Does Exchange Rate Uncertainty Affect Foreign Direct Investment?

An Empirical Analysis of the Swedish Case

Nils Kottmann*
Stockholm School of Economics

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Supervisor: Paul S. Segerstrom
Discussant: Andreas Born
Examiner: Örjan Sjöberg

Abstract

The purpose of this thesis is to study empirically what the effect of exchange rate volatility is on foreign direct investment (FDI) stock in Sweden, as well as on Swedish FDI stock abroad. To this date, neither empirical nor theoretical research has reached consensus on the nature of this effect. I test this relationship through panel data fixed-effects estimation techniques with Driscoll and Kraay (1998) corrected standard errors in a gravity equation framework for the period between 1993-2011. I choose control variables that have performed consistently well across a range of FDI studies and use a conditional measure of exchange rate volatility – GARCH – which is used in financial contexts. I find strong evidence that exchange rate volatility has a significant positive effect on both inward as well as outward FDI stock. However, this effect seems to become weaker over time in the case of outward FDI. In addition, I find some evidence that Swedish multinationals consider the volatility between the krona and several major currencies when making investment decisions.

Keywords: Exchange Rate Volatility, GARCH, FDI
JEL classification: F21, F31

*Student ID no.: 40425

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1 Introduction

Foreign direct investment – or FDI – has been of growing interest with policy makers as it has become an increasingly important part of firm behaviour. It offers benefits that entice policy makers in many places to attract FDI through preferential treatment. There are effects benefiting the recipient of FDI – the host country – and the sender of FDI – the home country. Through FDI, firms transfer financial resources to acquire or establish a lasting investment in a foreign country. However, capital is not the only thing that crosses borders. Firms investing abroad bring technology and managerial know-how with them from their home countries that – because it is impossible to keep them perfectly secret – spread to other firms and sectors in the recipient country, creating positive externalities that benefit the recipient country in more ways than just capital gains. The transferred capital increases productive capacity while productivity increases through transfers of know-how and technology. Sales and procurement networks are also transferred; enabling further business opportunities, and competition among local firms is increased, leading to a more efficient resource allocation in the host country as well as technological improvements in its firms. The positive effects to the home country should also not be neglected. Giving firms the opportunity to choose where to invest enables them to allocate their capital in the most efficient way. All these positive effects of foreign direct investment beg the question what policy makers can do to harness these effects and, in order to answer this, it is important to identify the factors influencing FDI behaviour between countries (Kiyota & Urata, 2004).

The agents of FDI, multinational enterprises (MNEs), are an increasingly large part of the economic activity within and between countries and their profitability depends on a variety of external factors. One of these is the development of exchange rates, which is often quoted by MNEs to explain profits or losses. In December 2013, Peugeot reported an asset impairment charge of $1.5 billion due to weaker sales and unfavourable exchange rate developments in Russia and Latin America (Nurse, 2013). In the first quarter of 2013, Hyundai Motor profits dropped by 15% partly due to a strong won, which made the Korean cars less price competitive relative to Japanese competitors (BBC News, 2013). Google's quarterly results were hurt in 2012 by a strong dollar: earnings would have been $136 million higher had exchange rates stayed constant (BBC News, 2012b). Carlos Ghosn, the head of Nissan Motor Company, said in 2012 that the company increased internationalization of production due to the need to reduce exchange rate risk (BBC News, 2012c). The CEO of Air France-KLM mirrors these sentiments when talking about the challenges facing the ailing airline: "in an increasingly uncertain global economic environment compounded by oil price and exchange rate volatility, an improvement in our productivity and costs is even more necessary" (BBC News, 2012a). The profitability of MNEs is clearly impacted by exchange rates and MNEs take these into account when making decisions.

The purpose of this thesis is to empirically answer the question: Does exchange rate volatility influence Sweden's bilateral FDI stock? To achieve this, I use panel data analysis on this relationship from 1993 to 2011 with an unbalanced panel of 29 countries.[a] I analyse the relationship between Sweden and a sample of OECD countries as well as some other major international partners. 1993 is selected as the starting date due to the fact that Sweden switched to its current free-floating regime in January of 1993. This insures that inference is not threatened by structural breaks caused by a change in the exchange rate regime.

Understanding how exchange rate variability affects FDI is important in order to formulate effective FDI policies for a country with a flexible exchange rate. Do firms shy away from uncertain future cash flows and disregard foreign markets with relatively volatile exchange rates or do they establish foreign subsidiaries in these markets in order to deal with the challenges of volatile currencies?

[a] The included countries are: Australia, Austria, Belgium and Luxembourg, Canada, China, Czech Republic, Denmark, Finland, France, Germany, Greece, Hong Kong, Hungary, Ireland, Italy, Japan, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Russia, Singapore, South Korea, Spain, Switzerland, United Kingdom, and the United States.

This question is of particular importance in Sweden. MNEs are of great importance to the Swedish economy, much more so than in other developed countries. Figure 1.1 shows foreign direct investment stock in Sweden (inward) as well as Swedish direct investment stock abroad (outward) as a share of GDP compared to developed, developing, and transitioning economies. Especially in more recent years, Sweden has gained a much higher share than other developed countries, which indicates Sweden's higher interdependence between direct investments and the Swedish economy. Due to this greater impact in Sweden, it is important to understand how FDI and Sweden interact to be able to make informed decisions regarding FDI policy.

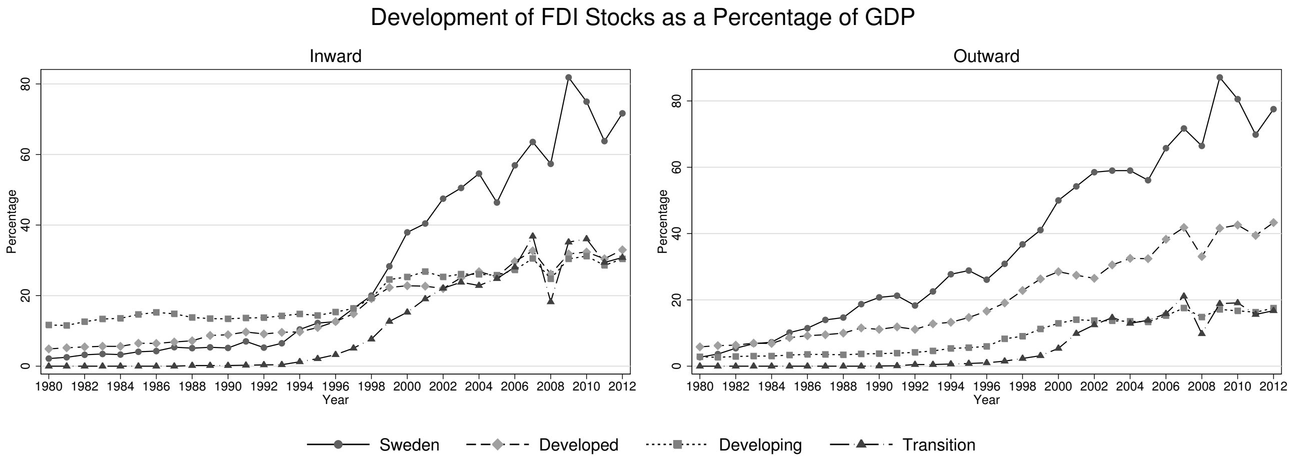


Figure 1.1: **The development of FDI stocks as a percentage of GDP from 1980 to 2012 for different country groups and Sweden.**

Source: Author's illustration based on data by UNCTAD

This paper makes a number of contributions to the existing literature. It expands the scope of the researched countries by focusing on an economy that has not been at the center of international research (which mainly focuses on the US, Japan, and a few other major economies) and by focusing on a more recent time period, which is meaningful due to the fact that data on FDI is increasingly available and of higher quality. By focusing on a small economy it is also possible that the results vary from previous studies focusing on large economies since there is evidence that the relationship between FDI and exchange rate uncertainty is influenced by the size of the economies (Ricci, 2006). In addition, this paper uses control variables that have been found to be consistently good predictors across a variety of FDI determinants studies – and not just in studies considering exchange rate volatility (Blonigen & Piger, 2011).

This thesis is structured as follows:

In section 2, I provide the background of this thesis by discussing the meaning of and causes for exchange rate volatility, as well as foreign direct investment. Moreover, I give an overview of the previous literature on this topic to familiarize the reader with the current state of knowledge.

Section 3 explains the theoretical model linking exchange rate volatility and foreign direct investment and gives some idea of what the determining factors could be.

Section 4 presents the empirical model that I use to answer the research question and the reasoning behind the particular specification. This section also provides an overview of the data, the variables included in the empirical model, the descriptive statistics of these variables, and an overview of the diagnostics to ensure validity.

Section 5 provides the analysis of the empirical results. I compare the results to the theoretical predictions, suggest explanations for the obtained results, and perform some robustness checks.

Section 6 concludes this thesis by summarising my findings and offering suggestions for future studies.

2 Background

In this section, I first establish some background knowledge of the core concepts of this thesis – foreign direct investment and exchange rate volatility – and then give an overview of the previous literature in this field. I define foreign direct investment, discuss the state of FDI in Sweden and the world, and cover some of the motivations for a firm to engage in FDI. Moreover, I deal with how exchange rate volatility develops and how it affects firms.

2.1 Foreign Direct Investment

> "Foreign direct investment reflects the objective of obtaining a lasting interest by a resident entity in one economy ('direct investor') in an entity resident in an economy other than that of the investor ('direct investment enterprise'). The lasting interest implies the existence of a long-term relationship between the direct investor and the enterprise and a significant degree of influence on the management of the enterprise." – OECD (1996)

The OECD specifies this lasting interest as the case where the investor owns at least ten percent of the ordinary shares or voting power of an incorporated enterprise or the equivalent in an unincorporated enterprise (in line with the International Monetary Fund's (IMF) definition). In the case of a foreign subsidiary which in turn has a subsidiary, it is common practice to cover all directly and indirectly owned subsidiaries, associates, and branches down to a ten percent participating interest in the statistics (OECD, 1996; SCB, 2012). Due to this long-term relationship, FDI is different from other forms of investment and needs to be analysed in a different framework. This special relationship also means that the consequences of FDI will be different from other forms of investment: it creates long-lasting links between economies and encourages the transfer of technology and know-how between countries and allows the host economy to promote its products more widely in international markets. FDI is also an additional source of funding for investment and, under the right policy environment, it can be an important vehicle for development.

The majority of FDI is still located in and owned by developed countries. Figure 2.1 shows the development of global FDI stocks as a percentage of total FDI stocks in the world from 1980 to 2012 for Sweden and the groups of developed, developing, and transition economies. Developing countries have been acting as home as well as host countries for an increasing proportion of the FDI stock since the 1990s. However, developed countries still accounted for 62% of all inward stock and 79% of all outward stock. Sweden has also acted as an increasingly popular recipient of FDI: in 1980, Sweden received 0.4% of global FDI, while it received 1.6% in 2012. As a direct investor abroad, Sweden has been fairly consistent, accounting for 1.5-2% over the last two decades. Since the majority of FDI is conducted by developed countries, I choose a sample of OECD as well as a few large transition and developing partner countries in the empirical analysis. The selection of a larger sample of partner countries is hindered by a lack of data availability, however, it covers the major actors in foreign direct investments.

