral cross-border equity flows of the US with 7 industrialized countries and 6 emerging markets (International Monetary Fund classification). The US had the highest portfolio investments in these countries in 2013 according to Table 1 of the Coordinated Portfolio Investment Survey. Table 3.1 shows that the industrialized countries with the highest asset share in the US investment portfolios are Australia, Canada, the euro area, Japan, Sweden, Switzerland and the UK. US investors hold the highest share of portfolio assets of the following emerging markets: China, Argentina, South Africa, Russia, Mexico and Poland. The euro area has the highest share of the US portfolio investments (22,329%). Among the considered emerging markets, the US investments are the highest in Mexico (1,638%).

Tab. 3.1: US portfolio investments assets, 2013

Investments in	Share of total international portfolio, %
Euro area	22.329
United Kingdom	14.502
Canada	8.953
Japan	7.331
Switzerland	4.919
Australia	3.662
Sweden	1.807
Mexico	1.638
China	1.502
South Africa	0.860
Russia	0.763
Poland	0.345
Argentina	0.126

Note: Calculations are based on Table 1 of the Coordinated Portfolio Investment Survey, 2013.

I employ monthly data from 01M2000 to 07M2014. Brooks et al. (2004) find that portfolio flows for the period preceding 1988 are insignificant. From 1998 until 2000, portfolio flows grow rapidly. After 2000, the growth of portfolio flows stabilizes. That is why 01M2000 represents the most suitable starting date for this research.

The TIC provides the following disaggregated monthly equity flows: purchases of foreign stocks by US residents and sales of foreign stocks by US residents, purchases of US stocks by foreign residents and sales of US stocks by foreign residents. Because of the problem of nonstationarity, I employ first differences of logs of these equity flows in my analysis. Net purchases of foreign stocks by US residents are calculated as differences between purchases of foreign stocks by US residents and sales of foreign stocks by US residents. Net purchases of US stocks by foreign residents are calculated as differences between purchases of US stocks by foreign residents and sales of US stocks by foreign residents. Further on, I refer to purchases of foreign stocks by US residents and to purchases of US stocks by foreign residents as purchases; to sales of foreign stocks by US residents and to sales of US stocks by foreign residents as sales; to net purchases of foreign stocks by US residents and to net purchases of US stocks by foreign residents as net purchases.

Nominal exchange rates as a dollar price of foreign currency are obtained from the Datastream database. RFER volatility innovations are calculated according to the procedure described in subsection 3.3.3. In order to calculate RFER, I deflate the nominal exchange rates by Morgan Stanley Capital International (MSCI) indexes, which are also obtained from the Datastream database. The returns on equity are calculated as log differences of the MSCI indexes. All equity returns are measured in local currency. Table 3.2 provides descriptive statistics of nominal exchange rates and RFERs for industrialized countries and developed markets. The coefficient of variation, which is a ratio of the standard deviation to the mean, indicates that variability of RFER is stronger than variability of nominal exchange rates for all analyzed countries except Japan, Switzerland and Argentina. This observation means that in the latter countries, the co-movements of domestic and US asset prices offset variation in nominal exchange rates. In the rest of the countries, movements of relative asset prices expressed in the same currency are more uncertain than movements of nominal exchange rates. Especially in emerging markets, variation of RFER is several times higher than variation of nominal exchange rates.

I use industrial production growth as a proxy for economic growth because the data on industrial production are available on a monthly basis. Monthly data on industrial production are taken from the OECD Statistics database for the following countries: Canada, the euro area, Japan, Sweden, Mexico, Poland and Russia. The data on industrial production for Switzerland, China, Argentina and South Africa are obtained from the Datastream database. For Australia, I employ industrial production growth of all OECD countries because the data on Australian industrial production are not available. Growth in industrial production is calculated in terms

Tab. 3.2: Descriptive statistics for nominal exchange rates and RFER

Country	Mean		Median		CV	
	ER	RFER	ER	RFER	ER	RFER
Australia	0.790	0.587	0.777	0.607	0.215	0.301
Canada	0.850	0.992	0.874	1.011	0.157	0.293
Euro area	1.235	0.180	1.285	0.173	0.150	0.185
Japan	0.977	0.569	0.936	0.579	0.151	0.147
Sweden	0.134	0.811	0.138	0.859	0.145	0.225
Switzerland	0.861	0.631	0.835	0.679	0.205	0.182
United Kingdom	1.665	2.282	1.615	2.259	0.105	0.114
Argentina	0.355	2604.081	0.315	2353.597	0.691	0.538
China	0.136	0.005	0.129	0.005	0.118	0.503
Mexico	0.089	1.508	0.090	1.676	0.125	0.414
Poland	0.307	0.406	0.312	0.382	0.174	0.357
Russia	0.034	0.019	0.034	0.017	0.089	0.527
South Africa	0.130	0.061	0.132	0.064	0.162	0.382

Note: Descriptive statistics are calculated from monthly nominal exchange rates (ER) and Real Financial Market Exchange Rates (RFER) over the period 01M2000-07M2014. The coefficient of variation (CV) is a ratio of the standard deviation to the mean.

of log differences of industrial production.

For a short-term interest rate of the majority of countries used in my analysis, I employ differences of interbank three-month interest rates which are obtained from the Datastream database. As interbank three-month interest rates are unavailable for some countries, I employ differences of the following time series: prime lending rate for China, 90 day deposit rate for Argentina, one month deposit rate for South Africa and 28 day certificate rate for Mexico. These time series are also obtained from the the Datastream database. The Chicago Board Option Exchange S&P 500 VIX is obtained from the Datastream database.

3.5 Empirical results

3.5.1 Granger Causality test

In order to investigate causal relationships between equity flows and RFER volatility, I employ the Granger causality test. The test regression includes three lags according to the Akaike Information Criteria. The results of the test are exhibited in Tables B.1 and B.2 for the industrialized and emerging countries respectively. In most of the cases (18 out of 32) for the industrialized countries, unidirectional Granger causality goes from RFER volatility to the purchases and sales. There are bi-directional causal relationships between RFER volatility and Swiss stocks bought and UK stocks sold by the US as well as US stocks purchased by Australia, Sweden and the UK. In the case of net purchases, RFER volatility Granger causes US net stock acquired by Japan, Sweden and Switzerland. For the industrialized countries, the Granger causality test detects only two unidirectional relationships where causality goes from stock flows to RFER volatility. These relationships are between RFER volatility and the Australian net stock purchases and the US stock purchases by Australia.

The Granger causality test reveals fewer unidirectional relationships between RFER volatility and stock flows for the emerging markets than for the industrialized economies. In particular, the results suggest that causality goes from RFER volatility to Mexican and Russian stock purchases and sales by US residents, South African stock purchases and Chinese stock sales by US residents, US stock purchases by Argentina and China as well as US stock purchases and sales by Mexico. There is one bi-directional causal relationship between US stock sales by Argentina and RFER volatility. According to the results, the following stock flows Granger cause RFER volatility: South African net stock purchases, US stock purchases by China and US net stock purchases by Argentina and China.

In contrast to the model of Hau and Rey (2006), which shows that portfolio flows generate exchange rate volatility, I find strong evidence that causality goes from RFER volatility to stock flows. The highest number of such significant relationships is found for industrialized countries' purchases and sales of US assets as well as for US purchases of industrialized countries' assets. RFER volatility does not Granger cause foreign net purchases by US residents but does Granger cause US net purchases by foreign residents. It seems that international investors form future expectations of foreign equity risk based on past RFER volatility. The results for the emerging economies are consistent with the results for the industrialized countries. However, the number of relationships where causality goes from RFER volatility to stock flows is lower for the emerging economies. It might be due to the fact that emerging financial markets are less efficient. Investors of the emerging markets do not incorporate all past information to form their expectations. Furthermore, US investors hold a smaller share of emerging market assets in their portfolios comparing to assets of developed countries. That is why US investors might not react so strongly to changes in the RFER volatility of emerging markets than to changes in the RFER volatility of developed economies. Hau and Rey (2008a) find that funds with overexposure to exchange rate risk are more likely to rebalance their portfolios than funds with underexposure to exchange rate risk.

3.5.2 Model specification

Estimating the relationships between equity flows and RFER volatility and other explanatory variables requires introducing lags of the dependent and independent variables in order to capture delayed effects in these relationships. Investors may rebalance their portfolios not often enough to react immediately to changes in RFER volatility. Moreover, investors may form expectations about the dependent variables based on their past values. That is why there may be lags associated with the impact of exchange rate uncertainty on equity flows. Hence, the model used to estimate these relationships must capture the dynamic pattern which exists between equity flows and RFER volatility and other explanatory variables.

Baum and Caglayan (2010) state that the Autoregressive Distributed Lag model (ADL) is computationally tractable and sufficiently flexible to capture the dynamic pattern that exists between trade flows and exchange rate uncertainty. The ADL model is also suitable for modeling the relationship between equity flows and RFER volatility. I estimate ADL models for purchases, sales and net purchases for all 13 countries. In total, I estimate 78 different regressions. To study the relationship between equity flows and RFER volatility, I regress an equity flow on its lagged values, bilateral RFER volatility, equity returns, short term interest rate, industrial production growth and the VIX. Equity returns, short term interest rate and industrial production growth come from the country whose stocks are considered in the regression. The estimated equations take the following form:

$$\begin{aligned} Flow_t = \alpha + \sum_{i=1}^{3} \beta_i Flow_{t-i} + \sum_{i=1}^{3} \gamma_i Vol_{t-i} + \sum_{i=1}^{3} \delta_i Ret_{t-i} + \sum_{i=1}^{3} \zeta_i VIX_{t-i} \\ + \sum_{i=1}^{3} \eta_i Int_{t-i} + \sum_{i=1}^{3} \mu_i Ind_{t-i} + \varepsilon_t \end{aligned} \tag{3.13}$$

where $Flow$ is an equity flow (purchases, sales or net purchases); Vol is RFER volatility innovations; Ret is equity returns; VIX is the VIX index; Int is interest rates; Ind is industry production growth; β, γ, δ, ζ, η and μ are corresponding coefficients.

According to the Akaike Information Criteria, the ADL models should include three lags. I introduce additional lags of the dependent variable in the regressions where the LM Serial Correlation test detects serial correlations. In the regression of Russian stock purchases, some serial correlation remains but this regression does not reveal significant coefficients and I do not include the results in further analysis. The results of the Breusch-Pagan-Godfrey test suggest that residuals of regressions are homoscedastic in most cases. In the regressions where residuals are found to be heteroscedastic, I employ White heteroscedasticity consistent standard errors.

The chosen variables explain equity purchases and sales better than they explain net purchases. For the purchases and sales, the adjusted R-squared is in the range from 0.12 to 0.46 with the average value of 0.27. For the net purchases, the adjusted R-squared is lower and is in the range from -0.01 to 0.37 with the average value of 0.11. The F-statistics are significant in all regressions for purchases and sales, except for US sales by Australia. The F-statistics are significant for the most of the regressions of net purchases, except for the regressions incorporating Swiss and Argentinian net purchases by the US as well as US stock purchases by Canada, the euro area, China, Russia and South Africa. As the aim of this research is not to explain the equity flows, but to study the relationship between equity flows and RFER volatility, these results are acceptable for the further analysis.

3.5.3 Impact of RFER volatility on equity flows

Tables B.3 and B.4 present estimated short-run coefficients of RFER volatility on equity flows. The results reveal a number of significant short-run relationships between RFER volatility and equity flows. The short-run impact of RFER volatility on purchases is negative, which means that investors acquire less foreign equity when RFER risk increases. Surprisingly, the significant short-run relationships between RFER volatility and sales are also negative. It implies that investors sell less foreign equity in response to increased RFER volatility. The significant short-run multipliers indicate that the impact of RFER volatility on net purchases is positive. Thus, when RFER uncertainty increases, the decrease in sales is stronger than the decrease in purchases, which leads to an increase in net purchases. The results for the emerging markets are consistent with the results for the developed countries.

Among the industrialized countries analyzed, only in the euro area do the results not reveal any significant relationship between RFER volatility and equity flows. Investors might consider risks of equity markets of the individual countries of the euro area rather than risks of euro area equity market as a whole. Among the emerging markets, Russia alone does not have any significant relationship between RFER volatility and equity flows. OECD (2013) states that changes in capital flows to emerging markets can reflect shifts in the sentiments toward emerging markets and commodity prices rather than fundamentals. Moreover, capital flows to emerging markets can be affected by actions such as quantitative easing in advanced countries.

Table B.5 exhibits long-run multipliers for the industrialized countries and emerging markets. I analyze those long-run multipliers where at least one short-run multiplier is significant. The long-run impact of RFER volatility on purchases and sales is negative. In contrast to this result, the long-run impact of RFER volatility on net purchases is positive. It implies that in the long-run, RFER volatility has a stronger negative impact on sales than on purchases.

The result that some lagged values of RFER volatility significantly influence equity flows implies that there is some delay in investors' responses to changes in RFER uncertainty. This can be explained by the fact that investors do not rebalance their portfolios immediately after RFER risk changes. Almadi et al. (2014) state that in order to take advantages of dynamic investment opportunities, investors can rebalance their portfolios every month. However, investors may rebalance their portfolios less frequently than this because the predictability of assets increases with a longer horizon, and signals provided by longer-horizon techniques are more reliable. Moreover, forecasting techniques are based on past information, which induces investors to react to changes in RFER volatility with lags.

The empirical results, which suggest that RFER volatility negatively affects purchases, is in line with the portfolio optimization theory. When the riskiness of foreign assets increases, the optimal weight of foreign assets in the portfolio decreases. Therefore, investors purchase less foreign equity.

The finding that RFER volatility negatively influences sales contradicts the portfolio optimization theory. This result implies the following: when investors hold foreign stocks, they are reluctant to sell these stocks when their riskiness increases. The decrease in sales as a response to increased risk can be explained by the theory of behavioral finance. When the riskiness of assets increases, the probability that the assets will underperform increases as well. Investors are reluctant to sell their holdings because they do not want to realize losses. Vayanos (2004) states that increased risk makes asset managers more likely to hold riskier assets because withdrawals are personally costly for managers. Also, the loss aversion behavior is empirically established in the literature (see Köbberling and Wakker (2005)). Past research confirmed that agents are more sensitive to losses than to gains. Such behavior leads to a utility function which is steeper for losses than for gains.

My finding that both purchases and sales decrease in response to an increase in RFER volatility is in line with other studies, which show that purchases and sales of foreign assets are correlated (Dvořák, 2003; Albuquerque et al., 2007). Dvořák (2003) and Albuquerque et al. (2007) provide a possible explanation for this fact. First, investors may increase the frequency of trading, which is aggregated into large monthly flows. Second, investors may buy some assets of a foreign country and sell other assets of the same country. Finally, because of within-country investors' heterogeneity, some investors may buy an asset while others sell the same asset in response to a shock. The assumption of within-country investors' heterogeneity is incorporated into a quantitative model by Albuquerque et al. (2007).

My results are consistent with the results of Hau and Rey (2008a) that investors rebalance their portfolios in response to changes in exchange rate risk. The finding that RFER volatility does not affect all portfolio flows can be explained by the fact that investors have different exposure to exchange rate risk. Caporale et al. (2015) find that exchange rate volatility does not affect net equity flows of Canada and Japan. In contrast to these results, my findings show that RFER volatility influences some Canadian and Japanese disaggregated flows. Gross equity flows are found to be more volatile by Broner et al. (2013). This means that gross equity flows react more strongly to risk. Furthermore, if equity purchases of the domestic and foreign countries react to the risk in the same way, the influence of risk cannot be shown in net equity flows. In contrast to my results that RFER volatility does not influence any considered equity flows of the euro area, the results of Caporale et al. (2015) show that net equity flows react to nominal exchange risk negatively.

3.5.4 Impact of other factors on equity flows

In the estimated regressions, equity flows significantly depend on their lagged values. Purchases and sales are more persistent than net purchases. In most regressions of purchases and sales, the first and second lags of equity flows are significant. In some cases, lags of higher orders are significant. Purchases and sales depend mostly negatively on their past values, while net purchases depend on their past values positively. Persistence in equity flows was also found by Dvořák (2003), Albuquerque et al. (2007) and Heimonen (2009). Froot et al. (2001) explain that persistence in equity flows may be caused by investors' willingness to reach their desired portfolio position slowly in order to reduce transaction costs. Institutional factors can also contribute to the persistence of equity flows. For example, institutional investors may undertake structural shifts in asset allocations on a phased basis.

Further, I analyze the relationships between equity flows and the control variables. The ADL regressions reveal a high number of significant relationships between equity returns and capital flows for the developed countries and for the emerging markets (see Tables B.6 and B.7). In most cases, the significant impact of equity returns on capital flows is positive. Equity returns seem to influence purchases and sales more strongly than net purchases. Moreover, US net purchases react to equity returns more strongly than foreign net purchases. The latter finding can be explained by the fact that the share of US stocks in portfolios of investors from emerging markets is higher than the share of emerging market stocks in portfolios of US investors. That is why investors from emerging markets may react to changes in returns of US equity more strongly. Furthermore, the behavior of US investors and investors from emerging markets may differ because of different investment strategies and incentives. The USA has, for example, more hedge funds than emerging markets (Tremblay, 2012). The asymmetry of investors' behavior among countries was also found by Heimonen (2009).

My results, which state that investors purchase more international equity as its price increases, are consistent with the portfolio optimization theory. These results are also consistent with my finding that investors purchase less international equity when RFER volatility increases. Thus, returns influence purchases positively, and uncertainty has a negative impact on purchases. The significance of lagged values of equity returns implies that investors form expectations of returns based on their past values.

The finding that investors sell more international stocks when their returns increase contradicts the portfolio optimization theory. It is, however, in line with my finding that investors sell less international equity when RFER risk increases. Investors may be willing to realize profits. That is why they sell assets which have increased in value. According to the portfolio rebalancing effect, investors define limits of foreign risk exposure and keep the share of foreign assets in line with these limits. Therefore, investors sell foreign assets after they appreciate (Bohn and Tesar, 1996; Hau and Rey, 2004, 2008a, 2008b; Tille and Van Wincoop, 2010; Evans and Hnatovska, 2014). Albuquerque et al. (2007) provide an alternative explanation for such behavior. They state that some sophisticated investors may have a possibility to participate in private opportunities of foreign countries. Private opportunities are broadly available during a boom when prices of equities increase. Investors consider private opportunities as substitutes to their stock holdings and sell equity when they participate in private opportunities in order to diversify their portfolios.

As we see, purchases and sales respond in the same way not only to RFER risk but also to equity returns. These results are consistent with the above discussed literature, which documents correlation of purchases and sales. As the portfolio optimization theory predicts, net purchases positively respond to increased returns. Thus, purchases increase more strongly than sales when asset returns increase. Also, Dvořák (2003) and Albuquerque et al. (2007) show that net purchases and returns of assets are positively correlated.

Tables B.8 and B.9 exhibit the estimated short-run coefficients of equity flows on the VIX. According to the estimated regressions, there is a higher number of significant relationships between equity flows and the VIX for the developed countries than for the emerging markets. Among the developed countries, US investors react more strongly to changes in the VIX than foreign investors. As the VIX is constructed based on implied volatility of the S&P 500 index, it measures the volatility of the US financial market. Thus, US investors take into account uncertainty related to the US financial market while making decisions about purchases and sales of foreign equity. It implies that the VIX can be characterized as a push factor. The significant impact of the VIX on equity flows is positive for some countries and negative for other countries. Fratzscher (2012) also finds a heterogeneity in the VIX effect on portfolio capital flows across country groups. As the results suggest, foreign investors react more strongly to uncertainty related to RFER volatility than to the VIX.

Tables B.10 and B.11 show estimated short-run coefficients of equity flows on interest rates. Some significant relationships between interest rates and purchases and between interest rates and sales are positive and some are negative. The significant impact of interest rates on net purchases is negative. The latter result is in line with my finding that net purchases increase when asset returns increase. An increase in interest rates implies that expected returns of assets decrease. Consequently, investors sell more foreign assets, reducing the share of foreign assets in their portfolios. Forbes and Warnock (2012) also find that retrenchments of capital are more likely to happen when global interest rates are high.

According to the results exhibited in Tables B.12 and B.13, there is a number of significant relationships between equity flows and industrial production for the developed countries and emerging markets. Investors react heterogeneously to changes in industrial production growth of countries in which they invest. The positive relationships between net purchases and industrial production are consistent with the return chasing evidence which is discussed above. Investors may incorporate information about foreign economic growth in their expectations of foreign stock performance. Numerous studies reveal positive relationships between GDP or industrial production growth and stock prices in advanced and developing countries (Asprem, 1989; Nasseh and Strauss, 2000; Kim, 2003; Ewing and Thompson, 2007; Hosseini et al., 2011). That is why investors may expect an increase in stock returns and purchase more foreign equity when industry production increases. The negative relationships between net purchases and industrial production can be explained by the fact that industrial production indexes of domestic and foreign countries can be correlated. When macroeconomic activity decreases in both domestic and foreign countries, investors may reduce their investments, decreasing net purchases of foreign stocks.

3.6 Conclusions

This chapter examines the impact of RFER volatility on equity flows between the US and developed countries and between the US and emerging markets. RFER volatility is calculated using the realized volatility methodology. According to the Granger causality test, causality goes from RFER volatility to purchases and sales, but not to net purchases. The results for the emerging markets are consistent with the results for the developed countries. However, the evidence that RFER volatility Granger causes purchases and sales is weaker for the emerging markets.

I find some evidence that RFER volatility influences purchases and sales negatively, while RFER volatility influences net purchases positively. The negative impact of RFER volatility on purchases is consistent with the portfolio optimization theory. When the riskiness of foreign assets increases, investors try to reduce the share of foreign assets in their portfolios by buying less foreign equity. The result that RFER volatility also negatively affects sales contradicts the portfolio optimization theory. It implies that investors sell less foreign equity when its riskiness increases. This finding can be explained by the theory of behavioral finance. As the riskiness of foreign assets increases, there is a higher probability that investors' portfolios will underperform. Investors might sell less foreign stocks because they are unwilling to realize losses of their portfolios. RFER volatility might influence net purchases positively when a decrease in sales is higher than a decrease in purchases.

The analysis of returns, which is another important factor for asset allocation decisions, reveals that purchases and sales also react to changes in returns in the same way. The positive impact of returns on purchases is consistent with return chasing evidence. The positive relation between returns and sales is consistent with my result of negative relation between RFER volatility and sales. Another important finding of this chapter is that the impact of VIX on equity flows is weaker than the impact of RFER volatility on equity flows.

This chapter contributes to the current literature by shedding new light on the relationship between RFER volatility on equity flows. RFER volatility has not been studied before. In contrast to the theoretical model of Hau and Rey (2006) which show that exchange rate volatility is caused by portfolio flows the empirical evidence suggests that causality goes from RFER volatility to equity flows. Additionally, the disaggregated analysis of equity flows helps to understand investor's behavior which has a direct impact on equity flows. As I find that equity flows react to RFER volatility more strongly than to VIX, RFER volatility can be incorporated in further research as a proxy for riskiness of international financial markets. Furthermore, investors could use RFER volatility as a measure of riskiness of foreign assets. Policy makers could also employ RFER volatility as a warning signal for high capital movements which are harmful for economic and financial stability. That is why it is important to analyze further the role of RFER volatility as a warning signal for capital surges.

Appendix B

Tab. B.1: Results of the Granger causality test for industrialized countries

Country	H0	FP	FS	FN	USB	USS	USN
Australia	RFER	1.921	5.234***	2.024	5.363***	5.914***	0.728
		(0.128)	(0.002)	(0.113)	(0.002)	(0.001)	(0.537)
	Equity flows	0.273	1.549	3.449***	2.402***	1.601	2.413*
		(0.845)	(0.204)	(0.018)	(0.070)	(0.191)	(0.069)
Canada	RFER	3.095**	6.085***	0.702	2.612*	2.780**	0.487
		(0.029)	(0.001)	(0.552)	(0.053)	(0.043)	(0.692)
	Equity flows	0.180	0.228	0.213	0.486	0.796	1.275
		(0.910)	(0.877)	(0.888)	(0.693)	(0.498)	(0.285)
Euro area	RFER	7.121***	7.920***	0.822	7.930***	9.499***	3.165**
		(0.000)	(0.000)	(0.484)	(0.000)	(0.000)	(0.027)
	Equity flows	0.370	0.815	1.883	0.122	0.507	0.903
		(0.775)	(0.488)	(0.135)	(0.947)	(0.678)	(0.441)
Japan	RFER	1.067	3.142**	1.732	1.843	1.033	4.343***
		(0.365)	(0.027)	(0.163)	(0.142)	(0.380)	(0.006)
	Equity flows	0.123	0.842	1.871	1.320	1.085	0.409
		(0.947)	(0.473)	(0.137)	(0.270)	(0.357)	(0.747)
Sweden	RFER	2.557**	3.474***	0.271	2.638**	7.964***	2.630*
		(0.057)	(0.018)	(0.846)	(0.051)	(0.000)	(0.052)
	Equity flows	0.123	0.617	1.208	2.164*	1.292	1.326
		(0.947)	(0.605)	(0.309)	(0.094)	(0.279)	(0.268)
Switzerland	RFER	4.228***	6.387***	1.053	1.706	6.049***	2.782**
		(0.007)	(0.000)	(0.371)	(0.168)	(0.000)	(0.043)
	Equity flows	3.060**	0.899	1.596	1.348	0.369	2.260*
		(0.030)	(0.443)	(0.192)	(0.261)	(0.776)	(0.083)
UK	RFER	13.356***	14.965***	0.995	10.971***	15.252***	1.320
		(0.000)	(0.000)	(0.397)	(0.000)	(0.000)	(0.265)
	Equity flows	1.279	2.206*	1.759	2.962**	1.788	1.453
		(0.283)	(0.090)	(0.157)	(0.034)	(0.151)	(0.219)

Note: The abbreviations in the head of the table are defined as follows: FB: foreign stocks bought by US residents; FS: foreign stocks sold by US residents; FN: the difference between FB and FS; USB: US stocks bought by foreign residents; USS: US stocks sold by foreign residents; USN: the difference between USB and USS. H0 RFER indicates the null hypothesis that RFER does not influence equity flows; H0 Equity flows indicate the null hypothesis that equity flows do not influence RFER; p-values are provided in parentheses; asterisks show significance level at 1% (***), 5%(**) and 10%(*).