In the case of Sweden, the factors that influence the behaviour of multinationals are of particular concern. Multinational firm networks occupy a dominant position in the Swedish economy and this makes it integral for policy makers and researchers to understand how FDI works in the Swedish economy. Figure 2.2 shows the development of Swedish and foreign-controlled multinationals in Sweden. The left axis shows the total number of MNEs active in Sweden in thousands in the years 1996-2011 and the right axis shows the share of those employed by a MNE (or one of the firms it controls) in Sweden as a percentage of total private employment in Sweden. The number of foreign MNEs active in Sweden has drastically increased from about 3,500 firms in 1996 to around 14,000 firms in 2011. The number of Swedish multinational firms has increased at a slower rate from about 800 firms in 1996 to more than 2,400 in 2011. This graphs also

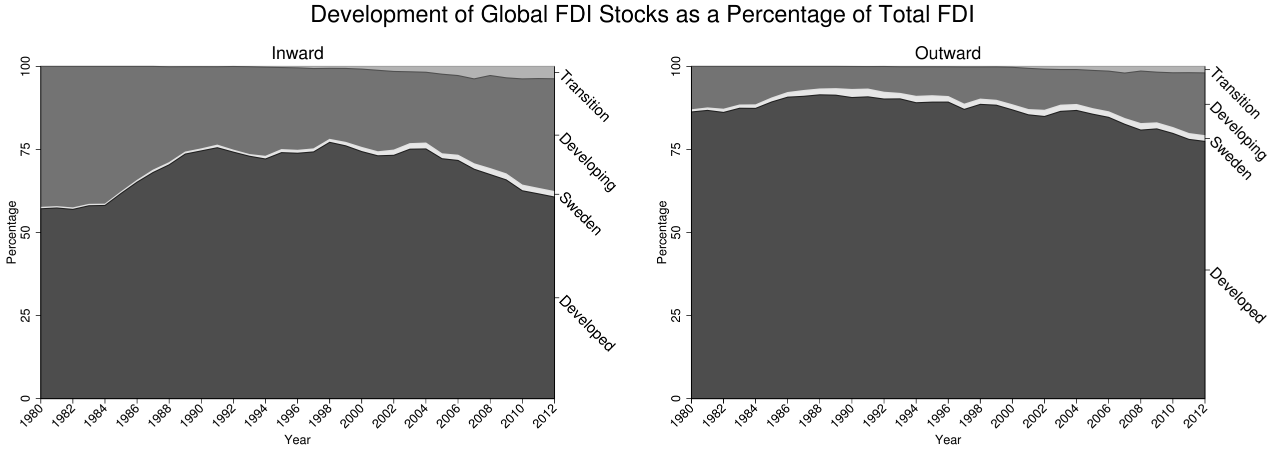


Figure 2.1: **The development of global FDI stocks as a percentage of total FDI stock from 1980 to 2012.**

Source: Author's illustration based on data by UNCTAD

illustrates the importance of multinationals to the Swedish labour market and economy, employment by multinational-controlled firms account for about 40% of private employment in Sweden with an increasing importance of foreign-controlled firms. Firms controlled by Swedish MNEs account for approximately 17% in 2011 (roughly 510,000 employees) while firms under foreign control account for almost 22% in the same year (about 630,000 employees). Figure 2.2 suggests that the amount of FDI in Sweden also grew over

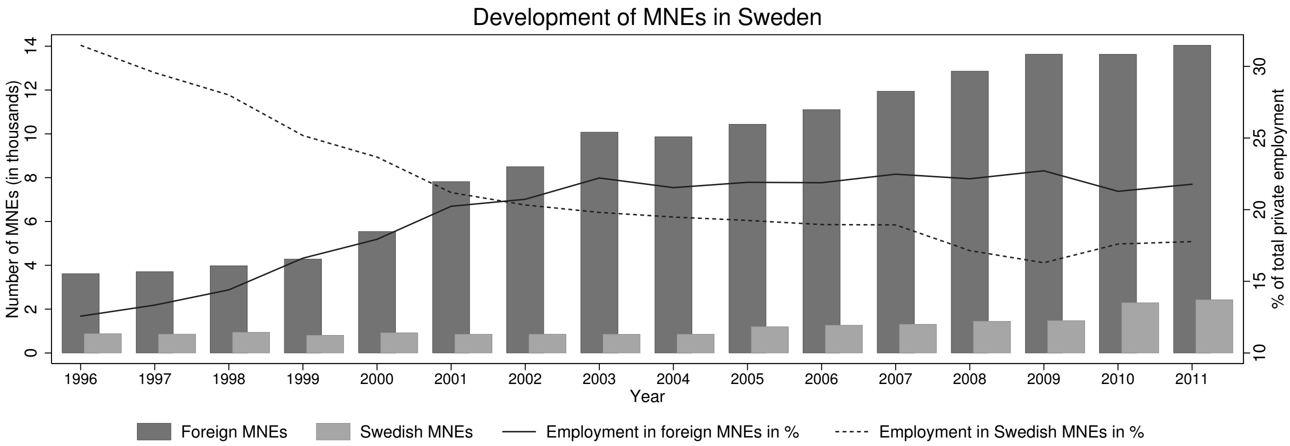


Figure 2.2: **Development of the number of foreign and Swedish-controlled MNEs and their employment in Sweden.**

Source: Author's illustration based on data by SCB and Swedish Agency for Growth Policy Analysis

that period, which is confirmed by FDI stocks, shown in Figure 2.3. The figure shows the development of the total Swedish FDI stock abroad and of the foreign FDI stock in Sweden over the years 1986-2011 in billion US$. The amount of both inward and outward FDI stock has increased dramatically over this period: inward stock increased from $10 billion to over $300 billion while outward stock rose from $28 billion to over $330 billion. The right axis displays these figures as a percentage share of Swedish GDP, which shows that the shares have risen from about 5% and 15% to above 90% and 100% for inward and outward stock, respectively (these numbers differ from the numbers in Figure 1.1 due to the different data sets used). Foreign direct investment in Sweden is still lower than Swedish foreign direct investment abroad, however, it has caught up considerably compared to the 1990s where inward stock was less than half of outward stock for most of the decade. This further illustrates the importance of FDI to the Swedish economy as an investor as well as a receiver of foreign capital. A similar picture can be drawn for other aspects of the Swedish economy: e.g. a majority of Sweden's trade is conducted by MNEs active in Sweden (Johansson & Lööf, 2005). These linkages between countries through multinationals obviously have an effect on how the international economy functions and develops.

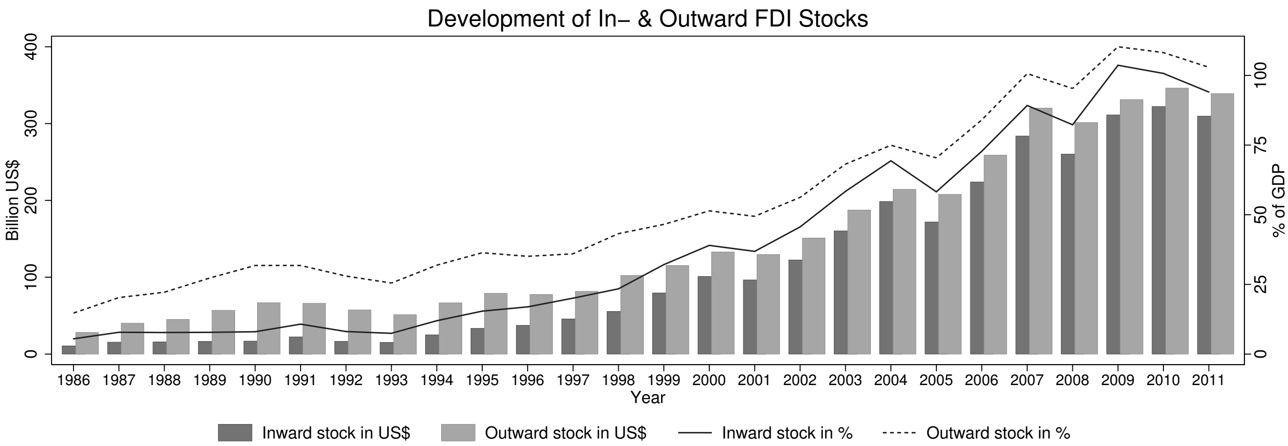


Figure 2.3: **Swedish inward and outward FDI, total and % of GDP in 2005 US$.**

Source: Author's illustration based on data by OECD statistics

Foreign direct investment is obviously a very common and increasingly important phenomenon, however, the question remains: what motivates a firm to commit to a long-lasting investment in another country in light of other options such as trade (which also have been increasingly deregulated)? To shed light on this, a concise overview of the theory behind a firm's motivation to become international is presented. The work of John Dunning has been among the most influential. In the eclectic paradigm of international production, he outlines three types of advantages that motivate the behaviour of MNEs: ownership, location, and internalisation (OLI). The ownership advantage refers to firm-specific competitive advantages such as better technology, patents, differentiated products, or human capital. These intangible assets offer an advantage to the firm relative to other firms and especially to firms in a foreign country where the domestic firm is considering to invest or expand production. The location advantage describes how the comparative characteristics of different economies interact with the firm-specific advantages. The more the immobile, natural, or created endowments of a country in conjunction with the firm-specific advantages favour production in a foreign rather than domestic location, the more firms will choose to strengthen their firm-specific advantages by engaging in FDI. The internalisation advantage deals with why a firm would prefer to have a foreign subsidiary rather than a foreign trading partner. There are advantages for a firm to engage in foreign production itself since it enables them to internalise market transaction costs that can arise from, for example, incomplete contracting and uncertainty about business partners. Depending on the motivations for FDI, Dunning (1993) outlines five distinct main types of FDI. First, an important distinction is between *market-seeking* FDI (or *horizontal* FDI) and *resource-seeking* FDI (or *vertical* FDI). Horizontal FDI seeks to serve local markets by local production rather than exports which can be preferable to a MNE when trade barriers such as tariffs, quotas, and other import-substituting policies, or transportation costs make exports relatively expensive. Firms are attracted to big market sizes (i.e. large GDP) and growing markets (i.e. high GDP growth rates). Vertical FDI seeks to acquire resources and assets that are not available in the home country. This type of FDI can be motivated by comparative advantages in, for example, natural resources, labour costs, technology, or infrastructure. Vertical FDI also serves the home market or other international markets and is typically characterized by a firm's production spread out across different countries. The other three types of FDI outlined by Dunning are *rationalized or efficiency-seeking* FDI, *strategic asset-seeking* FDI, and *export-substituting* FDI. An efficiency-seeking firm aims to take advantage of economies of scale and benefits of common ownership while a strategic asset-seeking firm aims to acquire new assets such as technology and experience. An export-substituting firm initially serves a foreign market through exports but substitutes this by investing in the foreign country to serve it through local production. The eclectic paradigm offers different ways to think about the motivations and incentives for firms to become multinational or expand their multinational operations. However, the factors that are actually relevant differ in each case. Thus, the paradigm serves as a way to analyse and motivate the international production decisions of firms (Dunning, 1993, 2000, 2001).