Tab. B.2: Results of the Granger causality test for emerging markets

Country	H0	FB	FS	FN	USB	USS	USN
Argentina	RFER	1.655 (0.179)	0.947 (0.411)	0.226 (0.878)	3.322** (0.021)	2.584** (0.055)	0.943 (0.422)
	Equity flows	1.296 (0.278)	1.031 (0.381)	0.677 (0.567)	1.602 (0.191)	2.553** (0.057)	3.571** (0.015)
China	RFER	1.842 (0.142)	3.581** (0.015)	1.697 (0.170)	1.333 (0.266)	2.638** (0.051)	1.025 (0.383)
	Equity flows	2.291 (0.080)	0.218 (0.884)	0.615 (0.606)	2.451* (0.065)	1.450 (0.230)	2.240* (0.086)
Mexico	RFER	10.455*** (0.000)	5.754*** (0.001)	0.095 (0.963)	6.596*** (0.000)	5.070*** (0.002)	1.478 (0.223)
	Equity flows	0.093 (0.964)	0.247 (0.863)	0.606 (0.612)	0.306 (0.821)	0.297 (0.828)	0.340 (0.796)
Poland	RFER	1.786 (0.153)	1.166 (0.325)	1.012 (0.390)	1.201 (0.312)	0.920 (0.433)	0.306 (0.821)
	Equity flows	0.568 (0.637)	0.175 (0.913)	1.347 (0.262)	0.745 (0.527)	0.338 (0.798)	0.493 (0.688)
Russia	RFER	3.846** (0.011)	6.559*** (0.000)	1.207 (0.309)	0.867 (0.460)	1.195 (0.313)	0.540 (0.656)
	Equity flows	1.867 (0.137)	0.508 (0.678)	1.872 (0.136)	0.970 (0.409)	1.197 (0.313)	0.971 (0.408)
South Africa	RFER	2.176* (0.093)	0.726 (0.334)	1.142 (0.538)	1.578 (0.197)	1.445 (0.232)	0.082 (0.970)
	Equity flows	1.012 (0.389)	3.051 (0.411)	0.965** (0.030)	0.400 (0.753)	0.906 (0.440)	0.767 (0.514)

Note: The abbreviations in the head of the table are defined as follows: FB: foreign stocks bought by US residents; FS: foreign stocks sold by US residents; FN: the difference between FB and FS; USB: US stocks bought by foreign residents; USS: US stocks sold by foreign residents; USN: the difference between USB and USS. H0 RFER indicates the null hypothesis that RFER does not influence equity flows; H0 Equity flows indicate the null hypothesis that equity flows do not influence RFER; p-values are provided in parentheses; asterisks show significance level at 1% (***), 5%(**) and 10%(*).

Tab. B.3: Estimates for ADL regression of foreign equity flows on RFER volatility

Equity flow	FB			FS			FN		
Lag	1	2	3	1	2	3	1	2	3
Developed countries									
Australia	-0.060	0.216	2.943	-5.487	1.536	-0.064	6.571***	0.745	3.557
	(0.988)	(0.960)	(0.475)	(0.132)	(0.710)	(0.987)	(0.005)	(0.775)	(0.159)
Canada	-6.134	7.570	0.710	-9.327	9.629	0.496	10.336	15.344*	7.499
	(0.590)	(0.529)	(0.952)	(0.402)	(0.415)	(0.966)	(0.166)	(0.056)	(0.329)
Euro area	-5.430	0.533	-3.457	-4.608	-3.502	-2.962	-1.356	1.332	-0.845
	(0.201)	(0.909)	(0.431)	(0.263)	(0.436)	(0.492)	(0.615)	(0.649)	(0.763)
Japan	3.546	-3.527	1.597	-11.643**	-3.665	-1.291	14.283***	0.299	0.201
	(0.470)	(0.519)	(0.755)	(0.034)	(0.550)	(0.820)	(0.008)	(0.960)	(0.971)
Sweden	-16.333	-9.181	8.668	-23.472*	-17.876	9.256	1.227	5.329	1.475
	(0.217)	(0.544)	(0.501)	(0.068)	(0.272)	(0.440)	(0.915)	(0.666)	(0.898)
Switzerland	-4.011	3.349	-1.960	-7.608	2.492	-6.317	9.707**	4.128	7.604
	(0.470)	(0.565)	(0.753)	(0.185)	(0.635)	(0.251)	(0.030)	(0.382)	(0.117)
UK	-27.596*	4.535	-13.368	-32.078***	1.060	-14.921	4.536	6.571	5.625
	(0.001)	(0.654)	(0.177)	(0.000)	(0.916)	(0.126)	(0.326)	(0.233)	(0.290)
Emerging markets									
Argentina	1.981	-5.053	-7.842	-1.495	-1.882	-1.942	1.295	-5.094	-5.022
	(0.691)	(0.319)	(0.128)	(0.689)	(0.622)	(0.548)	(0.760)	(0.239)	(0.244)
China	9.767	0.637	-10.321	-7.824	-4.625	9.588	12.605	2.988	-16.280
	(0.436)	(0.964)	(0.432)	(0.367)	(0.644)	(0.287)	(0.321)	(0.832)	(0.217)
Mexico	-12.617**	-18.625**	-16.393**	-7.475	-3.201	-7.756	-1.995	-1.090	-1.210
	(0.043)	(0.005)	(0.015)	(0.296)	(0.676)	(0.305)	(0.746)	(0.866)	(0.845)
Poland	12.230	-7.116	-11.361	21.866	-13.191	-4.998	-15.235	2.987	-12.420
	(0.266)	(0.527)	(0.314)	(0.109)	(0.338)	(0.711)	(0.242)	(0.821)	(0.336)
Russia	0.618	-11.401	-5.865	-11.933	-2.792	-13.365	12.214*	-6.420	7.812
	(0.930)	(0.217)	(0.481)	(0.103)	(0.738)	(0.103)	(0.099)	(0.406)	(0.315)
South	-6.917	-8.123	-6.253	-0.798	1.858	10.358	0.012	-5.527	-8.254
Africa	(0.418)	(0.367)	(0.454)	(0.932)	(0.853)	(0.266)	(0.999)	(0.591)	(0.384)

Note: The abbreviations in the head of the table are defined as follows: FB: foreign stocks bought by US residents; FS: foreign stocks sold by US residents; FN: the difference between FB and FS ; p-values are provided in parentheses; asterisks show significance level at 1% (***), 5%(**) and 10%(*).

Tab. B.4: Estimates for ADL regression of US equity flows on RFER volatility

Equity flow	USB			USS			USN		
Lag	1	2	3	1	2	3	1	2	3
Developed countries									
Australia	-22.343***	-6.340	-0.818	-0.851	1.542	0.098*	-4.303	-3.152	-2.738
	(0.000)	(0.245)	(0.873)	(0.853)	(0.753)	(0.983)	(0.363)	(0.529)	(0.564)
Canada	-31.621**	-14.942	-1.913	-24.669*	-3.213	2.401	2.184	-8.369	-1.956
	(0.040)	(0.364)	(0.903)	(0.083)	(0.832)	(0.871)	(0.795)	(0.343)	(0.817)
Euro area	-7.947	0.500	-8.995	-4.736	-3.221	-3.022	-0.780	-1.062	-1.684
	(0.144)	(0.934)	(0.117)	(0.258)	(0.482)	(0.492)	(0.637)	(0.567)	(0.351)
Japan	0.882	-7.659	7.136	3.422	-9.071	-12.759	-0.635	2.336	16.217*
	(0.938)	(0.527)	(0.518)	(0.722)	(0.315)	(0.218)	(0.931)	(0.795)	(0.051)
Sweden	-10.400	7.650	-6.779	-30.512**	5.829	-30.225*	15.536*	-3.172	26.56***
	(0.593)	(0.711)	(0.698)	(0.045)	(0.766)	(0.060)	(0.097)	(0.745)	(0.007)
Switzerland	1.784	3.911	4.474	3.045	-1.709	-2.710	-1.385	5.083	3.902
	(0.722)	(0.460)	(0.371)	(0.511)	(0.728)	(0.549)	(0.657)	(0.126)	(0.214)
UK	-18.919**	-9.633	-8.284	-27.721**	-7.313	-9.089	7.090**	3.640	2.294
	(0.037)	(0.368)	(0.413)	(0.002)	(0.479)	(0.353)	(0.034)	(0.359)	(0.532)
Emerging markets									
Argentina	-4.955	-3.141	0.615	-3.768	-6.884	4.314	-0.176	4.087*	-0.821
	(0.116)	(0.320)	(0.847)	(0.116)	(0.320)	(0.847)	(0.936)	(0.061)	(0.711)
China	7.537	-0.477	7.903	-6.705	2.128	2.728	13.842*	6.485	7.423
	(0.389)	(0.958)	(0.339)	(0.319)	(0.765)	(0.680)	(0.052)	(0.387)	(0.276)
Mexico	-7.859	-14.870**	-14.257**	-5.778	-17.244**	-17.377**	-5.454	-1.329	0.987
	(0.229)	(0.029)	(0.034)	(0.388)	(0.013)	(0.012)	(0.313)	(0.812)	(0.856)
Poland	-5.374	19.072	13.407	-18.601	13.671	2.014	6.910	3.915	23.243*
	(0.729)	(0.229)	(0.392)	(0.193)	(0.349)	(0.887)	(0.619)	(0.784)	(0.096)
Russia	0.458	0.429	4.827	-3.229	0.674	-0.686	5.539	-1.586	5.505
	(0.951)	(0.955)	(0.488)	(0.662)	(0.928)	(0.920)	(0.156)	(0.698)	(0.138)
South	5.231	-4.320	-8.645	-1.998	-7.544	-7.614	6.033	11.775	7.936
Africa	(0.684)	(0.742)	(0.488)	(0.862)	(0.526)	(0.507)	(0.611)	(0.333)	(0.490)

Note: The abbreviations in the head of the table are defined as follows: USB: US stocks bought by foreign residents; USS: US stocks sold by foreign residents; USN: the difference between USB and USS; p-values are provided in parentheses; asterisks show significance level at 1% (***), 5%(**) and 10%(*).

Tab. B.5: Long run multipliers for ADL regression of equity flows on RFER volatility

Equity flow	FB	FS	FN	USB	USS	USN
Developed countries						
Australia	1.403	-2.039	*13.144*	*-13.423*	0.543	-12.861
Canada	1.096	0.392	*31.416*	*-37.867*	*-18.998*	-12.065
Euro area	-2.848	-4.649	-1.178	-10.428	-4.582	-2.939
Japan	0.775	*-6.313*	*27.005*	0.163	-8.540	*24.508*
Sweden	-9.227	*-22.735*	19.199	-4.957	*-29.445*	*48.409*
Switzerland	-1.416	-5.405	*31.151*	4.328	-0.732	13.405
UK	*-25.392*	*-34.005*	17.745	*-20.410*	*-23.442*	*26.124*
Emerging markets						
Argentina	-3.970	-4.765	-10.537	-4.824	-4.109	*3.702*
China	0.036	-0.337	-2.887	7.368	-1.116	*31.403*
Mexico	*-17.072*	-2.689	-11.204	*-22.075*	*-25.483*	-7.781
Poland	-3.260	-10.473	-40.571	13.163	-1.463	*40.909*
Russia	-9.088	8.096	*18.388*	3.666	-2.002	9.087
South Africa	-10.085	-4.644	-19.157	-2.663	-3.887	32.582

Note: The abbreviations in the head of the table are defined as follows: FB: foreign stocks bought by US residents; FS: foreign stocks sold by US residents; FN: the difference between FB and FS; USB: US stocks bought by foreign residents; USS: US stocks sold by foreign residents; USN: the difference between USB and USS. Coefficients in italics are calculated based on short-run coefficients, where at least one short-run coefficient is significant at least at 10% significance level (see also Tables B.3 and B.4 for details).

Tab. B.6: Estimates for ADL regression of foreign equity flows on equity returns

Equity flow	FB			FS			FN		
Lag	1	2	3	1	2	3	1	2	3
Developed countries									
Australia	1.293***	0.017	-0.508	0.868**	0.886*	-0.803*	0.620**	-0.469	0.417
	(0.002)	(0.974)	(0.312)	(0.029)	(0.064)	(0.097)	(0.015)	(0.121)	(0.175)
Canada	0.922	0.277	0.538	0.860	1.181	0.134	0.892**	-0.321	0.767
	(0.139)	(0.708)	(0.461)	(0.151)	(0.107)	(0.856)	(0.025)	(0.507)	(0.123)
Euro area	0.202	0.446	-0.169	0.139	0.450	0.278	0.178	0.072	-0.325*
	(0.396)	(0.116)	(0.554)	(0.549)	(0.106)	(0.320)	(0.242)	(0.692)	(0.074)
Japan	0.901**	0.523	0.502	1.355***	0.265	-0.432	-0.187	0.299	0.549
	(0.039)	(0.289)	(0.177)	(0.005)	(0.627)	(0.299)	(0.687)	(0.571)	(0.177)
Sweden	1.311	0.206	1.475*	1.316	1.429	1.560	0.465	-0.620	-0.467
	(0.177)	(0.847)	(0.098)	(0.119)	(0.141)	(0.107)	(0.477)	(0.399)	(0.528)
Switzerland	0.608	1.601**	-1.052*	0.289	1.135*	-0.844	0.546	0.509	0.254
	(0.262)	(0.030)	(0.097)	(0.569)	(0.072)	(0.121)	(0.143)	(0.234)	(0.541)
UK	1.785**	1.168	-0.921	1.421**	0.623	-0.644	0.639	0.458	0.162
	(0.015)	(0.152)	(0.206)	(0.047)	(0.428)	(0.361)	(0.114)	(0.311)	(0.695)
Emerging markets									
Argentina	0.253	0.466*	0.090	0.231	0.446**	0.023	0.019	0.055	0.083
	(0.319)	(0.098)	(0.739)	(0.272)	(0.017)	(0.919)	(0.928)	(0.816)	(0.721)
China	1.053	0.020	-0.382	0.750	0.166	-0.020	-0.026	-0.274	-0.140
	(0.118)	(0.978)	(0.626)	(0.125)	(0.759)	(0.974)	(0.969)	(0.708)	(0.858)
Mexico	0.977***	1.143***	0.415	0.786**	0.523	0.383	-0.241	0.298	0.254
	(0.006)	(0.007)	(0.309)	(0.046)	(0.263)	(0.406)	(0.489)	(0.457)	(0.520)
Poland	1.512*	0.772	0.675	1.515	0.578	-0.680	-0.848	-0.648	0.982
	(0.065)	(0.351)	(0.389)	(0.122)	(0.560)	(0.474)	(0.383)	(0.508)	(0.285)
Russia	0.890	0.382	-0.283	0.438	1.782	0.626	1.285	-0.630	-0.315
	(0.118)	(0.527)	(0.647)	(0.440)	(0.003)	(0.279)	(0.018)	(0.235)	(0.557)
South	1.895***	-0.295	0.811	-0.161	0.392	0.660	2.259***	-0.143	0.174
Africa	(0.003)	(0.656)	(0.221)	(0.799)	(0.552)	(0.320)	(0.001)	(0.847)	(0.809)

Note: See notes to Table B.3.

Tab. B.7: Estimates for ADL regression of US equity flows on equity returns

Equity flow	USB			USS			USN		
Lag	1	2	3	1	2	3	1	2	3
Developed countries									
Australia	1.357***	-0.493	0.943*	0.131	-0.951*	-0.225	1.059***	-0.570	-0.554
	(0.001)	(0.388)	(0.086)	(0.744)	(0.082)	(0.665)	(0.009)	(0.305)	(0.295)
Canada	-0.259	0.011	-2.854***	-0.237	0.555	-2.472**	0.042	-0.349	-0.351
	(0.735)	(0.992)	(0.006)	(0.740)	(0.579)	(0.010)	(0.918)	(0.545)	(0.524)
Euro area	-0.476	-0.313	-0.366	0.090	0.308	0.269	0.040	0.088	0.025
	(0.114)	(0.391)	(0.288)	(0.703)	(0.280)	(0.334)	(0.687)	(0.460)	(0.828)
Japan	0.385	1.073	-0.491	1.199	2.494*	-1.882	-0.429	-0.811	1.674
	(0.724)	(0.466)	(0.724)	(0.231)	(0.057)	(0.161)	(0.623)	(0.484)	(0.141)
Sweden	0.689	1.157	1.989	-0.577	3.671**	0.423	2.347**	-0.743	1.690
	(0.633)	(0.561)	(0.361)	(0.682)	(0.047)	(0.813)	(0.018)	(0.554)	(0.109)
Switzerland	0.884**	0.609	-0.606	0.888**	0.307	-0.600	0.193	0.314	0.000
	(0.021)	(0.246)	(0.229)	(0.010)	(0.522)	(0.169)	(0.389)	(0.272)	(0.999)
UK	2.044**	0.314	-0.412	1.396*	1.011	-0.324	0.226	-0.288	0.049
	(0.011)	(0.726)	(0.607)	(0.067)	(0.241)	(0.674)	(0.432)	(0.366)	(0.869)
Emerging markets									
Argentina	1.679***	-0.567	-0.735	-0.021	-1.390**	0.131	1.426***	1.167**	-0.491
	(0.003)	(0.388)	(0.223)	(0.970)	(0.028)	(0.823)	(0.000)	(0.011)	(0.245)
China	2.596**	-0.798	-0.308	0.468	-0.316	0.442	1.271	0.161	-0.338
	(0.016)	(0.493)	(0.777)	(0.587)	(0.738)	(0.614)	(0.149)	(0.866)	(0.705)
Mexico	1.869***	-1.442**	-0.176	0.955*	-0.778	-0.530	0.370	-0.728	0.206
	(0.001)	(0.023)	(0.767)	(0.096)	(0.219)	(0.371)	(0.424)	(0.158)	(0.665)
Poland	2.430	-2.467	1.191	1.196	0.475	-2.564	1.355	-2.812*	4.707***
	(0.215)	(0.210)	(0.534)	(0.510)	(0.791)	(0.146)	(0.423)	(0.099)	(0.008)
Russia	0.095*	0.100	-0.432	-0.664	0.155	-1.074	-0.252	-0.301	0.422
	(0.937)	(0.940)	(0.728)	(0.579)	(0.905)	(0.377)	(0.683)	(0.653)	(0.507)
South	2.034	0.472	-1.502	0.998	1.701	-0.343	0.649	-0.829	-0.189
Africa	(0.111)	(0.723)	(0.242)	(0.380)	(0.162)	(0.769)	(0.575)	(0.498)	(0.873)

Note: See notes to Table B.4.

Tab. B.8: Estimates for ADL regression of foreign equity flows on VIX

Equity flow	FB			FS			FN		
Lag	1	2	3	1	2	3	1	2	3
Developed countries									
Australia	-0.004**	0.001	0.001	-0.001	-0.001	0.002	-0.002**	0.001	-0.001
	(0.038)	(0.617)	(0.394)	(0.404)	(0.538)	(0.156)	(0.024)	(0.415)	(0.511)
Canada	-0.006**	0.001	0.002	-0.005*	-0.001	0.003	0.000	0.000	-0.001
	(0.048)	(0.763)	(0.471)	(0.090)	(0.694)	(0.329)	(0.805)	(0.987)	(0.745)
Euro area	-0.001	-0.002	0.001	0.000	-0.001	0.000	-0.001	-0.002	0.001
	(0.510)	(0.230)	(0.307)	(0.993)	(0.741)	(0.987)	(0.491)	(0.132)	(0.379)
Japan	-0.002	-0.001	0.004**	-0.003	0.004	-0.001	0.001	-0.005*	0.004*
	(0.298)	(0.601)	(0.046)	(0.178)	(0.160)	(0.751)	(0.690)	(0.085)	(0.077)
Sweden	-0.004	0.014*	-0.015**	-0.002	0.017*	-0.014*	-0.003	-0.003	-0.002
	(0.580)	(0.069)	(0.030)	(0.763)	(0.058)	(0.064)	(0.509)	(0.602)	(0.637)
Switzerland	-0.003	0.000	0.002	-0.003	-0.001	0.003*	-0.001	0.001	-0.001
	(0.135)	(0.990)	(0.314)	(0.182)	(0.668)	(0.071)	(0.374)	(0.448)	(0.640)
UK	0.003	-0.007**	0.004*	0.003	-0.005**	0.003	0.000	-0.002	0.000
	(0.292)	(0.021)	(0.069)	(0.345)	(0.092)	(0.179)	(0.945)	(0.247)	(0.714)
Emerging markets									
Argentina	0.001	-0.004	0.000	-0.003	0.001	0.001	0.007***	-0.003	-0.002
	(0.728)	(0.269)	(0.945)	(0.205)	(0.671)	(0.662)	(0.008)	(0.424)	(0.336)
China	-0.011	0.004	0.005	-0.004	-0.002	0.006	-0.007	0.008	-0.007
	(0.109)	(0.634)	(0.438)	(0.416)	(0.746)	(0.158)	(0.308)	(0.383)	(0.280)
Mexico	-0.001	-0.002	0.000	-0.002	0.000	0.001	0.001	0.000	-0.001
	(0.749)	(0.492)	(0.970)	(0.385)	(0.916)	(0.527)	(0.715)	(0.950)	(0.533)
Poland	-0.002	0.004	-0.001	0.000	0.006	-0.006	0.000	-0.005	0.005
	(0.528)	(0.433)	(0.803)	(0.996)	(0.356)	(0.164)	(0.993)	(0.449)	(0.250)
Russia	0.001	0.000	-0.002	0.003	-0.002	0.000	0.000	0.001	-0.005
	(0.862)	(0.942)	(0.604)	(0.462)	(0.658)	(0.923)	(0.938)	(0.823)	(0.199)
South	-0.001	0.002	-0.002	-0.004	0.002	0.000	-0.001	0.001	-0.005
Africa	(0.699)	(0.512)	(0.572)	(0.245)	(0.697)	(0.911)	(0.823)	(0.730)	(0.165)

Note: See notes to Table B.3.

Tab. B.9: Estimates for ADL regression of US equity flows on VIX

Equity flow	USB			USS			USN		
Lag	1	2	3	1	2	3	1	2	3
Developed countries									
Australia	-0.001	0.007**	-0.004**	-0.003	0.001	0.002	0.001	-0.001	0.002
	(0.699)	(0.028)	(0.042)	(0.302)	(0.730)	(0.412)	(0.710)	(0.660)	(0.339)
Canada	-0.006	0.004	0.003	-0.005	0.002	0.004	-0.002	0.001	-0.001
	(0.178)	(0.465)	(0.471)	(0.219)	(0.756)	(0.275)	(0.446)	(0.710)	(0.697)
Euro area	-0.007***	0.002	0.003	-0.001	0.000	-0.001	0.000	0.000	0.000
	(0.001)	(0.268)	(0.104)	(0.580)	(0.900)	(0.655)	(0.652)	(0.911)	(0.506)
Japan	-0.007	0.007	-0.001	0.001	-0.004	0.003	-0.006	0.006	0.002
	(0.270)	(0.360)	(0.873)	(0.814)	(0.571)	(0.597)	(0.272)	(0.352)	(0.642)
Sweden	-0.006	0.015	-0.015	-0.001	0.007	-0.012	-0.004	0.003	0.001
	(0.413)	(0.241)	(0.209)	(0.937)	(0.506)	(0.161)	(0.563)	(0.683)	(0.844)
Switzerland	-0.001	-0.004*	0.004**	-0.003	-0.002	0.003*	0.001	-0.001	0.001
	(0.656)	(0.093)	(0.048)	(0.161)	(0.460)	(0.083)	(0.429)	(0.401)	(0.446)
UK	-0.002	-0.003	0.004	-0.001	-0.002	0.002	-0.001	-0.001	0.001
	(0.568)	(0.467)	(0.163)	(0.843)	(0.580)	(0.445)	(0.650)	(0.538)	(0.536)
Emerging markets									
Argentina	0.000	-0.001	0.000	-0.003	0.000	0.003	0.002	-0.001	-0.002
	(0.836)	(0.603)	(0.894)	(0.154)	(0.919)	(0.171)	(0.200)	(0.640)	(0.104)
China	-0.005	-0.001	0.004	-0.004	-0.001	0.004	-0.001	0.002	0.002
	(0.268)	(0.880)	(0.228)	(0.241)	(0.837)	(0.140)	(0.750)	(0.618)	(0.436)
Mexico	-0.001	-0.001	0.001	-0.002	0.001	-0.001	0.000	-0.001	0.003
	(0.594)	(0.810)	(0.645)	(0.444)	(0.646)	(0.543)	(0.882)	(0.581)	(0.113)
Poland	-0.004	0.003	0.000	-0.004	-0.003	0.007	-0.010**	0.014**	-0.008*
	(0.410)	(0.596)	(0.974)	(0.441)	(0.561)	(0.124)	(0.049)	(0.022)	(0.075)
Russia	-0.010**	0.005	0.004	-0.012**	0.007	0.004	0.001	-0.001	0.000
	(0.042)	(0.376)	(0.408)	(0.012)	(0.217)	(0.421)	(0.634)	(0.650)	(0.827)
South	-0.004	0.003	0.000	-0.001	0.004	-0.007*	-0.004	-0.001	0.006
Africa	(0.412)	(0.595)	(0.923)	(0.904)	(0.370)	(0.069)	(0.357)	(0.862)	(0.117)

Note: See notes to Table B.4.