Before exploring the results of the previous findings on the question of the effects of exchange rate volatility on foreign direct investment, I give an overview on exchange rates and their volatility, its causes, and how exchange rate issues affect firms.

2.2 Exchange Rate Volatility

The nominal bilateral exchange rate is defined as the amount of domestic currency necessary to purchase one unit of foreign currency. This is in contrast to the real exchange rate (RER), which takes the relative price levels of two countries into account. The real exchange rate is defined as the ratio of the amount domestic currency (exchanged on the foreign exchange markets) necessary to purchase a market basket of goods in the foreign country relative to the amount of domestic currency necessary to purchase that market basket in the domestic country. Formally,

$$RER = \frac{ER * P^*}{P}, \tag{2.1}$$

where ER is the nominal exchange rate, P^* is the foreign price level, and P is the domestic price level. Exchange rate volatility σ describes the degree to which the exchange rate fluctuates. The larger the range of values that the exchange rate takes on during a certain period, the more volatile is the exchange rate (Visser, 2009). Figure 2.4 shows the average monthly nominal exchange rate of Swedish kronor per euro from 1993 until 2013. The figure illustrates that the volatility of krona-euro exchange rate is not constant over time: the range of values the exchange rate takes on is clearly smaller during some periods (2002-2008) than others (1996-2000 and 2008-2012).

The distinction between using real and nominal exchange rates to derive the exchange rate volatility measure could be significant in empirical work since the different variables capture different relationships. However, in practice the two move very closely together and this is especially the case when looking at short-term fluctuations, which I use to calculate the volatility series. Figure 2.5 shows the real (REER) and nominal (NEER) effective exchange rate index of the Swedish krona. The effective exchange rate is a measure of the krona against a basket of weighted foreign currencies and signifies a measure of general international competitiveness. The effective exchange rates are shown as an index with 2005 as the base year and they illustrate how both real and nominal effective exchange rate develop very similarly. I derive the volatility series from the nominal bilateral exchange rates due to this fact.

With the establishment of flexible exchange rates after the end of the Bretton Woods system, the determination of exchange rates has become an important part of international economics. Macroeconomic

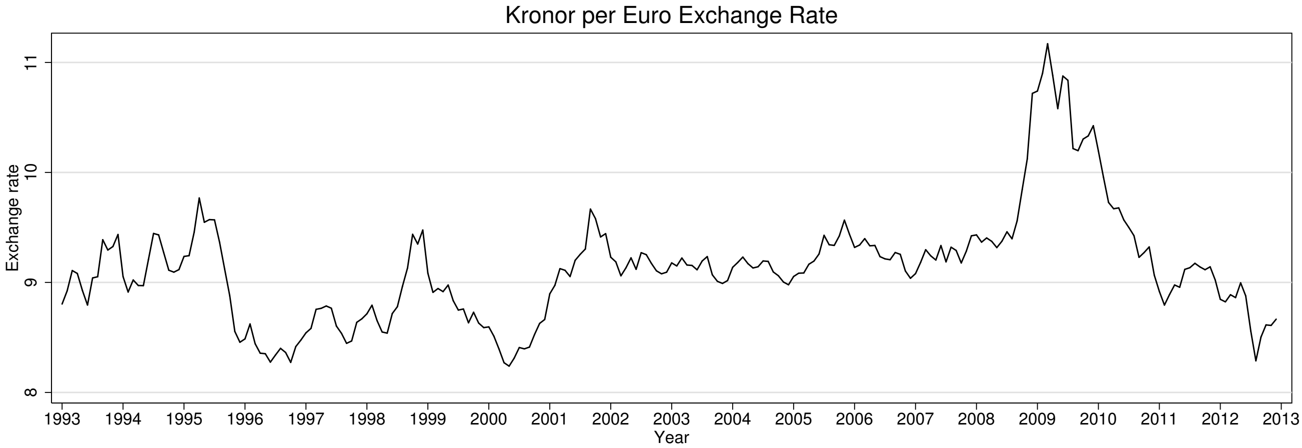


Figure 2.4: **The monthly krona-euro exchange rate between 1993 and 2013.**

Source: Author's illustration based on data by Riksbank

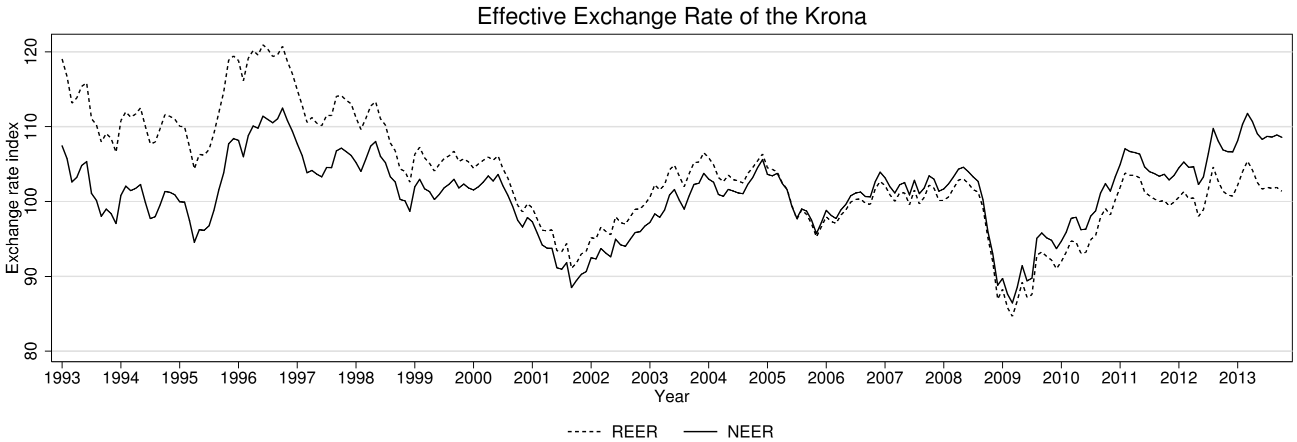


Figure 2.5: **The monthly real (REER) and nominal (NEER) effective exchange rate of the krona between 1993 and 2013.**

Source: Author's illustration based on data by IMF

approaches typically use shocks to macroeconomic fundamentals (e.g. the money stock, income, price level, and interest rates) to explain exchange rate dynamics. Through the link of fundamentals to exchange rates, they establish a link between volatility in the fundamentals to the volatility of the exchange rates (Copeland, 2008).

The usefulness of these types of models has been questioned by Meese and Rogoff (1983), who establish that out of sample forecasting of several models cannot outperform random walk time series of the exchange rate. In a random walk, the value of a variable in the next period is equal to the value in current period plus a random, stochastic component. The basic findings by Meese and Rogoff still stand, which suggests that firms and financial markets are, at the very least, not able to predict future exchange rates with a high degree of certainty (Frankel & Rose, 1995; Friberg, 1999).

There are several factors that explain why actual exchange rate volatility is larger than explanations based on the fluctuations in the fundamentals predict. Empirical evidence indicates that fluctuations in the nominal exchange rate are not fully passed through to local price levels and Devereux and Engel

(2002) suggest that this is due to local-currency pricing, where firms set prices in the local currency of the respective markets the firms sell their goods in. They then show that under certain conditions this can induce a high level of exchange rate volatility. Another explanation for volatility is the presence of *noise trading* – i.e. trading based on non fundamental influences, such as fads or herd behaviours – in the foreign exchange markets. Policy makers could be able to lower volatility by discouraging noise traders from participating in the market in addition to the traditional channel of reducing exchange rate volatility by reducing volatility in the underlying fundamentals (Jeanne & Rose, 2002). Financial markets are also influenced by their confidence in the central bank, where low confidence is associated with a high degree of fluctuations and vice versa (Dunn Jr. & Mutti, 2004).

Due to the complex nature of exchange rate determination and movement, it is difficult to reliably predict exchange rates. This introduces an uncertainty for firms considering a foreign direct investment that not only will be determined prior to the exchange rate materializing but will also involve a long-term relationship with a subsidiary and an even less certain development of the exchange rate. However, firms are not helplessly exposed to exchange rate fluctuation due to a variety of hedging products that mature financial markets offer. Hedging works by creating an offsetting exposure for the firm. This means that if cash flows move in one direction due to an unforeseen exchange rate movement, the firm also has a contract with a value that moves in the opposite direction. The most common instruments for hedging are forwards, futures, swaps, and options (Friberg, 1999).

Forward currency contracts set an amount of foreign currency to be sold (bought) at a specified date in the future at a price that is determined today. This type of instrument is available for a variety of forward time periods and can eliminate the uncertainty arising from uncertain future spot exchange rates as long as the amount of foreign currency required is known. *Futures* contracts are contracts available for high-turnover currency markets to sell (buy) a standardized amount of currency at a specific future date at a price set today. This instrument is typically available for relatively shorter time horizons and on account of the standardized nature, at a lower cost than forward contracts. *Swaps* exchange obligations denominated in one currency for obligations in another. These three instruments have one common drawback: they require that a currency exchange takes place at a predetermined price. This can be undesirable for a firm when the exchange rate has turned in its favour. *Options* solve this by giving the owner of the option the right but not the obligation to sell (buy) foreign currency at a specified rate. This option is only exercised when the spot exchange rate is less favourable than the specified rate. Forwards and options are among the most frequently used instruments to protect against foreign exchange exposure (Friberg, 1999).

Even with these (and various other) methods to protect against uncertain exchange rate movements, a cost is always associated with them. There is numerous empirical evidence to support the fact that exchange rate volatility influences a firm's foreign direct investment behaviour as well as other aspects of international transaction (e.g. trade), even though it remains difficult to determine the exact nature of these influences (Bahmani-Oskooee & Hegerty, 2007; Phillips & Ahmadi-Esfahani, 2008). In the following section, I will give an overview of the literature on the effects of exchange rate volatility on FDI and their results.

2.3 Previous Studies

After the end of the era of fixed exchange rate regimes, marked by the collapse of the Bretton Woods system, the question of the dangers of exchange rate uncertainty has been on the mind of policy makers, going as far as building large currency areas to eliminate exchange rate uncertainty between countries all together. The issue of exchange rate uncertainty has been researched in many settings and foreign direct investment is no exception. Even though the relationship between exchange rate uncertainty and FDI has been researched and is of interested for policy makers, the literature has not yet reached consensus on what this effect is and how it works. As of this writing, the question remains unanswered both empirically as well as theoretically. This section explores the findings of previous studies and the theories that link FDI and exchange rate uncertainty. In the following section, I expand on the theories presented here and present competing theories in-depth.

Empirical Evidence

A detailed summary of the results of the empirical studies mentioned in this section can be found in Table A.1 in the appendix, including the results of a selection of control variables. The country names are abbreviated according to the ISO-3166-1 alpha-3 codes, which are listed for reference in Table A.2. The selected studies are by no means exhaustive but hopefully representative enough.