Tab. B.10: Estimates for ADL regression of foreign equity flows on interest rates

Equity flow	FB			FS			FN		
Lag	1	2	3	1	2	3	1	2	3
Developed countries									
Australia	0.011	0.003	-0.022	0.082**	0.009	-0.009	-0.062***	0.008	-0.028
	(0.762)	(0.939)	(0.558)	(0.018)	(0.809)	(0.807)	(0.006)	(0.749)	(0.219)
Canada	0.088	-0.059	0.017	0.067	-0.047	-0.019	0.002	0.033	0.023
	(0.140)	(0.274)	(0.752)	(0.251)	(0.378)	(0.722)	(0.950)	(0.340)	(0.497)
Euro area	-0.029	0.004	0.074	0.047	-0.035	0.082*	-0.069**	0.022	-0.010
	(0.560)	(0.947)	(0.108)	(0.339)	(0.504)	(0.064)	(0.032)	(0.530)	(0.741)
Japan	-0.272	0.354	0.105	0.575**	0.217	-0.690***	-0.865***	0.038	0.579**
	(0.241)	(0.156)	(0.627)	(0.027)	(0.435)	(0.005)	(0.001)	(0.889)	(0.018)
Sweden	-0.107	0.101	0.194	-0.039	0.114	0.344*	-0.080	-0.069	-0.233**
	(0.362)	(0.358)	(0.319)	(0.786)	(0.284)	(0.091)	(0.425)	(0.476)	(0.024)
Switzerland	-0.031	0.018	-0.006	-0.005	-0.019	0.003	-0.024	0.031	-0.002
	(0.524)	(0.746)	(0.901)	(0.902)	(0.720)	(0.942)	(0.529)	(0.406)	(0.956)
UK	-0.002	0.043	-0.124**	0.050	-0.059	-0.026	-0.047	0.059*	-0.075**
	(0.971)	(0.468)	(0.029)	(0.372)	(0.298)	(0.641)	(0.153)	(0.076)	(0.019)
Emerging markets									
Argentina	-0.002	-0.006***	-0.005**	-0.002	-0.005	-0.003	0.000	0.000	0.000
	(0.403)	(0.009)	(0.031)	(0.200)	(0.125)	(0.250)	(0.937)	(0.817)	(0.909)
China	0.139	-0.012	-0.246	-0.025	0.129	-0.020	0.193	-0.074	-0.292
	(0.486)	(0.953)	(0.309)	(0.852)	(0.359)	(0.906)	(0.327)	(0.720)	(0.227)
Mexico	0.002	-0.023*	0.002	0.003	-0.005	0.019	-0.004	-0.022*	0.004
	(0.867)	(0.064)	(0.839)	(0.867)	(0.738)	(0.207)	(0.772)	(0.066)	(0.708)
Poland	-0.072	-0.057	0.239**	-0.117	-0.208	0.253*	0.015	0.135	0.088
	(0.557)	(0.673)	(0.040)	(0.443)	(0.212)	(0.076)	(0.916)	(0.392)	(0.526)
Russia	-0.019	-0.013	-0.022	0.005	0.018	-0.009	-0.013	-0.015	-0.001
	(0.155)	(0.606)	(0.316)	(0.730)	(0.219)	(0.505)	(0.305)	(0.213)	(0.918)
South	0.054*	-0.023	-0.019	-0.049	-0.008	0.001	0.093***	0.012	-0.001
Africa	(0.055)	(0.404)	(0.503)	(0.106)	(0.798)	(0.964)	(0.004)	(0.716)	(0.980)

Note: See notes to Table B.3.

Tab. B.11: Estimates for ADL regression of US equity flows on interest rates

Equity flow	USB			USS			USN		
Lag	1	2	3	1	2	3	1	2	3
Developed countries									
Australia	-0.025	-0.003	-0.004	0.016	0.003	0.015	-0.010	-0.029	0.036
	(0.511)	(0.949)	(0.923)	(0.657)	(0.929)	(0.687)	(0.783)	(0.462)	(0.341)
Canada	0.071	-0.126	0.046	0.056	-0.068	0.004	0.002	-0.024	0.033
	(0.324)	(0.103)	(0.528)	(0.404)	(0.352)	(0.949)	(0.963)	(0.561)	(0.388)
Euro area	0.025	-0.042	0.059*	0.016	-0.022	0.037	0.003	-0.001	0.013
	(0.407)	(0.150)	(0.051)	(0.492)	(0.330)	(0.114)	(0.724)	(0.903)	(0.188)
Japan	0.014	0.023	-0.071	0.187**	-0.034	-0.131	-0.226	0.031	-0.016
	(0.891)	(0.827)	(0.486)	(0.023)	(0.754)	(0.215)	(0.138)	(0.738)	(0.852)
Sweden	0.037	-0.065	0.123	-0.130	0.174	-0.005	0.092	-0.241***	0.031
	(0.756)	(0.564)	(0.285)	(0.159)	(0.102)	(0.963)	(0.165)	(0.000)	(0.681)
Switzerland	0.043	0.008	0.013	0.070***	-0.041	0.024	-0.029	0.022	-0.002
	(0.144)	(0.803)	(0.669)	(0.008)	(0.140)	(0.372)	(0.116)	(0.241)	(0.902)
UK	-0.023	-0.039	0.029	-0.047	0.001	-0.001	0.009	-0.009	0.010
	(0.634)	(0.450)	(0.558)	(0.317)	(0.980)	(0.992)	(0.608)	(0.637)	(0.594)
Emerging markets									
Argentina	0.038	-0.040	-0.024	0.054	-0.036	0.010	-0.044	-0.021	-0.069**
	(0.331)	(0.336)	(0.540)	(0.173)	(0.397)	(0.812)	(0.115)	(0.481)	(0.014)
China	0.102	0.011	0.031	0.055	0.004	-0.002	0.009	-0.002	0.017
	(0.142)	(0.875)	(0.645)	(0.317)	(0.940)	(0.971)	(0.882)	(0.969)	(0.762)
Mexico	0.013	-0.033	-0.011	0.039	-0.054	-0.001	-0.014	0.028	-0.001
	(0.734)	(0.428)	(0.779)	(0.331)	(0.195)	(0.987)	(0.664)	(0.410)	(0.980)
Poland	0.389***	-0.175	-0.238*	0.147	0.062	-0.047	0.310***	-0.182	-0.158
	(0.002)	(0.181)	(0.072)	(0.186)	(0.588)	(0.692)	(0.006)	(0.107)	(0.165)
Russia	-0.071	0.068	-0.005	-0.066	0.032	0.054	-0.042	0.025	-0.066
	(0.395)	(0.448)	(0.957)	(0.419)	(0.717)	(0.530)	(0.325)	(0.579)	(0.144)
South	0.048	0.098	-0.045	0.038	0.070	-0.050	0.102	0.004	0.078
Africa	(0.557)	(0.249)	(0.580)	(0.618)	(0.368)	(0.510)	(0.179)	(0.964)	(0.307)

Note: See notes to Table B.4.

Tab. B.12: Estimates for ADL regression of foreign equity flows on industrial production

Equity flow	FB			FS			FN		
Lag	1	2	3	1	2	3	1	2	3
Developed countries									
Australia	0.414	1.860	-1.296	0.441	0.935	-2.337**	-0.424	0.548	0.146
	(0.745)	(0.145)	(0.293)	(0.720)	(0.442)	(0.047)	(0.587)	(0.474)	(0.845)
Canada	-3.144	7.878***	-2.579	-3.092	8.099***	0.836	1.385	-0.935	-1.337
	(0.254)	(0.006)	(0.371)	(0.253)	(0.005)	(0.767)	(0.434)	(0.607)	(0.458)
Euro area	-0.360	0.115	0.304	-0.143	-0.918	-0.267	-0.400	0.633	0.173
	(0.771)	(0.926)	(0.810)	(0.907)	(0.448)	(0.830)	(0.611)	(0.422)	(0.829)
Japan	-0.416	-1.808*	0.155	-1.468	0.195	-0.495	1.279	-1.098	0.943
	(0.650)	(0.050)	(0.864)	(0.155)	(0.849)	(0.622)	(0.200)	(0.273)	(0.333)
Sweden	1.409	3.642	-1.811	-0.322	3.181	2.563	1.742	0.666	-3.232
	(0.629)	(0.187)	(0.476)	(0.896)	(0.269)	(0.260)	(0.392)	(0.755)	(0.109)
Switzerland	0.001	0.001	-0.001	-0.001	0.005**	0.000	0.002	-0.004	-0.001
	(0.649)	(0.705)	(0.799)	(0.724)	(0.018)	(0.985)	(0.374)	(0.138)	(0.565)
UK	0.657	1.475	0.483	-1.422	1.785	0.520	1.719***	0.567	-0.044
	(0.531)	(0.201)	(0.652)	(0.167)	(0.120)	(0.623)	(0.004)	(0.395)	(0.943)
Emerging markets									
Argentina	-1.509	2.777	0.707	0.692	0.758	0.604	-1.833	1.905	-0.146
	(0.406)	(0.142)	(0.703)	(0.636)	(0.638)	(0.691)	(0.236)	(0.232)	(0.927)
China	-1.394	0.127	2.684	-2.343	-1.296	-0.898	0.560	1.068	3.359*
	(0.515)	(0.958)	(0.153)	(0.174)	(0.494)	(0.522)	(0.794)	(0.658)	(0.074)
Mexico	-3.775*	-3.308	-8.094***	2.014	-2.057	-2.659	-4.700**	1.585	-3.202
	(0.098)	(0.155)	(0.000)	(0.430)	(0.419)	(0.284)	(0.036)	(0.495)	(0.151)
Poland	-4.130	-0.881	7.800**	1.264	2.192	-0.627	-3.958	-3.427	5.600
	(0.146)	(0.766)	(0.010)	(0.716)	(0.546)	(0.863)	(0.234)	(0.324)	(0.110)
Russia	-0.609	-3.559	-5.778*	1.229	-2.755	-2.729	0.051	1.331	-2.497
	(0.868)	(0.207)	(0.087)	(0.708)	(0.402)	(0.357)	(0.986)	(0.648)	(0.311)
South	-2.994**	-1.409	-0.611	-0.357	0.391	-1.746	-2.899**	-3.012**	-1.198
Africa	(0.014)	(0.292)	(0.614)	(0.785)	(0.777)	(0.165)	(0.037)	(0.046)	(0.385)

Note: See notes to Table B.3.

Tab. B.13: Estimates for ADL regression of US equity flows on industrial production

Equity flow	USB			USS			USN		
Lag	1	2	3	1	2	3	1	2	3
Developed countries									
Australia	3.063**	0.260	-2.498*	1.709	-0.850	0.152	2.798**	2.090*	-1.916
	(0.017)	(0.841)	(0.069)	(0.161)	(0.492)	(0.908)	(0.025)	(0.097)	(0.155)
Canada	5.598**	2.500	-4.321*	3.279	2.463	-0.535	0.436	0.216	-1.392
	(0.019)	(0.323)	(0.099)	(0.137)	(0.288)	(0.826)	(0.729)	(0.872)	(0.315)
Euro area	0.301	0.618	-0.614	0.208	-0.281	0.361	-0.185	0.532	-1.057**
	(0.834)	(0.655)	(0.668)	(0.856)	(0.799)	(0.754)	(0.690)	(0.235)	(0.024)
Japan	0.649	-2.488	-0.987	-0.783	1.031	-3.620	2.448	-3.190	2.126
	(0.845)	(0.457)	(0.786)	(0.716)	(0.726)	(0.195)	(0.348)	(0.213)	(0.578)
Sweden	-3.078	-0.401	2.602	-2.172	-2.228	4.098	0.412	1.891	-3.177
	(0.537)	(0.923)	(0.550)	(0.681)	(0.565)	(0.290)	(0.867)	(0.476)	(0.255)
Switzerland	-0.889	0.266	0.259	-0.731	0.837	-1.387	0.142	-1.174*	0.951
	(0.358)	(0.794)	(0.808)	(0.396)	(0.359)	(0.148)	(0.815)	(0.068)	(0.155)
UK	1.356	2.019	-1.009	0.069	2.936*	0.276	0.529	0.020	-0.143
	(0.434)	(0.238)	(0.592)	(0.966)	(0.073)	(0.879)	(0.411)	(0.976)	(0.839)
Emerging markets									
Argentina	-0.621	0.352	-2.404*	-0.784	2.291*	-1.979	0.326	-1.190	-0.320
	(0.632)	(0.790)	(0.092)	(0.546)	(0.087)	(0.165)	(0.719)	(0.204)	(0.746)
China	-0.018	2.596	-5.431**	-0.526	2.106	-3.343*	1.594	2.638	0.573
	(0.994)	(0.260)	(0.029)	(0.766)	(0.252)	(0.086)	(0.393)	(0.169)	(0.781)
Mexico	-0.239	-0.064	-0.451	-1.002	0.367	-2.125	0.839	0.599	2.898**
	(0.848)	(0.961)	(0.742)	(0.435)	(0.784)	(0.131)	(0.422)	(0.588)	(0.013)
Poland	-5.533	5.713	-2.780	-0.651	-2.872	1.661	-5.490	7.373**	-6.819*
	(0.168)	(0.182)	(0.502)	(0.859)	(0.463)	(0.658)	(0.132)	(0.052)	(0.074)
Russia	1.519	-0.650	2.173	1.840	-1.528	1.575	-1.093	0.627	1.231
	(0.573)	(0.830)	(0.480)	(0.490)	(0.612)	(0.605)	(0.422)	(0.679)	(0.420)
South	-4.446*	3.238	-0.225	-3.396	2.047	-4.063	-1.121	1.521	1.407
Africa	(0.096)	(0.243)	(0.939)	(0.154)	(0.419)	(0.123)	(0.654)	(0.559)	(0.602)

Note: See notes to Table B.4.

4. EQUITY FLOWS AND RELATIVE STOCK PRICES: EMPIRICAL EVIDENCE FROM NORTH AMERICA

Magister Valentyna Ozimkovska and Prof. Dr. Stefan Reitz

4.1 Introduction

International capital mobility and financial market deregulation were perceived to promote the efficient allocation of resources and optimal international risk sharing. Having experienced a number of financial crisis situations, policy makers now question the expected favorable effects of capital flows. Fueled by global liquidity trends, capital flows are now perceived to also promote boom and bust cycles in a country's financial markets. Of course, the share of portfolio flows in total capital flows has been increasing steadily and was the first to recover after the global financial crisis (OECD, 2011). Moreover, portfolio flows are more volatile than overall capital flows. Thus, in 2012, the IMF changed its disposition towards the liberalization of capital flows by declaring that under specific circumstances the management of capital flows may be an appropriate policy measure to mitigate risks to financial systems (IMF, 2012). However, in order to adopt an appropriate set of monetary, fiscal and exchange rate policies it is of utmost importance to understand the underlying forces influencing portfolio flows.

The literature on capital flows generally classifies determinants of capital flows as push factors and pull factors. Push factors are global or domestic conditions which create incentives for domestic investors to invest in foreign assets. Push factors may reflect macroeconomic conditions or may be related to financial innovations which broaden possibilities for investing in foreign countries (Montiel, 2014). Pull factors reflect a recipient country's economic and financial conditions which attract foreign investors (Sarno et al., 2015). The role of returns as the most important pull factor of portfolio flows has been studied widely since the 1990s. Contributions such as Bohn and Tesar (1996) and Froot et al. (2001) show that investors increasingly buy and sell assets of recently appreciating markets simultaneously. This positive correlation of purchases and sales of foreign assets is typically explained by two separate mechanisms. The positive impact of asset returns on portfolio flows implies that investors increase the weight of outperforming assets in their portfolios. This is known as the return chasing effect (Bohn and Tesar, 1996). One of the causes of the return chasing effect is that investors update their expectations of returns on foreign assets based on past returns. Evidence for this behavior is also found in Froot et al. (2001) and Ülkü and Weber (2014). Return chasing effects can be understood as momentum trading strategies which induce positive capital flows after positive returns. The evidence for momentum trading strategies is found by Bohn and Tesar (1996), Brennan and Cao (1997), Froot et al. (2001), Bekaert et al. (2002) and Evans and Hnatovska (2014). Brennan and Cao (1997) state that foreign investors employ momentum trading strategies because they are less informed than domestic investors. Ülkü and Weber (2014), however, show that foreign investors are as well-informed as domestic investors.

The most popular explanation for the negative relationship between portfolio flows and returns is the so-called portfolio rebalancing effect. Investors attempt to keep the share of foreign assets in their portfolio in line with predefined limits of foreign risk exposure. As a result, investors sell a part of their foreign holdings when foreign assets appreciate relative to domestic assets. Evidence of portfolio rebalancing is found in Bohn and Tesar (1996), Hau and Rey (2004), Hau and Rey (2006), Hau and Rey (2008b), Heimonen (2009), Tille and Van Wincoop (2010) and Evans and Hnatovska (2014). Hau and Rey (2008b) also point out that the profit taking behavioral hypothesis can be an alternative explanation for the negative relationship between portfolio flows and returns.

Alternatively, the negative relationship between portfolio flows and returns can be explained by the fact that trading sophistication differs among investors. Albuquerque et al. (2007) show that in periods of asset appreciation, alternative private opportunities arise only for sophisticated investors. Private investment opportunities belong to private equity, real estate, foreign exchange and derivative markets. When asset prices increase, sophisticated investors sell foreign equity in order to participate in private opportunities. In such a way they diversify their portfolios. Less sophisticated investors do not have access to private opportunities, thus continuing to buy foreign assets.

Fratzscher (2012) and Sarno et al. (2015) state, however, that returns also act as a push factor. Fratzscher (2012) finds that both push factors and country-specific pull factors determine portfolio flows. However, global factors became more important than country-specific factors during the financial crisis. The latter result is confirmed by Sarno et al. (2015). The authors find that push factors contribute more than 80%

to portfolio flows' variance, whereas pull factors contribute less than 20%.

Conversely, portfolio flows are expected to influence asset prices. Hau and Rey (2006) argue that if international financial markets are order-driven trading venues, portfolio flows exert a price pressure on stock and/or foreign exchange markets. Some of the related literature tries to disentangle permanent and transitory effects. This is important as permanent increases in asset prices would cause a long-lasting decrease in the cost of equity associated with risk sharing benefits. Bekaert et al. (2002) and Ülkü and Weber (2014) find that some effects of capital flows on asset prices are permanent while some are temporary.

The impact of asset prices on portfolio flows has been studied in isolation from returns on domestic assets and exchange rates. Hau and Rey (2008b), Tille and Van Wincoop (2010) and Fratzscher (2012) investigate the impact of relative prices of foreign and domestic assets on portfolio flows. Froot et al. (2001) also include exchange rates in their regressions while studying the impact of asset prices on portfolio flows. As investors have to convert sales of foreign assets into domestic currency, returns on foreign assets depend also on the behavior of exchange rates. Moreover, investors choose an optimal weight of foreign assets in their portfolios based on returns of foreign assets compared to returns of domestic assets. In fact, Gelman et al. (2015) find a cointegration relationship between a country's net foreign asset position in equities and an index of relative equity prices, ensuring that returns are denominated in the same currency. The index can be interpreted as a real exchange rate deflated by stock market prices, or a real financial exchange rate (RFER). The authors' results also provide support for the uncovered return parity and portfolio rebalancing behavior.

This paper sheds new light on this issue by investigating the interaction of capital movements and the RFER, focusing on capital movements between the US and Canada. The detailed analysis of gross and net equity flows of Canadian and US investors and their sub-categories enables the identification of the above mentioned portfolio effects. Overall, our results confirm the dominance of the portfolio rebalancing effect in the behavior of Canadian investors, while the returns chasing effect prevails among US investors.

The remainder of the chapter is organized as follows. Section 4.2 provides a simple model which shows possible effects of the RFER on portfolio flows. Section 4.3 describes the data. Section 4.4 shows the empirical methodology employed and the empirical results. The last section concludes the chapter.

4.2 Methodological Background

Our analysis of capital flows and relative asset prices is based on the RFER. The RFER represents the relative price of domestic to foreign assets expressed in the same currency (Gelman et al., 2015):

$$RFER = S_{D/F}\frac{P_F}{P_D} \tag{4.1}$$

where P_F and P_D are the prices of foreign and domestic equities, $S_{D/F}$ is the price of the foreign currency in terms of the domestic currency. Equation 4.1 can be rewritten in logarithms as:

$$rfer = s_{D/F} + p_F - p_D \tag{4.2}$$

To show how changes in the RFER may influence portfolio flows, we follow the framework of Bohn and Tesar (1996). In period t domestic investors purchase or sell foreign assets, generating cross-border portfolio flows (F):

$$F_t = x_{Ft}W_t - x_{Ft-1}(1+g_{F_t})W_{t-1} \tag{4.3}$$

where x_F is the share of foreign assets in the portfolio of the domestic investors, W is the total wealth which investors allocate between domestic and foreign assets and g_F is the gain in foreign assets.

Investors' wealth in period t can be expressed as

$$W_t = (1+g_{P_t})W_{t-1} \tag{4.4}$$

where g_P is the gain in the investors' total portfolio. By substituting Equation 4.4 into Equation 4.3, it is possible to show both the portfolio rebalancing effect and the returns chasing effect of the RFER on portfolio flows:

$$F_t = (x_{Ft} - x_{Ft-1})W_{t-1} + (g_{P_t}x_{F_t} - g_{F_t}x_{F_t-1})W_{t-1} \tag{4.5}$$

If investors keep the share of foreign assets in their portfolios constant ($x_{Ft} = x_{Ft-1} = x_{Ft}$), the first term on the right-hand side of Equation 4.5 is equal to zero. The rest of Equation 4.5 can be rewritten as:

$$F_{Ft} = (g_{P_t} - g_{F_t})x_F W_{t-1} \tag{4.6}$$

The gain in the investors' portfolios consists of the gain in domestic and foreign assets:

$$g_P = g_D(1 - x_F) + g_F x_F \tag{4.7}$$

The gain in foreign assets depends on the gain in foreign assets expressed in foreign currency (g_{FA}) and on the gain in the exchange rate ($s_{D/F}$). The exchange rate is the price of the foreign currency in terms of the domestic currency:

$$g_F = g_{FA} + s_{D/F} \tag{4.8}$$

Substituting Equations 4.7 and 4.8 into Equation 4.6, we obtain:

$$F_{Ft} = -(s_{D/Ft} + g_{FAt} - g_{Dt})(1 - x_F)x_F W_{t-1} \tag{4.9}$$

The first term on the right-hand side of Equation 4.9 is the RFER in logarithms (see Equation 4.2). According to Equation 4.9, an appreciation of foreign assets expressed in domestic currency relative to domestic assets leads domestic investors to sell some share of their foreign asset holdings.

The optimal weight of foreign assets is obtained by maximizing the Sharpe ratio of the portfolio:

$$max_{w_i} S_p = \frac{E(g_P) - r_f}{\sigma_P} \tag{4.10}$$

where $E(g_P)$ is the expected gain in the portfolio, r_f is the risk free return and σ_P is the standard deviation of the portfolio.

The optimal weight of the foreign assets is

$$x_F = \frac{(E(g_P) - r_f)\sigma_D^2 - (E(g_D) - r_f)\sigma_F \sigma_D \rho_{F,D}}{(E(g_F) - r_f)\sigma_D^2 + (E(g_D) - r_f)\sigma_F^2 - (E(g_F) - r_f + E(g_D) - r_f)\sigma_F \sigma_D \rho_{F,D}} \tag{4.11}$$

where $E(g_D)$ and $E(g_F)$ are expected gains in domestic and foreign assets respectively, σ_D and σ_F are standard deviations of domestic and foreign assets respectively and $\rho_{D,F}$ is the correlation between domestic and foreign assets (Baker and Filbeck, 2013, p. 31).

Equations 4.8 and 4.11 imply that the weight of foreign assets in investors' portfolios depends not only on the expected appreciation of foreign assets but also on the performance of domestic assets and exchange rates. If the expected return on foreign assets expressed in domestic currency increases relative to the expected return of domestic assets, implying an appreciation of the RFER, investors increase x_{Ft} relative to x_{Ft-1}. In such a case, according to Equation 4.5, investors will purchase additional foreign assets when the RFER increases, demonstrating the return chasing effect.

Portfolio flows are likely to affect the RFER due to their high influence on the overall demand for foreign assets and foreign currency. The impact of portfolio flows on the RFER depends on several linkages. The first linkage is how costs of capital are related to foreign portfolio flows. Increased demand for domestic equity from abroad pushes the price of domestic equity up (Bekaert et al., 2002). However, increased portfolio flows from abroad may decrease the costs of domestic capital because foreign investors diversify their portfolios. That is why foreign investors may require lower returns on domestic equity. Therefore, the cost of domestic equity may decrease when portfolio flows from abroad increase.

The second crucial linkage is the way in which the nominal exchange rate reacts to capital flows and to asset returns. In order to acquire domestic equity, foreign investors have to purchase the corresponding amount of domestic currency. On the one hand, increased demand for the domestic currency puts an appreciation pressure on the domestic currency. On the other hand, Brooks et al. (2004) documents that returns and nominal exchange rates are negatively correlated. Cappiello and De Santis (2007) propose the uncovered return parity condition to explain the negative relationship between exchange rates and returns:

$$E\Delta s_{t+1} = E(r_{t+1}) - E(r^*_{t+1}) + \textit{second moment}_{t+1} \tag{4.12}$$

where $E\Delta s$ is the expected change of the exchange rate, $E(r)$ and $E(r^*)$ are expected returns on domestic and foreign assets respectively, and *second moment* includes the conditional variance and covariance of exchange rates and returns. Cappiello and De Santis (2007) argue that if foreign assets are expected to outperform domestic assets, foreign investors will only invest in domestic assets if the domestic currency will appreciate against the foreign currency. The appreciation of the domestic currency will then compensate for the possible loss on the domestic asset position of foreign investors.

As we see, the impact of portfolio flows on returns on foreign assets can be positive as well as negative. Moreover, the correlation between foreign asset returns and foreign exchange rates can also be positive or negative. That is why the impact of foreign asset flows on the RFER can evoke either sign.