There is no consensus which exchange rate volatility measure is the best. Variations on moving average standard deviation (MASD) of the exchange rate over a certain number of periods are common, while generalized autoregressive heteroskedasticity (GARCH) is less common. The literature generally either uses variations on gravity model specification (Bénassy-Quéré, Fontagné, & Lahrèche-Révil, 2001; Görg & Wakelin, 2002) or simpler single equation time series models with only exchange rate levels, volatilities, and sometimes trend variables included (Goldberg & Kolstad, 1995; Amuedo-Dorantes & Pozo, 2001; Kiyota & Urata, 2004). Other specifications, such as hazard rate models, are also sometimes used but not very common. Gravity model specifications vary widely on which variables to include, which is a potential source of the ambiguous results (Phillips & Ahmadi-Esfahani, 2008).

The empirical evidence is quite mixed. For the studies included in this review section, estimation results are negative in 10 cases, 6 are positive, and 7 offer mixed or insignificant results. In a review of the literature, Phillips and Ahmadi-Esfahani (2008) state that almost half of the papers they review find a significant negative sign, while less than 15 percent manage to find a significant positive relationship.

A negative relationship on FDI inflows into the US is found by Campa (1993) and Amuedo-Dorantes and Pozo (2001). Campa (1993) studies the effect on the number of firms entering the US market during the 1980s, and the usage of number of firms as the dependent variable sets it apart from other studies reported on. However, Tomlin (2000) criticizes Campa's statistical method and finds no significant effect in a statistically preferred model. Amuedo-Dorantes and Pozo (2001) study the period between 1976-1998 and find that conditional volatility (measured by GARCH) has a significant negative short- and long-run impact, while they do not find a significant impact using an unconditional volatility measure (MASD). This indicates that results can be sensitive to the volatility measure used, while others argue that this choice is probably not very important (Carruth, Dickerson, & Henley, 2000). Bénassy-Quéré et al. (2001) measure volatility in the coefficient of variation (CV) of the nominal exchange rate – the CV is equal to the ratio of the standard deviation to the mean – and study FDI flows from developed to developing countries. They also find evidence for a negative relationship which is stronger when host countries are close to potential investors. Urata and Kawai (2000) establish evidence for a negative effect in two machinery industries on outward Japanese FDI, which is particularly strong for developing countries. Moreover, Barrell, Gottschalk, and Hall (2003) and Crowley and Lee (2003) discover evidence for a negative relationship using GARCH as volatility proxy. Crowley and Lee (2003) report an insignificant effect on outward Swedish direct investment but a significant effect on inward FDI. They note that countries with relatively stable exchange rates produce largely insignificant estimates for exchange rate volatility. Further evidence for a negative relationship can be found when looking at Japanese (Kiyota & Urata, 2004), British (De Vita & Abbott, 2007), and Indian (Kumarasamy & Velan, 2011) FDI.

Evidence for a positive relationship on US FDI is found by Cushman (1985, 1988) and Goldberg and Kolstad (1995). Cushman (1985) finds the exchange rate volatility effect to increase US FDI flows by as much as 15-20% when comparing high-risk to low-risk periods. Goldberg and Kolstad (1995) conclude that exchange rate volatility can be a factor driving internationalization of production activity without adversely affecting economic activity in the home market. Moreover, de Ménil (1999) and di Giovanni (2005) find evidence for a positive relationship when investigating bilateral FDI flows and bilateral M&A investment flows, respectively. Investigating large developed economies, Pain and Van Welsum (2003) find evidence for a positive effect when looking separately – but not when looking jointly – at the different locations.

Mixed evidence has been found by Goldberg (1993), Ricci (2006), Schmidt and Broll (2009), Lin, Chen, and Rau (2010), and Russ (2012). Goldberg (1993) obtains both significant and insignificant as well as negative and positive results when looking at FDI by US industries. The effects appear to be stronger in the 1980s than the 1970s. Ricci (2006) studies the effects of exchange rate uncertainty on agglomeration of firms and finds a significant positive effect on net FDI inflows in large economies, while it has a significant negative impact in small economies. Ricci concludes that uncertainty induces firms to locate in large economies, where they can benefit from a lower variability of sales compared to a small economy. Similar to Amuedo-Dorantes and Pozo (2001), Schmidt and Broll (2009) find distinct effects depending on the risk measure. They find a negative effect in all industries using MASD. However, using the variance of the real exchange rate that is not explained by the failures of the law of one price, they find a negative effect for manufacturing and the opposite for non-manufacturing industries. Lin et al. (2010) use a hazard model approach and find evidence that FDI motivation matters: volatility has a negative effect on market-seeking FDI, while it has a positive impact on export-substituting FDI. Russ (2012) finds evidence that it matters from which country (home or host) volatility originates. While first-time FDI is discouraged by monetary volatility originating in the home country, it is encouraged by volatility originating in the host country.

Evidence for an insignificant effect is presented by Görg and Wakelin (2002) and Jeanneret (2006). Looking at US FDI flows between 1983-1995, Görg and Wakelin (2002) find no significant evidence on aggregate data or on the wholesale sector and speculate that foreign investment or exchange rate hedging markets have matured since earlier studies. Meaning that FDI is now less affected by exchange rate volatility than it used to be. In line with this, Jeanneret (2006) obtains insignificant results under her preferred estimation method and finds evidence that the effect has been significantly decreasing between 1990-2002.

Theoretical Developments

There are two main strands in the literature on the relationship between FDI and exchange rate uncertainty: real options and risk aversion approaches (Phillips & Ahmadi-Esfahani, 2008; Goldberg & Kolstad, 1995). The predictions for the effect of exchange rate uncertainty on FDI from these different approaches match the ambiguity that is prevalent in the empirical work. Below, I give an overview of the two main strands as well as some of the more recent contributions that aim to overcome the prevalent ambiguity. A thorough explanation of two competing theories is included in Section 3.

The real options approach deals with the effects of uncertainty in light of irreversible investment decisions. In this setting, a firm has the option to invest abroad and the expected return of this option can be influenced by exchange rate uncertainty. For example, Dixit and Pindyck (1994) show that exchange rate uncertainty can increase the value of holding on to this option (i.e. postponing investment). Campa (1993) follows this and predicts that a firm will wait longer to exercise its option (i.e. to enter the foreign market) the higher the uncertainty of the exchange rate is. This leads to a prediction of a negative effect of exchange rate uncertainty on FDI flows, even for risk-neutral firms. Darby, Hallett, Ireland, and Piscitelli (1999) conduct another study following this line of thinking but expand on Dixit and Pindyck (1994) by finding situations where investment increases when faced with exchange rate uncertainty, concluding that the effect could be ambiguous on the aggregate level. A related line of thinking started by Aizenman (1992) argues that firms gain the option to change the location of production in response to exchange rate movements by establishing factories in different countries – called production flexibility by Goldberg and Kolstad (1995). In this model, firms reallocate resources towards the facility that is more efficient or cheaper and FDI is negatively (positively) correlated with exchange rate volatility when nominal (real) shocks are dominant. In a similar vein, Rivoli and Salorio (1996) argue that under uncertainty, ownership and internationalisation advantages may be negatively related with FDI. They argue that high uncertainty will lead a MNE to delay its FDI decision to a later time. The argument is that the ownership advantage makes FDI postponable and internationalization makes it less reversible and when FDI becomes either more postponable or less reversible, it will occur at a later point in time. Sung and Lapan (2000) show that a risk-neutral MNE can choose to increase foreign direct investment in response to higher exchange rate uncertainty because the value of the production flexibility option increases with exchange rate uncertainty. However, Jeanneret (2006) notes that the variability of employment and capital expenditures are not large relative to exchange rate variability, suggesting that firms do not consider production flexibility. This approach is appealing because it allows firms more decisions than the risk aversion approach. Firms can either invest, wait and see, or not invest at all, while under risk aversion firms can only decide whether to invest or not.

In the risk aversion approach, exchange rate risks affect firms because there is a delay between investments and profits. A firm chooses to invest abroad when expected returns are equal to costs plus payment for the degree of exchange rate risk. Early influential papers in this approach include Kohlhagen (1977) and Itagaki (1981), which establish this approach, and Cushman (1985) and Goldberg and Kolstad (1995) who further develop it. Cushman (1985) argues that risk-adjusted expected real foreign currency appreciation lowers the foreign cost of capital, which stimulates direct investment. Goldberg and Kolstad (1995) and Bénassy-Quéré et al. (2001) build on Cushman's approach. Goldberg and Kolstad (1995) show that as long as foreign demand and exchange rate shocks are positively correlated, MNEs can decrease the variance of expected profits by increasing productive capacity abroad and, thus, increase their expected utility. Bénassy-Quéré et al. (2001) develop a theoretical model showing that risk averse MNEs can reduce profit uncertainty by exploiting exchange rate correlations between locations, when FDI is undertaken in order to re-export. What is interesting is that this model accounts for the fact that, in some cases, investment locations can be substitutes for one another. Barrell et al. (2003) further expand on this by incorporating firms with market power. Ricci (2006) argues that it is beneficial for firms, faced with exchange rate uncertainty, to be located in larger markets rather than smaller markets because this reduces their sales variability. However, within the market (currency area) agglomeration is not taking place because there is no exchange rate uncertainty between the regions (countries) and thus no incentive to locate in larger markets. This implies that Swedish net FDI inflows are negatively affected by not joining the European Monetary Union (EMU).

Alternative approaches have been developed that consider the heterogeneity of FDI motive (Lin et al., 2010) and exchange rate endogeneity (Russ, 2007). Lin et al. (2010) expand upon real options models (Dixit, 1989; Dixit & Pindyck, 1994) and risk aversion models (Cushman, 1985; Goldberg & Kolstad, 1995) by showing that volatility will have different results, depending on the FDI motive of the firm. They predict that market-seeking FDI increases the firm's exposure to exchange rate risk, while export-substituting FDI will reduce it. I explain this model in detail in Section 3.2 since it is an interesting combination of two of the more established approaches. Russ (2007) extends previous research by allowing for exchange rate endogeneity. Russ demonstrates that a MNE's response to exchange rate volatility depends on whether the source of the shock lies in the firm's home or host country. For example, Russ predicts a positive relationship when the variance of money growth rates (which affect exchange rate volatility) in the host country are larger than in the source country.

In conclusion, the prediction of the sign of the effect of exchange rate volatility on FDI is mixed, both across, as well as, within approaches. Among others, Dixit and Pindyck (1994), Campa (1993), and Rivoli and Salorio (1996) predict a negative relationship, while Cushman (1985, 1988), Goldberg and Kolstad (1995), and Sung and Lapan (2000) predict a positive relationship. The theoretical work is as divided as the empirical work, with the former trying to explain the heterogeneous results of the latter. Empirical work, on the other hand, tries through various strategies to find flaws in previous studies and correct them – as does this study. A more thorough summary of two major competing theoretical works is given in the following section.

3 Theoretical Framework

Many studies try to find a theoretical link between exchange rate volatility and foreign direct investment. However, due to the lack of conclusive empirical evidence, it is difficult to determine which model accurately describes FDI developments. I present two influential theoretical models in this section, each using a different approach: real options and risk aversion. This is meant to give a more thorough overview of the theorized link between exchange rate volatility and FDI and to give context to the analysis in Section 5. I chose the two models because they make opposing predictions regarding the nature of the exchange rate volatility effect (it should be kept in mind that the predicted sign of the relationship is not related to the approach). First, I present the model by Campa (1993), which predicts a negative effect of exchange rate volatility even when firms are indifferent to risk. Second, I present Lin et al. (2010), a model specification that predicts a positive relationship or a negative relationship depending on the FDI motive of the firm. It is interesting in that it combines both approaches: real options and risk aversion.

3.1 Campa (1993)

Based on a model developed by Dixit (1989) that investigates entry and exit decisions of a firm under uncertainty, Campa (1993) develops a model specific to exchange rate variability.

This branch of theories is built on an analogy between real and financial investment decisions. The opportunity of a firm to make a real investment is analogous to a call option on a stock that consists of the capital in place. Exercising the option is analogous to making the investment and the strike price of the option is the cost of the investment. Through standard financial economics it is possible to derive the price of the option – the value of the opportunity to invest to the firm – and the rule that tells the firm when to exercise it optimally – the investment criterion. This idea is expanded upon with the addition of sunk costs. By choosing to exercise the option to invest, the firm acquires another option: to abandon the investment. In finance, an investor will generally be able to sell the stock again if s/he wishes. However, with real investments this is not possible in the same manner. Entering a foreign market entails not only acquiring assets (e.g. factories and machinery) that can lose value quickly when not used (rust) but also marketing costs and the establishing of distribution networks. All these endeavours are costly and, if a firm decides to exit a market, not easy (or even impossible) to recover.

The firm can either enter the foreign market in the current period or wait until the next period (at which point it faces the same decision). In the model, a firm produces a good at home and can sell it in the foreign market at a constant price of p in foreign currency. In order to enter the foreign market (exercise its option), the firm needs to invest an amount of k in foreign currency that it cannot recover upon exit (i.e. it is a sunk cost). There is no depreciation but the investment rusts immediately if unused. Let ρ be the discount rate, and w avoidable operating costs per unit of time. The firm faces a certain price in foreign currency but, due to uncertain bilateral exchange rate fluctuations, its returns in home currency are uncertain. The exchange rate R (home currency per foreign currency) is assumed to follow some stochastic process, which is known to the firm. The output of the investment is normalized to one unit, so that the revenue from the project is simply Rp, the price in home currency.

Consider the case in period t where $R_t p$ is equal to $w + \rho k$ (the annualized full cost of making and operating the investment). In this case the cost of investing in and operating the plant now is equal to the revenue if R_t remains unchanged for the period. If $R_t p$ is equally likely to move up or down by the same amounts and the firm were to invest now and continue active forever, the expected present net value of the investment is zero. However, investing or not investing are not the firms only choices. It can wait one period. If by period $t + 1$ $R_{t+1}p$ has increased, and the firm invests, it captures a positive expected present value. If $R_{t+1}p$ decreased instead, the firm does not invest and the expected present value is still equal to zero. Since either outcome is equally likely (by assumption), they are weighed by $^1/_2$ and calculate expected present value of the option to invest in period t. Because the expected present value of the outcomes in period $t+1$ are zero and larger than zero respectively, the expected present value of the option to invest will also be larger than zero. It follows that the higher the variability of the exchange rate is (the exchange rate will increase/decrease by more), the higher the value of the option to invest is. This is the reason that firms, given an exchange rate, delay investment when faced with high exchange rate volatility.

The trade-off between waiting for a more favourable exchange rate and operating profits in the current period can be characterized so that there is a critical value of the exchange rate $\hat{R}$ that triggers entry at a given level of exchange rate volatility. Campa (1993) derives this condition that weighs the cost of investing against future pay-off:

$$\frac{\hat{R}p}{\rho-\mu} - \frac{w}{\rho} - \frac{\hat{R}p}{(\rho-\mu)\times\beta(\sigma)} = \hat{R}k, \tag{3.1}$$

where μ is the drift of the exchange rate, $\beta(\sigma)$ is a known function of the volatility of the exchange rate σ, and $\beta'(\sigma) < 0$.

In conclusion, the model predicts a negative effect of exchange rate volatility on FDI.

3.2 Lin, Chen, and Rau (2010)

The model developed by Lin et al. (2010) incorporates both a firm's attitude towards risk and the option value of investment flexibility simultaneously. The real options model (Dixit & Pindyck, 1994) as well as the risk aversion model (Cushman, 1985) are special cases of this model. Thus, it is an attempt at unifying the heterogeneous impacts of exchange rate volatility found in empirical studies. They find that the effect of exchange rate uncertainty depends on a firm's FDI motive: a market-seeking firm delays its investments in the face of rising volatility, while an export-substituting firm might accelerate its investments. I summarize the model and its predictions briefly.[b]

The firm is assumed to be a price taker that produces a one unit flow of output at fixed marginal costs per period with variable costs that comprise only of labour costs. The exchange rate R (in units of home currency per foreign currency) is assumed to follow a stochastic process and σ is the volatility of that exchange rate. The firm maximizes the expected utility of its profits $EU(\pi)$ in terms of its home currency and, for a risk averse firm, the expected utility of the profits decreases with their variance $Var(\pi)$. The variance of profits increases with σ.

The authors consider the effects on two extreme cases of FDI: export-substituting FDI (a firm considers serving a foreign market through FDI that it currently exports to) and market-seeking FDI (a firm considers serving a foreign market through FDI that it currently does not serve at all).

In the case of a firm considering export-substituting FDI, it is able to service a foreign market either through exports or FDI. In the initial state, the firm produces goods at home and exports them to the foreign market. The firm pays its domestic workers (its only workers) in domestic currency W_d but generates revenues in foreign currency P_f that are converted to domestic currency. Its profits are thus equal to revenues from abroad expressed in domestic currency minus domestic wages ($\pi_1 = P_f R - W_d$). If the firm invests abroad, it will pay its foreign wages in foreign currency W_f and generate revenues in foreign currency ($\pi_2 = P_f R - W_f R$). In the second state, the exposure to exchange rate risk is lower since revenues and wages expressed in domestic currency develop in the same way to exchange rate movements. When $R\uparrow$ (the home currency depreciates) in the second state both revenues ($P_f R$) $\uparrow$ and wages ($W_f R$) $\uparrow$

[b]For detailed proofs see Lin, Chen, and Rau (2006) and Lin et al. (2010).

expressed in domestic currency increase, while in the first state, only revenues change $(P_f * R) \uparrow$ and wages remain constant $W_d \longrightarrow$. This means that for any given change in the exchange rate, the variance of profits will be larger if the firm is located in home $(Var(\pi^1) > Var(\pi^2))$. The firm also has to choose the optimal time to enter the foreign market: it can either enter the foreign market now (and invest a sunk cost of k) and receive the expected utility gains $\xi_E(R)$ from lower profit variability or stay in the initial state and hold on to the option to invest in the next period. There is a threshold value of R_L below which the net value of entry $(\xi_E(R) - k)$ is higher than the value of the option to wait. When this occurs the firm will enter the foreign market through FDI.

Exchange rate volatility affects FDI through two channels: the risk attitude of the firm and the option value of investment flexibility. Lin et al. examine each channel separately to determine their individual effects. Through the risk attitude channel, exchange rate volatility has a positive effect on export-substituting FDI. Moving to the foreign market reduces the exposure of the firm's profits to exchange rate risks $(Var(\pi) \downarrow \rightarrow \xi_E(R) \uparrow)$ and the larger the volatility, the larger is the reduction$(\sigma \uparrow \rightarrow \xi_E(R) \uparrow)$. Through the option value channel, exchange rate volatility has a negative effect. Facing an irreversible investment decision and an uncertain future, a firm has an incentive to delay the investment in order to get additional information. The possibility to invest is similar to a call option in that its value rises if the underlying uncertainty increases. The larger the value of the option to wait, the lower the threshold R_L at which the firm engages in FDI $(\sigma \uparrow \rightarrow R_L \downarrow)$, thus reducing FDI. The two channels have opposite effects on an export-substituting FDI decision. Thus, the effect of exchange rate volatility on this type of FDI is ambiguous. However, there is a threshold depending on the degree of risk aversion of the firm such that the effect is positive (negative) if the firm's risk aversion is greater (smaller) than this threshold.

In the case of a firm considering market-seeking FDI, the firm is not serving the foreign market at all initially but is able to enter it through FDI. Through the risk attitude channel exchange rate volatility has a negative effect. Since initially the firm is not exporting to the foreign market, the profits – as well as the exchange rate risk exposure – from it are equal to zero. Comparing this with the state after engaging in FDI, exchange rate risk risk exposure is clearly larger $(Var(\pi) \uparrow \rightarrow \xi_E(R) \downarrow)$. For a risk averse firm, an increase in exchange rate volatility will reduce the expected utility gain from entering the foreign market $(\sigma \uparrow \rightarrow \xi_E(R) \downarrow)$. Through the option value channel, exchange rate volatility has a negative effect on market-seeking FDI. The reasoning is identical to the export-substitution case: an increase in the exchange rate volatility increases the option value of delaying the investment. The only difference is that the relationship between the expected utility gain and the exchange rate has changed and now there is upper threshold R_H for which the firm will engage in FDI. The higher the exchange rate volatility is, the higher the upper threshold will be $(\sigma \uparrow \rightarrow R_H \uparrow)$, thus reducing FDI. For a market-seeking firm this means that exchange rate volatility has an unambiguous negative effect on foreign direct investment.

In conclusion, this model predicts that the effect of exchange rate volatility on FDI depends the motive behind the investment. Lin et al. predict a negative effect for market-seeking FDI and a positive for export-substituting FDI as long as firms are sufficiently risk averse. The result for export-substituting firms also holds when the more realistic assumption of partial export-substitution is allowed. I begin the empirical investigation of the effect of exchange rate volatility on Swedish FDI stock in the next section.