4.3 Data

Our analysis focuses on cross-border equity flows between the US and Canada because these countries exhibit highly correlated business cycles (Voss, 2004). That is why differences in US and Canadian asset risk is not likely to substantially influence investors' decisions. The data set consists of monthly observations over the period between 01M1997 and 02M2015. Cross-border equity flows are obtained from the US Treasury International Capital (TIC) reporting system. The Chicago Board Options Exchange Volatility Index (VIX) is employed as a proxy for global volatility and investors' risk appetite. The VIX measures implied volatility of the S&P 500 index options. Returns on Canadian and US assets are calculated based on Canadian and US stock market indexes created by the Morgan Stanley Capital International (MSCI). US and Canadian MSCI indexes are designed to measure the performance of the large and middle capitalized segments of the US and Canadian markets. The VIX and MSCI indexes and exchange rates come from the Datastream database. The OECD Statistics database is the source for industrial production indexes. Industrial production differentials are calculated as a difference between Canadian and US industrial production growth. Therefore, an increase in the industrial production differential implies an increase of Canadian industrial production growth relative to that of the US.

The log of the Canadian real financial exchange rate is calculated as follows:

$$rfer = p_{ca} + s_{USD/CAD} - p_{us} \tag{4.13}$$

where p_{ca} and p_{us} are prices of Canadian and the US assets, respectively, and $s_{USD/CAD}$ is the price of Canadian dollars in terms of US dollars. An increase in the RFER implies a relative appreciation of Canadian assets with respect to US assets and vice versa.

We analyze the following US equity flows: purchases of US equity by Canadian residents, sales of US equity by Canadian residents, and net purchases of US equity by Canadian residents calculated as the difference between the two. The set of Canadian equity flows consists of purchases of Canadian equity by US residents, sales of Canadian equity by US residents and net purchases of Canadian equity by US residents. The latter flow is calculated as the difference between purchases and sales of Canadian equity by US residents. Additionally, we look at the net flow calculated as the difference between net purchases of Canadian equity and net purchases of US equity.

The TIC provides data on Canadian equity flows expressed in US dollars. In order to eliminate the impact of exchange rate movements on Canadian equity flows, these are converted to Canadian dollars. However, the net flow is based on US and Canadian equity flows and therefore is expressed in US dollars. In order to provide real equity flows we divide US equity flows by the US MSCI index and Canadian equity flows by the Canadian MSCI index.

Table 4.1 provides descriptive statistics of equity flows, the RFER, nominal exchange rates and ratios of MSCI indexes. In real terms, US portfolio flows are larger than Canadian portfolio flows. Therefore, Canadian investors invest in US equity more than US investors invest in Canadian equity. In real terms, there is a net outflow of equity investments from Canada to the US. According to the coefficient of variation, net purchases and the net flow are more volatile than gross purchases and sales of equity. Also, the RFER is more volatile than the nominal exchange rates (ER) or the ratios of asset prices (PR).

Tab. 4.1: Descriptive statistics over the period from 01M1997 until 02M2015

	Ca purchase	Ca sales	Ca net	US purchase	US sales	US net	Net flow	ER	PR	RFER
Mean	11.846	11.688	0.158	16.825	16.410	0.416	-0.266	0.824	1.076	0.911
Median	11.508	11.165	0.198	14.023	12.943	0.381	-0.160	0.828	1.017	0.913
Maximum	28.559	29.201	3.968	51.344	49.364	5.369	4.527	1.052	1.567	1.492
Minimum	5.615	5.551	-3.530	4.617	4.530	-4.796	-5.654	0.626	0.617	0.405
Std. Dev.	4.138	4.104	0.976	10.691	10.596	1.295	1.518	0.135	0.236	0.318
Coefficient of variation	0.349	0.351	6.177	0.635	0.646	3.112	-5.706	0.163	0.220	0.349

Note: The abbreviations in the head of the table are defined as follows: Ca purchase: purchases of Canadian equity by US residents; Ca sales: sales of Canadian equity by US residents; Ca net: difference between Ca purchase and Ca sales; US purchase: purchases of US equity by Canadian residents; US sales: sales of US equity by Canadian residents; net US: difference between US purchase and US sales; net flow: difference between Ca net and US net; ER: exchange rates; PR: ratio of Canadian and US asset prices; RFER: real financial exchange rates. Equity flows are analysed in real terms. US and Canadian equity flows expressed in the national currencies are divided by US and Canadian MSCI indexes respectively. ER are nominal exchange rates of the Canadian dollar in terms of the US dollars. PR is the ratio of the Canadian MSCI index over the US MSCI index. RFER is calculated according to Equation 4.13.

Purchases and sales of Canadian and US equity as well as the RFER are not stationary according to the Augmented Dickey-Fuller test. The Johansen Cointegration test suggests that purchases and sales of Canadian and US equity are not cointegrated with the RFER. That is why purchases and sales of Canadian and US equities as well as the RFER are employed in log first differences. We also use the log first differences of the VIX. The log of net purchases of Canadian and US equity, log net flow and log industrial production differentials are stationary according to the Augmented Dickey-Fuller test.

4.4 Empirical analysis

In order to study the relationship between equity flows and the RFER, we control for the global volatility and for the productivity gap between the US and Canada. The VIX is employed in the literature as a proxy for the global volatility and investors' risk appetite. Forbes and Warnock (2012) and Fratzscher (2012) find that the VIX influences capital flows. The difference between industrial production growth in Canada and the US serves as a proxy for the productivity gap between these countries. Changes in productivity influence economic growth. Moreover, fluctuations in economic growth may lead to lending booms and busts, which affect capital flows (Aguiar and Gopinath, 2007; Broner et al., 2013). Researchers often employ the Vector Autoregressive Model (VAR) to study the relationship between capital flows and returns (Bekaert et al., 2002; Froot et al., 2001). Caporale et al. (2015) state that results of VAR models of portfolio flows are characterized by conditional heteroscedasticity (Engle, 1982). As a result, we test the residuals of our VAR models for heteroscedasticity. Table 4.2 presents the results of the White test with cross terms and without cross terms (Doornik, 1995) applied to the residuals of the estimated VAR models. At the 1% significance level, the null hypothesis of homoskedasticity is rejected for all models except for Canadian and US equity purchases. For Canadian equity purchases and for US equity purchases, the results of the White heteroscedasticity test with cross terms and without cross terms are contradictory. Overall, the results of the White heteroscedasticity tests suggest the presence of the ARCH-effect in the estimated VAR models.

Tab. 4.2: VAR residual heteroscedasticity test

Model	Ca purchase	Ca sales	Ca net	US purchase	US sales	US net	Net flow
With cross term							
Chi-quared	120.070	378.705	393.984	308.793	342.850	396.612	343.802
P-value	0.003	0.000	0.000	0.052	0.002	0.000	0.000
Without cross term							
Chi-quared	52.695	137.724	147.912	130.875	136.060	133.924	112.854
P-value	0.036	0.000	0.000	0.000	0.000	0.000	0.000

Note: The White heteroscedasticity tests with cross terms and without cross terms are applied to residuals of the estimated VAR models. The abbreviations in the head of the table are used as in Table 4.1.

In order to overcome the problem of heteroscedasticity, we employ the Vector Autoregressive Generalized Autoregressive Conditional Heteroscedasticity (VAR-GARCH(1,1)) models. The VAR-GARCH(1,1) model was also used to study relationships between portfolio flows and exchange rate volatility by Caporale et al. (2015). According to the Akaike information criteria, two or three are the most appropriate lag orders for the VAR-GARCH(1,1) modes. However, in the models with two lags we find remaining residual autocorrelations, justifying the estimation of the models with three lags. Taking into account discussed above issues, our model is specified as follows:

$$y_t = \mu + \sum_{i=1}^{n} \psi_i y_{t-i} + \sum_{i=1}^{n} \alpha_i vix_{t-i} + \sum_{i=1}^{n} \beta_i ind_{t-i} + \varepsilon_t \tag{4.14}$$

where y_t is a 2×1 vector which includes an equity flow and the RFER, vix and ind are the VIX and the industrial production differentials respectively, ψ, α, β are corresponding coefficients, ε_t is the innovation vector and n is the number of lags in the model.

In order to ensure that the estimation of the model is feasible but still able to capture the volatility and covariance dynamics, we employ the VECH version of the GARCH model. The VECH(1,1) model is defined as:

$$h_t = c + A\eta_{t-1} + Gh_{t-1} \tag{4.15}$$

where

$$h_t = vech(H_t) \tag{4.16}$$

$$\eta_t = vech(\varepsilon_t \varepsilon_t') \tag{4.17}$$

$$\varepsilon_t = H_t^{1/2} z_t \tag{4.18}$$

where A and G are square parameter matricies of order $(N+1)N/2$ and c is a $(N+1)N/2 \times 1$ parameter vector. N is the number of variables. $vech(\cdot)$ is the operator that stacks the lower triangular portion of a $N \times N$ matrix as a $N/(N+1)/2 \times 1$ vector. $H_t^{1/2}$ is a $N \times N$ positive definite matrix, z_t is a $N \times 1$ random vector (Bauwens et al., 2006). It is assumed that z_t has a multivariate Student's t-distribution with ν degrees of freedom (z_t $iid \sim t(\nu)$). The degree of freedom is calculated as $\nu = m - 1$, where m is the number of observations. Additionally, we restrict the matrices A and G to be diagonal.

Table 4.3 reports adjusted R-squared for individual regressions of the estimated VAR-GARCH(1,1) models. Adjusted R-squared are in the range from 13,5% to 29,0% for gross purchases and sales. For net purchases of Canadian equity, net purchases of US equity and net flows, adjusted R-squared are 5,6%, 5,1% and -5,0% respectively. This implies that the chosen variables explain gross portfolio flows better than net portfolio flows. Adjusted R-squared figures show that fundamentals fail to explain nominal exchange rates and returns in the short-run.

Tab. 4.3: Adjusted R-squared for individual regressions of the VAR-GARCH(1,1) models

Equation	Ca purchase	Ca sales	US purchase	US sales	Ca net	US net	Net flow
Equity flows	0.206	0.290	0.135	0.175	0.056	0.051	-0.050
RFER	-0.018	0.007	0.005	0.005	-0.006	0.004	-0.014

Note: The abbreviations in the head of the table are used as in Table 4.1.

Table 4.4 exhibits estimated relationships between the change in equity flows and the change of the RFER according to the VAR-GARCH(1,1) models. The results suggest that the RFER has a significant impact on sales of Canadian equity, purchases and sales of US equity as well as on net purchases of US and Canadian equity.

However, the RFER does not have a significant impact on purchases of Canadian equity. There is slightly significant evidence that the third lag of the RFER positively influences the sales of Canadian equity. When Canadian equity appreciates relative to US equity, US investors increase their sales of Canadian equity. This finding supports the portfolio rebalancing hypothesis. However, the impact of the RFER on net purchases of Canadian equity is significant and positive. When Canadian assets appreciate relative to US assets, US investors acquire more Canadian equity than they sell. This finding implies that return chasing behavior of US investors dominates the portfolio rebalancing behavior.

The first lag of the RFER affects both purchases and sales of US assets positively. This implies that both effects of a relative price change can be observed. Firstly, Canadian investors purchase more US equity when US assets depreciate relative to Canadian assets, which is consistent with the portfolio rebalancing effect. When the share of foreign assets in Canadian portfolios decreases due to price changes, investors tend to fill the gap by purchasing additional US assets. At the same time, sales of US equity increase when US stocks depreciate relative to Canadian stocks. This observation is consistent with return chasing behavior. Investors may form expectations about foreign asset returns based on past foreign asset returns, actively managing the exposure in foreign assets according to the portfolio optimization theory. The impact of the RFER on net purchases of US assets is positive. Thus, an increase in US asset purchases is higher than an increase in US asset sales when US assets depreciate relative to Canadian assets. Therefore, the portfolio rebalancing effect dominates the active management of foreign assets among Canadian investors.

Our results suggest that US investors are more likely to manage their portfolio actively than Canadian investors. These findings are consistent with the fact that there is a higher number of hedge funds in the US than in Canada (Tremblay, 2012). Hedge funds are more likely to actively manage shares of foreign assets in their portfolios than other financial institutions.

The estimated coefficients generally reveal that equity flows do not significantly affect relative stock prices (Table 4.4). In the few cases where we find statistical significance the coefficients are of low magnitude. This corresponds to the observation that equity flows can explain only a small fraction of RFER movements as the Adjusted R-squared figure suggests (Table 4.3). These results might be due to the low frequency of the data set.