4 Empirical Model, Data, and Method

In this section, I describe the empirical model that I test and analyse in Section 5. I use a gravity-style model with bilateral FDI stocks as the dependent variables and exchange rate volatility as the independent variable of interest. As controls, I include variables that have proven to be good predictors of FDI patterns. The literature is varied on which covariates to introduce. However, Blonigen and Piger (2011) compare different possible model specifications using Bayesian Model Averaging to determine a set of variables with good predictive abilities to model FDI patterns (they do not test for exchange rate and price variables). I include these control variables recommended by Blonigen and Piger (2011): traditional gravity variables, GDP per capita of the home country, relative labour endowments, and regional trade agreements (Crowley & Lee, 2003; Abbott, Cushman, & De Vita, 2012; Blonigen & Piger, 2011).[c] I use an unbalanced panel approach for annual observations for a selection of 29 countries. I arrive at the following model specification, which estimates the effect of various variables on the bilateral FDI stocks in country i, and in Sweden attributable to foreign owners from country i, respectively. Equation (4.1) is the panel model specification for FDI stocks:

$$\begin{aligned} FDI_t^i = c + \beta_1 \ln \sigma_t^i + \beta_2 \ln RER_t^i + \beta_3 \ln GDP_t^{host} + \beta_4 \ln GDP_t^{home} + \beta_5 \ln GDP/capita_t^{host} \\ + \beta_6 \ln GDP/capita_t^{home} + \beta_7 squared\, skill\, difference_t^i + \beta_8 RTA_t^i + \varepsilon_t, \end{aligned} \tag{4.1}$$

where the bilateral FDI stock in country i or in Sweden from country i is the dependent variable, $\ln \sigma_t^i$ is the natural logarithm of the volatility of the nominal exchange rate with partner country i at time t, $\ln RER_t^i$ is the natural logarithm of the real exchange rate with country i at time t, $\ln GDP_t^{host}$ is the natural logarithm of the real gross domestic product of the host country at time t, $\ln GDP_t^{home}$ is the natural logarithm of the real gross domestic product of the home country at time t, $\ln GDP/capita_t^{host}$ is the natural logarithm of the real GDP per capita of the host country at time t, $\ln GDP/capita_t^{home}$ is the natural logarithm of the real GDP per capita of the home country at time t, $squared\, skill\, difference_t^i$ is the difference in the endowment of skilled labourers between country i and Sweden at time t, RTA_t^i is equal to 1 if Sweden is in a regional trade agreement with country i at time t and 0 otherwise, and ε_t is the error term at time t. Equation (4.1) is applied separately to inward and outward FDI stocks and is estimated annually. Equation (4.2) shows the expected sign for each variable:

$$\begin{aligned} FDI^i = f(\overset{?}{\ln \sigma^i},\ \overset{?}{\ln RER^i},\ \overset{+}{\ln GDP^{host}},\ \overset{+}{\ln GDP^{home}}, \\ \overset{+}{\ln GDP/capita^{host}},\ \overset{+}{\ln GDP/capita^{home}}, \overset{+}{sq.\, skill\, diff.^i},\ \overset{\pm}{RTA^i}). \end{aligned} \tag{4.2}$$

I make no a priori prediction about the relationship of exchange rate volatility and levels and FDI flows as this relationship is empirically and theoretically unclear. I expect a positive effect of real host country GDP, a positive effect of real home country GDP, a positive effect of real home country GDP per capita, a positive effect of the squared skill difference, and a positive or negative effect of regional trade agreements. These predictions are in line with empirical evidence from the comparative study by Blonigen and Piger (2011). A short reasoning for the sign of each variable and how they are calculated is given in the subsection for each variable.

4.1 Data

For the countries that adopt the euro during the observation period, I replace the change in the exchange rate with their previous currency with the change in the krona-euro exchange rate, even though the

[c] Distance and language proximity were also considered and implemented, however, since the chosen estimation technique does not allow for time-invariant variables, they are not included in the main text. They are considered in the alternative estimation technique, there they obtain insignificant estimation results (see Table A.3).

Riksbank sometimes quotes exchange rates to those previous currencies after the country adopted the euro. That means that from January 1999, I use the change in the krona-euro exchange rate for Austria, Belgium, Finland, France, Germany, Ireland, Italy, the Netherlands, Portugal, and Spain and, beginning January 2001, also Greece (European Union, 2013). Moreover, for these countries I use the permanently fixed exchange rate between the previous national currency and the euro to convert the krona-euro exchange rate into the exchange rate per previous national currency and construct the real exchange rate measure from that. This is also done at the previously mentioned dates. Due to the fact that FDI data is unavailable or censored in some periods for some countries, I use an unbalanced panel approach.

4.2 Variables

In this section, I present the variables that are used in the regression and how they are transformed, starting with the dependent variable – bilateral FDI stock – followed by the variable of interest – exchange rate volatility – and the control variables.

4.2.1 Bilateral FDI Stocks

The data on annual bilateral FDI stocks are compiled by OECD statistics in million US$ and obtained by Statistics Sweden (and prior to 2007 by the Riksbank) through surveys that cover Swedish enterprises with subsidiaries or associate companies abroad and enterprises in Sweden that are wholly or partly owned by non-residents (OECD statistics). Nominal FDI data are converted to real 2005 prices using the appropriate GDP deflator from OECD statistics. I do not use the logarithm of the FDI flows due to negative values present in the data.

Swedish outward FDI (Swedish direct investments assets abroad) in country i at time t is defined as:

$$Outward\,FDI\ stock_t^i = ek_t + lf_t + kf_t - ls_t - ks_t + df_t, \tag{4.3}$$

where ek is the total equity in foreign direct investment companies, lf are the long-term claims on foreign direct investment companies, kf are the current claims on foreign direct investment companies, ls are the long-term liabilities to foreign direct investment companies, ks are the current liabilities to foreign direct investment companies, and df are direct-owned properties abroad. The value of inward FDI (foreign direct investment assets in Sweden) belonging to firms situated in country i at time t is defined as:

$$Inward\,FDI\ stock_t^i = ek - lf - kf + ls + ks, \tag{4.4}$$

where ek is the total equity in the Swedish company, lf are long-term claims on the foreign owner, kf are current claims on the foreign owner, ls are long-term liabilities to the foreign owner, and ks are current liabilities to the foreign owner (SCB, 2012).

The inclusion of liabilities and claims means that it is possible that the recorded stock is actually negative. This is the case for 13 observations for outward FDI stocks and for 111 for inward FDI stocks. Figure A.1 in the appendix shows the development of in- and outward FDI stocks over the sample period for each included country, where the inward stock is denoted by dashed lines and the outward stocks by solid lines. Since a complete set of FDI data is not available for all countries, there are some gaps in the displayed graphs. The pattern is quite diverse with some close partner countries like Denmark or Finland expanding both inward and outward FDI stock in parallel upward trends and some less developed countries such as China and Russia receiving significantly more FDI than they invest in Sweden.

4.2.2 Exchange Rate Volatility

Since the available Riksbank data on monthly average exchange rates is not comprehensive, I am instead using data from the OECD for the following countries: China, Czech Republic, Hungary, South Korea, Mexico, New Zealand, and Poland. Additional exchange rate data is also used for Ireland, Hong Kong, and Greece from the Bank of England, as well as for Singapore from the Monetary Authority of Singapore. The exchange rates are available in national currency per US$ and are converted to Swedish krona/foreign currency.

Exchange rate volatility is not directly observable and because of that it is necessary to use a proxy to model its stochastic process over time (Crowley & Lee, 2003). Exchange rate volatility is the most difficult variable to estimate in this thesis and there are many approaches as to how to do this. I have chosen to use generalized autoregressive conditional heteroskedasticity (GARCH) to estimate the volatility of the exchange rate in line with (Kumarasamy & Velan, 2011; Crawford & Kasumovich, 1996). GARCH is the generalized form of the autoregressive conditional heteroskedasticity (ARCH) developed prior by Engle (1982). GARCH is widely used in assessing riskiness in financial contexts and to estimate volatility of the exchange rate in empirical economic studies. In addition, Seabra (1995) finds that GARCH performs better than alternative measures of volatility. For these reasons, I use GARCH as the measure of volatility of the exchange rate.

In order to generate a suitable proxy for exchange rate volatility, I use the GARCH method in accordance with Engle (2001). The GARCH method is based on the assumption that the variance of the error terms of a variable is not equal over time. It assumes that this variance is larger in some periods than others and that periods of higher variance are clustered together, i.e. that it is more likely that a period of high volatility is followed by another period of high volatility. GARCH is useful in that it uses the heteroskedasticity present in exchange rates and models it. This corrects the problem that the inclusion of a variable with heteroskedastic error terms would have on an ordinary least squares regression (standard errors and confidence intervals of the estimated regression coefficients will be too narrow).

GARCH uses the “weighted average of the long-run variance, the variance predicted for this period, and the most recent squared residual” to predict the variance in the following period (Engle, 2001). A GARCH model fits a data generating process and estimates the variance of the error term. This is expressed in the following Equation (4.5):

$$y_t = \mathbf{x}_t\beta + \varepsilon_t,$$
$$Var(\varepsilon_t) = \sigma_t^2 = \omega_0 + \omega_1\varepsilon_{t-1}^2 + \omega_2\sigma_{t-1}^2, \tag{4.5}$$

where

$$\omega_0 > 0,$$
$$\omega_1, \omega_2 \geq 0,$$

and $\mathbf{x}_t$ are the variables determining the underlying data generating process with their coefficients β, ε_t is the error term, ω_0 is the constant term, ω_1 is the parameter coefficient of the autoregressive lag, ε_{t-1}^2(ARCH term), and ω_2 is the parameter coefficient of the moving average lag, σ_{t-1}^2(GARCH term). Equation (4.5) shows the simple case with one ARCH term and one GARCH term. This is, however, not always the appropriate fit for a time series. Equation (4.6) shows the formula with variable ARCH and GARCH terms. It is annotated as GARCH(p,q), where p is the number of ARCH terms and q is the number of GARCH terms included

$$Var(\varepsilon_t) = \sigma_t^2 = \omega_0 + \sum_{j=1}^{p} \alpha_j\varepsilon_{t-j}^2 + \sum_{k=1}^{q} \beta_k\sigma_{t-k}^2, \tag{4.6}$$

where

$$\omega_0 > 0,$$
$$\alpha_j, \beta_k \geq 0 \, \forall \, j = 1, \ldots, p; \; k = 1, \ldots, q,$$

and ω_0 is the constant term, α_j is the parameter coefficient of the ARCH term with p lags, and β_k is the parameter coefficient of the GARCH term with q lags. The GARCH condition of stationarity needs to be fulfilled to avoid spurious regressions:

$$\sum_{j=1}^{p} \alpha_j + \sum_{k=1}^{q} \beta_k < 1.$$

To ensure validity, I test for unit roots in the exchange rate series using Augmented Dickey-Fuller tests (Dickey & Fuller, 1979), according to the strategy by Elder and Kennedy (2001). Before I can fit the appropriate GARCH specification, I first have to apply the Box-Jenkins methodology to find the best fitting autoregressive and moving-average (ARMA) process of the exchange rates. This is done to ensure that the GARCH process will model the volatility appropriately. An ARMA(d,e) model with d autoregressive terms and e moving-average terms is specified as

$$y_t = c + \varepsilon_t + \sum_{i=1}^{d} \zeta_i y_{t-i} + \sum_{j=1}^{e} \theta_j \varepsilon_{t-j},$$

where c is a constant, $\zeta_1, \cdots, \zeta_d$ and $\theta_1, \cdots, \theta_e$ are the parameters of the model, y_t is the variable, and ε_t is the error term. The Box-Jenkins methodology is a four-step process in which first the ARMA model is identified with the help of the autocorrelation function (ACF) and partial autocorrelation function (PACF) and the resulting correlograms, which display the autocorrelation and partial autocorrelation of the variable in question with its lagged values. The ACF at lag v is calculated by

$$\hat{\rho}_v = \frac{\hat{R}(v)}{\hat{R}(0)},$$

where

$$\hat{R}(v) = \frac{1}{n} \sum_{i=1}^{n-|v|} (x_i - \bar{x})(x_{i+v} - \bar{x}),$$

where $x_1, x_2, \cdots, x_n$ are elements in a time series, and $\bar{x}$ is the sample mean. The vth PACF is calculated by:

$$\hat{\phi}_{vv} = \frac{\hat{\rho}_v - \sum_{j=1}^{v-1} \hat{\phi}_{v-1,j} \hat{\rho}_{v-j}}{1 - \sum_{j=1}^{v-1} \hat{\phi}_{v-1,j} \hat{\rho}_j},$$

and

$$\hat{\phi}_{vj} = \hat{\phi}_{v-1,j} - \hat{\phi}_{vv} \hat{\phi}_{v-1,v-j}, \qquad where \, j = 1, 2, \cdots, v-1,$$

denotes the partial autocorrelation between the jth and vth lag (StataCorp, 2011b). That model is then estimated and tested for constant mean and variance in the residuals with a Ljung-Box (LB) test. The LB statistic is defined as follows:

$$LB = n(n+2) \sum_{k=1}^{m} \left(\frac{\hat{\rho}_k^2}{n-k} \right) \sim \chi_m^2,$$

where n is the sample size, m is the lag length that is being tested, and $\hat{\rho}_k$ is the sample autocorrelation function at lag k and follows in large samples a chi-square distribution with m degrees of freedom (Gujarati & Porter, 2009). If the null hypothesis of independently distributed data cannot be reject, I accept the ARMA specification and use it for estimating the GARCH model (Box & Jenkins, 1976). Then, to find the best fitting GARCH specification, I compare different possible specifications and find the best fitting specification using the Akaike Information Criterion (AIC), given the previously mentioned constraints (Bollerslev, 1986). The GARCH specification that minimizes the value of the AIC and satisfies all constraints is then applied to the exchange rate series to generate a series of volatility estimates that I use as the proxy for exchange rate volatility. The resulting series is then tested with a Ljung-Box (LB) test with $m = 15$ lagged autocorrelations to ensure the error terms have a constant mean and variance (i.e. that the error terms are white noise), in line with Engle (2001). If the null hypothesis of no autocorrelation cannot be rejected, I conclude that the true variance process is specified by the GARCH(p,q) specification.

In the literature both, the volatility in the nominal as well as the real exchange rate is used. In this thesis, I use the nominal exchange rate in line with Bini-Smaghi (1991), who argues that nominal exchange rate volatility better represents the uncertainty that foreign investors face. I use the approximate percentage change in the nominal exchange rate with the preferred model specification to obtain monthly volatility estimates. In order to calculate an annual estimate of the exchange rate volatility, I use the average monthly exchange rate to calculate a monthly volatility using GARCH and then take the average of the monthly volatility to calculate annual volatility. I use the approximate percentage change in the monthly nominal exchange rate and not the annual or quarterly values in order not to lose too much information in the data.

Example: Swedish Crown/Euro Exchange Rate

To illustrate this method more clearly, I use the exchange rate of the Swedish Crown to the Euro as an example. I take the average monthly Swedish Crown/Euro exchange rate shown in Figure 2.4 over the period from 1991 to 2013 and transform it into the approximate percentage change of the exchange rate by using the first difference of the natural logarithm of the exchange rate, shown in Figure 4.1. I use time periods before the start period of my regression in 1993 in order to be able to include lagged values of the exchange rate volatility. To this series (change in the krona-euro exchange rate), I apply the augmented

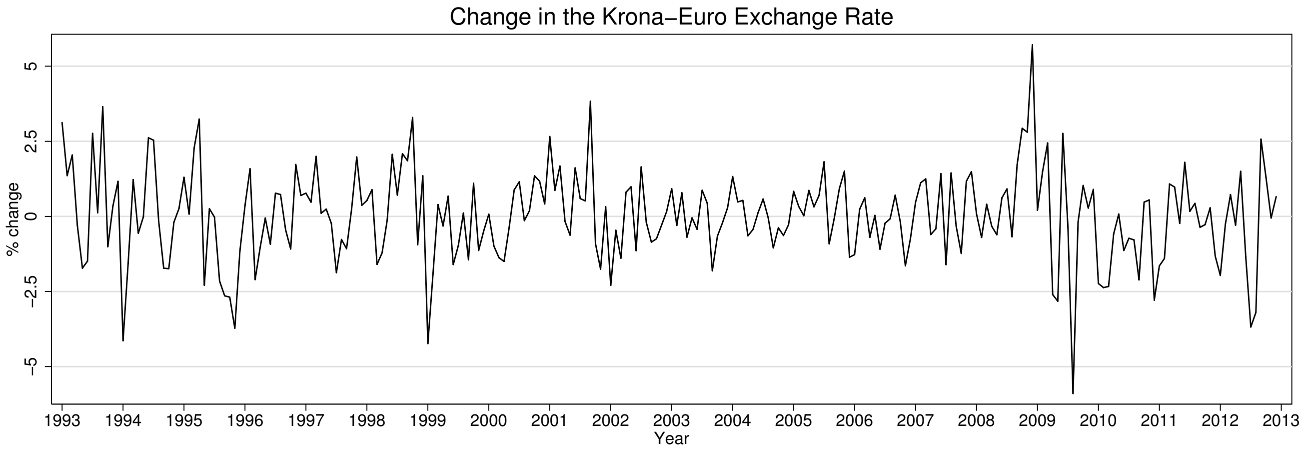


Figure 4.1: **Percentage change in the krona-euro exchange rate.**

Source: Author's illustration based on data by Riksbank

Dickey-Fuller test for unit roots and reject the null hypothesis that the variable contains a unit root at the 1% significance level. Since I am testing the first difference of the exchange rate, this is not very surprising. Nevertheless, this illustrates that it is necessary to take the first difference, because the null hypothesis cannot be rejected at the 10% level for the original variable (krona-euro exchange rate), suggesting that a unit-root process is present. Next, I apply the Box-Jenkins methodology where I determine the appropriate ARMA structure. Figure 4.2 shows the autocorrelation and partial autocorrelation of the change in the SEK/EUR exchange rate up to 20 lags (lines with markers) and 95% confidence bands (shaded area). We can see a spike in both the ACF and PACF for the first lag, as well as some minor spikes for later lags.

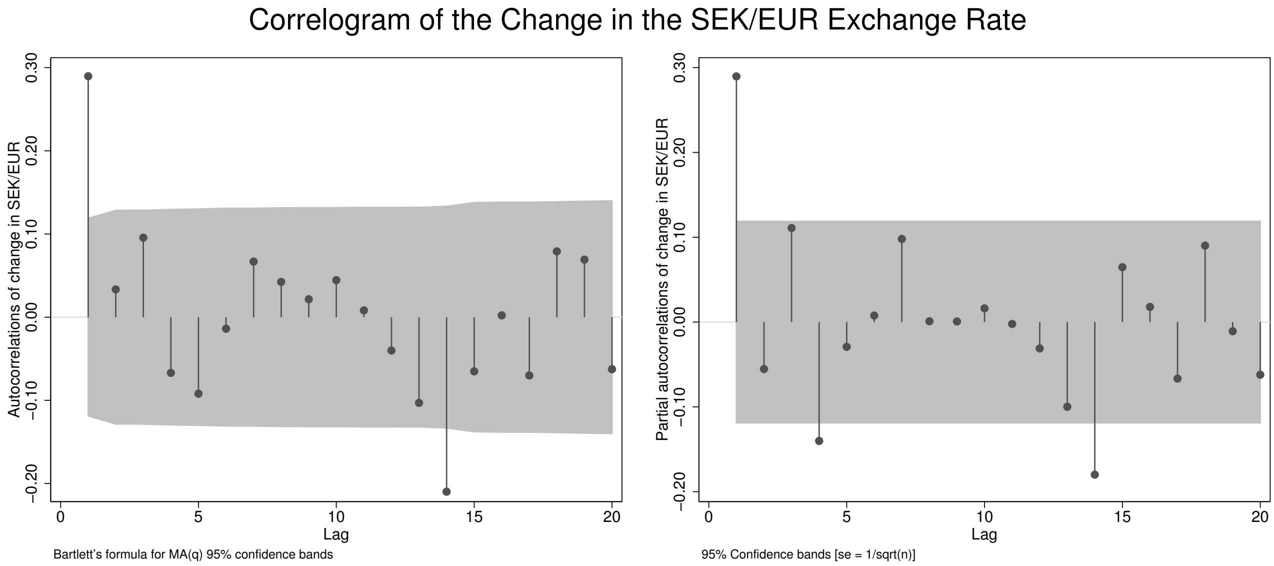


Figure 4.2: **Autocorrelation and partial autocorrelation of the change in the krona-euro exchange rate.**

Source: Author's illustration based on data by Riksbank

This suggests a possible ARMA(1,1) specification, which is then estimated and tested for white noise in the residuals. Table 4.1 shows the estimation results of the ARMA(1,1) specification and the results of the LB test. The estimated ARMA model in this case becomes:

$$y_t = c + \varepsilon_t + \zeta y_{t-1} + \theta\varepsilon_{t-1}.$$

We can see that the coefficients for the first lag of the AR term ($L.ar$) and the first lag of MA term $L.ma$ are statistically significant, which suggests that this is a fitting specification. In order to be certain that this ARMA specification is appropriate, I perform a LB test on the residuals. In this case I obtain a p-value of 0.2340 and thus cannot reject the null hypothesis that the residuals are independently distributed and conclude that ARMA(1,1) is an appropriate specification. Next, I find a fitting GARCH(p,q) specification by testing possible specifications and comparing their AICs and alternatively also their Bayesian Information Criterion (BIC) with the restriction that the specification needs to fulfil the aforementioned criteria mentioned. Table 4.2 shows the estimation results of a selection of GARCH(p,q) specifications and the corresponding AIC and BIC. The reported ARMA coefficents are the results of the ARMA(1,1) specification and the reported ARCH coefficients are the results of the different GARCH specifications, where $L.arch$ and $L2.arch$ are the estimates for the first and second lagged ARCH term respectively and $L.garch$ and $L2.garch$ are the estimates for the first and second lagged GARCH term respectively. GARCH(1,1) has the lowest AIC and BIC and the coefficient estimates meet all requirements. Thus, I conclude that GARCH(1,1) is the appropriate specification for the krona-euro exchange rate. The estimated GARCH model in this case is:

$$y_t = c + \varepsilon_t + \zeta y_{t-1} + \theta\varepsilon_{t-1}$$

Table 4.1: **SEK/EUR ARMA(1,1) regression and LB test output**

	dlnxrate	
ARMA		
L.ar	-0.271^{*}	(-1.89)
L.ma	0.587^{***}	(4.95)
LB-Statistic	46.12	
p-value	0.234	
Observations	272	

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Source: Author's calculations

$$Var(\varepsilon_t) = \sigma_t^2 = \omega_0 + \alpha\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2,$$

where the coefficient for $L.ar$ corresponds to ζ, the coefficient for $L.ma$ to θ, the coefficient for $L.arch$ to α, and the coefficient for $L.garch$ to β. I also test specifications with higher ARCH and GARCH terms, however, none of them outperform the specifications displayed here. It is also noteworthy that GARCH(2,1) and GARCH(2,2) are immediately disqualified (regardless of the AIC and BIC) because the coefficient estimates violate the previously mentioned requirements of being greater than zero. Finally,