Tab. 4.4: Relationship between equity flows and RFER

Impact of RFER on equity flows							
Lag	Ca purchase	Ca sales	US purchase	US sales	Ca net	US net	Net flow
1	-0.029	0.422	0.888**	0.729**	-0.101	0.032	-0.156
	(0.908)	(0.153)	(0.010)	(0.019)	(0.550)	(0.813)	(0.536)
2	0.199	-0.265	0.260	0.048	0.420***	0.128	0.266
	(0.452)	(0.348)	(0.469)	(0.879)	(0.005)	(0.305)	(0.170)
3	0.414	0.469*	-0.361	-0.169	0.277	0.269*	-0.220
	(0.112)	(0.089)	(0.343)	(0.658)	(0.073)	(0.052)	(0.354)
Impact of equity flows on RFER							
Lag	Ca purchase	Ca sales	US purchase	US sales	Ca net	US net	Net flow
1	-0.001	-0.007	0.028*	0.029*	0.010	0.020	0.015
	(0.948)	(0.672)	(0.068)	(0.060)	(0.692)	(0.455)	(0.465)
2	-0.039***	-0.033*	0.012	-0.007	-0.014	0.031	-0.025
	(0.007)	(0.057)	(0.437)	(0.653)	(0.561)	(0.224)	(0.170)
3	0.000	0.007	0.010	-0.002	-0.023	-0.019	-0.007
	(0.995)	(0.665)	(0.515)	(0.921)	(0.343)	(0.519)	(0.693)

Note: In VAR-GARCH(1,1) models, change in equity flows and change in the RFER are endogenous variables, change in VIX and industrial production differences are exogenous variables. P-values are provided in parenthesis; asterisks show significance level at 1%(***), 5%(**) and 10%(*) respectively. The abbreviations in the head of the table are used as in Table 4.1.

Table 4.5 displays estimates for VAR-GARCH(1,1) regressions of equity flows on the control variables. The VIX and industrial production differentials significantly influence mostly the gross equity flows. The first lag of the VIX significantly and positively affects purchases and sales of Canadian equity as well as purchases and sales of US equity. The positive impact of the VIX on sales of Canadian and US equity is consistent with the portfolio optimization theory. As the implied global volatility increases, investors decrease the share of risky assets in their portfolios. The positive impact of the VIX on purchases of Canadian and US equity may reflect safe haven flows. As pointed out in Fratzscher (2012) investors reallocate their exposures from emerging markets to more matured markets when risk perception increases, as observed during the global financial crisis. The first lag of the VIX has a significant and negative impact on net purchases of Canadian equity. This implies that the portfolio optimization behavior of US investors dominates safe haven flows. This is additional evidence that US investors actively manage shares of foreign assets in their portfolios.

Tab. 4.5: Relationships between RFER and control variables

Impact of the VIX on equity flows							
	Ca purchase	Ca sales	US purchase	US sales	Ca net	US net	Net flow
1	0.070***	0.102***	0.078***	0.069***	-0.031*	-0.019	-0.008
	(0.009)	(0.001)	(0.006)	(0.009)	(0.075)	(0.169)	(0.736)
2	0.006	-0.005	-0.015	-0.024	0.007	0.004	0.000
	(0.811)	(0.857)	(0.651)	(0.412)	(0.666)	(0.742)	(0.989)
3	0.004	0.009	0.037	0.040	-0.008	-0.008	-0.005
	(0.865)	(0.758)	(0.250)	(0.192)	(0.602)	(0.486)	(0.818)
Impact of the industrial production differentials on equity flows							
	Ca purchase	Ca sales	US purchase	US sales	Ca net	US net	Net flow
1	0.175	-1.252	-0.021	-0.982	0.554	0.815	0.044
	(0.875)	(0.284)	(0.988)	(0.465)	(0.354)	(0.206)	(0.961)
2	2.979***	3.448***	1.529	2.041	-0.066	0.349	-0.438
	(0.007)	(0.005)	(0.278)	(0.133)	(0.922)	(0.567)	(0.637)
3	0.507	2.635**	2.604*	4.188***	-0.644	-0.443	-0.286
	(0.653)	(0.030)	(0.061)	(0.002)	(0.350)	(0.413)	(0.780)

Note: In VAR-GARCH(1,1) models, change in equity flows and change in the RFER are endogenous variables, change in VIX and industrial production differences are exogenous variables. P-values are provided in parentheses; asterisks show significance level at 1%(***), 5%(**) and 10%(*) respectively. The abbreviations in the head of the table are used as in Table 4.1.

Interestingly, purchases and sales of Canadian equity react significantly to lagged changes of industrial production differentials. When industrial production in Canada increases relative to industrial production in the US, US investors purchase more Canadian equity. As an increase in industrial production implies higher returns on Canadian assets, this result is consistent with the return chasing effect or the portfolio optimization theory. However, sales of Canadian equity also increase when industrial production in Canada increases relative to industrial production in the US. This result is consistent with Albuquerque et al. (2007), suggesting that US investors may sell Canadian equity in order to participate in private opportunities which are more likely to be available during periods of increased production growth.

The relationship between the third lag of industrial production differentials and purchases of US equity as well as sales of US equity is significant and positive. When US industrial production decreases relative to Canadian industrial production, Canadian investors purchase more US equity. At the same time, Canadian investors sell more US equity. As a decrease in industrial production relates to a decrease in asset returns, these results are consistent with the relationship between the RFER and purchases as well as sales of US equity.

Tab. 4.6: Robustness check. Relationship between equity flows and RFER

Impact of RFER on equity flows							
Lag	Ca purchase	Ca sales	US purchase	US sales	Ca net	US net	Net flow
1	-0.011	0.462	0.901**	0.795**	-0.262	0.058	-0.310
	(0.968)	(0.160)	(0.021)	(0.027)	(0.209)	(0.705)	(0.262)
2	0.265	-0.143	0.080	-0.015	0.344	0.108	0.243
	(0.417)	(0.661)	(0.839)	(0.967)	(0.111)	(0.503)	(0.309)
3	0.382	0.418	-0.201	-0.224	0.414**	0.252*	0.010
	(0.222)	(0.180)	(0.631)	(0.581)	(0.033)	(0.088)	(0.969)
Impact of equity flows on RFER							
Lag	Ca purchase	Ca sales	US purchase	US sales	Ca net	US net	Net flow
1	0.002	-0.003	0.027*	0.034**	0.045	0.003	0.025
	(0.884)	(0.872)	(0.095)	(0.033)	(0.238)	(0.917)	(0.252)
2	-0.036**	-0.035**	0.012	0.001	0.007	0.030	-0.011
	(0.045)	(0.040)	(0.478)	(0.971)	(0.868)	(0.314)	(0.573)
3	0.005	0.004	0.012	0.002	-0.033	-0.019	0.009
	(0.799)	(0.830)	(0.452)	(0.922)	(0.334)	(0.543)	(0.643)

Note: In VAR-GARCH(1,1) models, change in equity flows, change in the RFER, change in VIX and industrial production differences are endogenous variables. P-values are provided in parenthesis; asterisks show significance level at 1%(***), 5%(**) and 10%(*) respectively. The abbreviations in the head of the table are used as in Table 4.1.

To check the robustness of our results, we consider an alternative specification of the VAR-GARCH(1,1) models. In particular, we estimate VAR-GARCH(1,1) models introducing changes in equity flows, the RFER and the VIX as well as industrial production differentials as endogeneous variables. Table 4.6 provides the estimated relationships between the change in equity flows and the change in the RFER according to the alternative specification of the VAR-GARCH(1,1) models.

The alternative model specification does not materially affect the results. Most variables which are found to be significant in the main analysis (Table 4.4) remain significant in the alternative model estimation. Also, the signs of the significant variables remain the same. There are, however, two exceptions. First, the third lag of the RFER is not significant in the regression for sales of Canadian equity. Second, in the regression for net purchases of Canadian equity, the third lag of the RFER is significant. In the main model specification, the second lag of the RFER is significant. In both cases the sign of the significant lags is positive. Therefore, the results of the robustness check correspond to our main results and do not affect our conclusions.

4.5 Conclusions

In this paper, we analyze the interaction between cross-border equity flows and relative stock prices. We use data from Canada and the US over the period from 1997 to 2015 to estimate a set of VAR-GARCH(1,1) models, also controlling for fluctuations of global risk aversion as well as productivity differentials. Changes of the relative stock prices exert a significant impact on equity flows between Canada and the US, particularly when it comes to gross purchases and sales. Our empirical evidence supports the portfolio rebalancing effect as well as the return chasing effect. However, the analysis of net purchases of US assets suggests that the portfolio rebalancing effect dominates the return chasing effect in Canadian portfolios, while return chasing behavior largely prevails among US investors. Our results imply that relative stock prices are an important factor in determining portfolio flows and, moreover, portfolio flows have to be studied using gross purchases and sales of foreign assets instead of net flows.

5. CONCLUDING REMARKS

This work investigates three important questions related to exchange rate regimes and capital flows. The first question is how the introduction of the common currency influenced output volatility in the EMU countries. The second question is how volatility of the RFER affects capital flows. The final question is how movements of RFER influence capital flows. The common conclusion of all three studies is that there is heterogeneity in the reaction of real economies to the introduction of the common currency. There is also heterogeneity in investors' behavior related to the RFER movements and RFER uncertainty.

The widely accepted macroeconomic theory states that countries which adopt a common currency should experience an increase in volatility of output. Our results, however, suggest that in Austria, Belgium, France, Luxemburg, the Netherlands and Spain, output volatility has not significantly changed after the introduction of the euro. An interesting fact is that all of these countries, except Spain, recovered faster after the global financial crisis than those countries where the output volatility increased. Differences in characteristics of the optimum currency fail to explain why in some countries output volatility has not changed after the introduction of the euro. However, the analysis of exchange rate regimes shows that in countries where fixed or pegged exchange rate regimes prevailed over longer periods output volatility stayed unchanged after the introduction of the euro. Belgium, France and Luxembourg fixed or pegged their exchange rates before joining the EMS. Austria and the Netherlands let their exchange rates fluctuate within a narrower range than other EMS countries until the introduction of the euro. The policy implication of this study is that it may be useful for countries which plan to adopt the euro in the future to fix their exchange rates to the euro for a certain period before joining the EMU.

In most cases, economic and financial theories model agents' behavior in a homogeneous way. This research finds that investors react to RFER volatility and RFER movements heterogeneously. Our results suggest that both purchases and sales of foreign assets decrease when RFER volatility increases. This implies that some investors behave according to the portfolio optimization theory when uncertainty increases. In contrast to the portfolio optimization theory, some investors decrease sales of foreign equity in response to increased uncertainty. Such behavior can be explained by the loss aversion theory. Also, the investigation of the relationships between RFER movements and capital flows shows that one group of investors reacts according to the portfolio rebalancing effect while the other group of investors manages its portfolios according to the return chasing hypothesis. Our results suggest that the portfolio rebalancing effect prevails among Canadian investors, while the return chasing hypothesis determines decisions of US investors. This research implies that studies of gross purchases and sales provide deeper understanding of investors' behavior than studies of net capital flows and may lead to more efficient policy decisions.

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Erklärung zum selbständigen Verfassen der Arbeit:

Ich erkläre hiermit, dass ich meine Doktorarbeit 'Essays on the common currency, real financial market exchange rates and capital flows' selbstständig und ohne fremde Hilfe angefertigt habe und dass ich als Koautor maßgeblich zu den weiteren Fachartikeln beigetragen habe. Alle von anderen Autoren wörtlich übernommenen Stellen, wie auch die sich an die Gedanken anderer Autoren eng anlehnenden Ausführungen der aufgeführten Beiträge wurden besonders gekennzeichnet und die Quellen nach den mir angegebenen Richtlinien zitiert.

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Kostopil School of General Education 5, Ukraine — Sep 1987 - Jun 1998

PROFESSIONAL EXPERIENCE

Risk Center, Deutsche Bank AG, Berlin, Germany — Sep 2015 - Current
Senior Risk Analyst

Economic Institute, University of Kiel, Kiel, Germany — Nov 2014 - Feb 2015
Research Assistant

National Bank of Poland, Warsaw, Poland — Sep 2014
Internship

Kiel Institute for the World Economy, Kiel, Germany — Aug 2013 - Sep 2014
Internship

Institute for Quantitative Business and Economic Research — Nov 2013 - Jan 2014
University of Kiel, Kiel, Germany, Research Assistant

LLC Swisspan Limited, Kostopil, Ukraine — Aug 2008 - Sep 2009
Interpreter of financial documents

PrivatBank, Kostopil, Ukraine — Jan 2003 - Apr 2007
Senior loan officer

SCHOLARSHIPS

- Scholarship from the Oluf-Rieke Foundation for the academic years 2014 - 2015
- Scholarship from the German CFA Society for the 2012 December CFA examination
- Scholarship from the Christian-Albrechts-University of Kiel for academic years 2012 - 2014
- Tuition waiver by the University of Warsaw for the Master Program European Finance and Banking
- The highest scholarship for academic performance during the studies at the National University Ostroh Academy

CONFERENCES AND WORKSHOPS

Spring Meeting of Young Economists, Gent, Belgium	May 2015
European Economic and Finance Society Conference, Brussels, Belgium	Jun 2015
International Economic Relationships, Göttingen, Germany	Feb 2015
Warsaw International Economic Meeting 2014, Warsaw, Poland	Jul 2014
Economic Challenges in Enlarged Europe, Tallinn, Estonia	Jun 2014
Warsaw International Economic Meeting 2013, Warsaw, Poland	Jun 2013

LANGUAGES

- Ukrainian - native
- English, Polish, Russian - fluent
- German - professional

COMEPTENCIES

MS Office, EViews, STATA, Matlab

INTERESTS

Classical music (Kostopil Music School is finished with honors diploma), travelling, sport, chess.

Valentyna Ozimkovska

13 March 2016