Table 4.2: **Comparison of different GARCH(p,q) specifications for the krona-euro exchange rate**

	GARCH(1,0)	GARCH(1,1)	GARCH(1,2)	GARCH(2,0)	GARCH(2,1)	GARCH(2,2)
ARMA						
L.ar	-0.445^{***}	-0.411^{***}	-0.406^{**}	-0.447^{***}	-0.420^{**}	-0.456^{***}
	(-3.61)	(-2.62)	(-2.49)	(-3.61)	(-2.50)	(-3.06)
L.ma	0.735^{***}	0.699^{***}	0.690^{***}	0.757^{***}	0.692^{***}	0.731^{***}
	(8.86)	(6.30)	(5.87)	(10.24)	(5.62)	(6.99)
ARCH						
L.arch	0.443^{***}	0.308^{***}	0.319^{***}	0.303^{***}	0.359^{***}	0.358^{***}
	(4.45)	(4.79)	(4.49)	(4.34)	(4.41)	(4.77)
L2.arch				0.261^{***}	-0.183	-0.338^{***}
				(2.94)	(-1.26)	(-4.52)
L.garch		0.529^{***}	0.418		0.730^{***}	1.259^{***}
		(6.52)	(1.46)		(4.12)	(5.97)
L2.garch			0.0964			-0.285
			(0.39)			(-1.54)
AIC	-1539.0	-1547.4	-1545.5	-1546.8	-1546.1	-1544.6
BIC	-1521.0	-1525.7	-1520.3	-1525.2	-1520.8	-1515.8

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Source: Author's calculations

I test the chosen GARCH(1,1) specification with the LB test to see whether it is adequately fitting the time series and obtain a p-value of 0.17. Thus, I cannot reject the null hypothesis of constant mean and variance in the residual. Thus, I accept that this specification is appropriate. In conclusion, I fit the GARCH specification of the SEK/EUR exchange rate as a GARCH(1,1) model with ARMA(1,1). With this specification I now create the volatility series, which is displayed in Figure 4.3. Comparing Figure 4.1 and Figure 4.3 the interested reader can see that periods with relatively large exchange rate movements are also periods with a relatively high degree of volatility calculated by GARCH (1999, 2001-2002, and 2009-2010) and that periods with relatively low volatility estimates (2003-2007) are also characterized by less significant changes in the exchange rate. Graphs showing the volatility series of the exchange rates

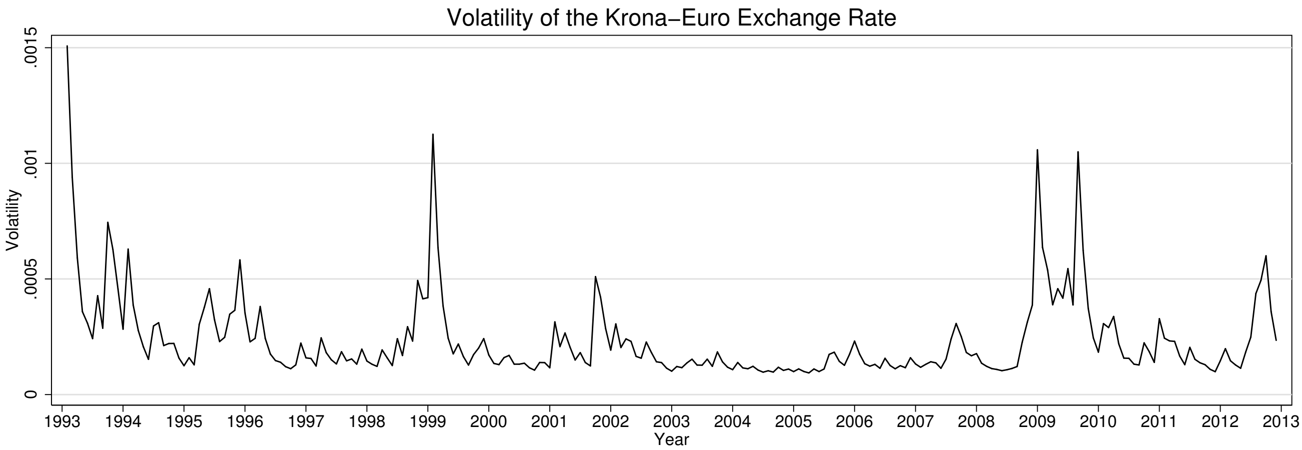


Figure 4.3: **Volatility of the SEK/EUR exchange rate.**

Source: Author's calculations

between Sweden and the other partner countries can be found in Figure 4.4. The chosen GARCH(p,q) specification is included in parentheses after the country name. The Stata .do file used to obtain all these results can be found in the Appendix: Stata Code *Garch.do*.

The sign of the possible effect of exchange rate volatility is uncertain and the focus of this study. I have laid out arguments for a positive as well as a negative effect. Together with the sign of the estimation, they are further investigated in Section 5.

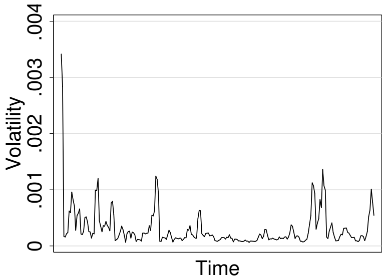
4.2.3 Real Exchange Rate

The real exchange rate (RER) takes into account the difference in price levels in the two countries. An appreciation of the real exchange rate means that the price of a bundle of goods in the foreign country, expressed in domestic currency, has risen. To obtain the level of the real exchange rate, I use the nominal exchange rate and apply equation (2.1) where national price levels are PPP conversion factor (GDP) to market exchange rate ratio.

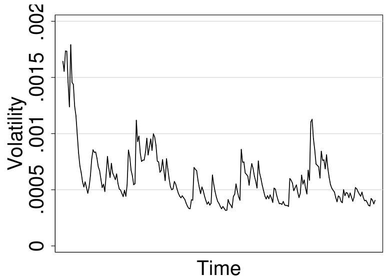
The sign that is associated with this relationship has been so far ambiguous in the literature, with arguments for a positive as well as a negative relationship. Because of this, it remains questionable what sign can be expected for this relationship.

4.2.4 GDP

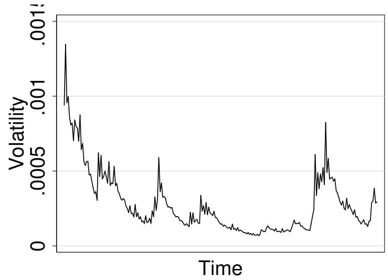
The data on gross domestic product (GDP_t^i) of partner country i at time t is accessed from OECD statistics and is denominated in million US$, seasonally adjusted, with a reference year of 2005 and fixed PPPs. The data is transformed into natural logarithms. Data from the OECD is supplemented with data



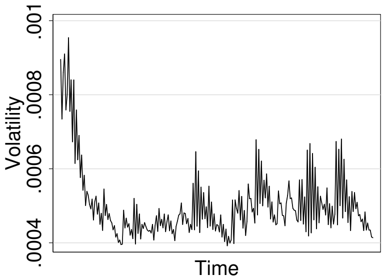
(i) **Austria (3,0).**



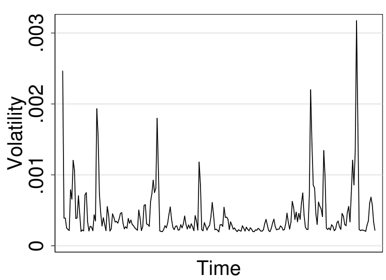
(ii) **Australia (1,1).**



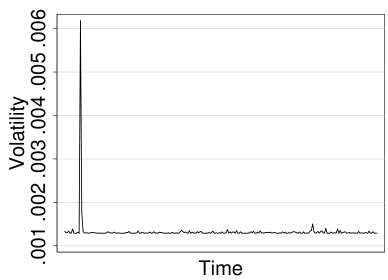
(iii) **Belgium & Luxem. (1,2).**



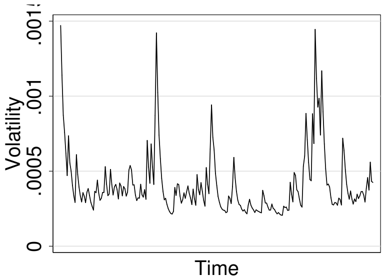
(iv) **Canada (1,2).**



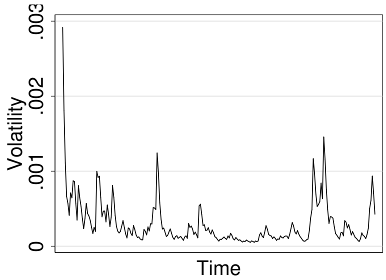
(v) **Switzerland (2,0).**



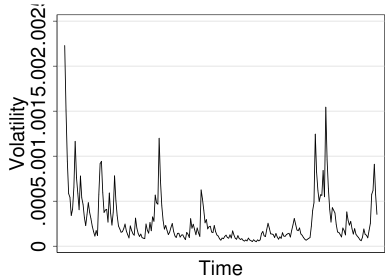
(vi) **China (1,0).**



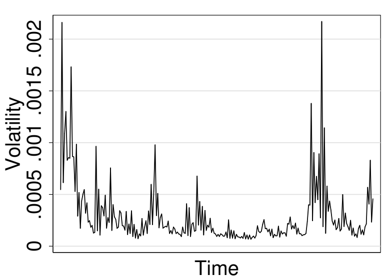
(vii) **Czech Republic (1,1).**



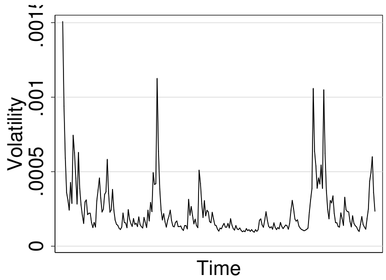
(viii) **Germany (2,1).**



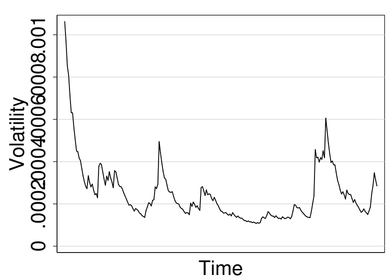
(ix) **Denmark (1,1).**



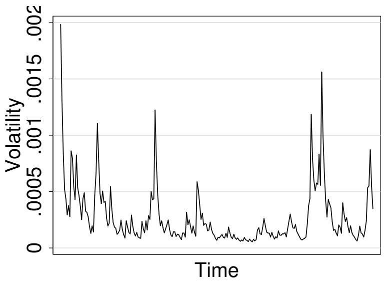
(x) **Spain (1,2).**



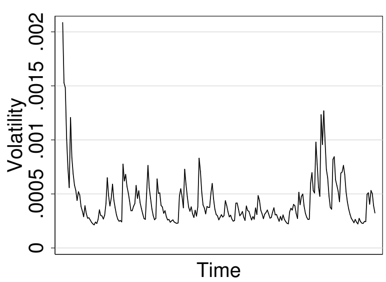
(xi) **Eurozone (1,1).**



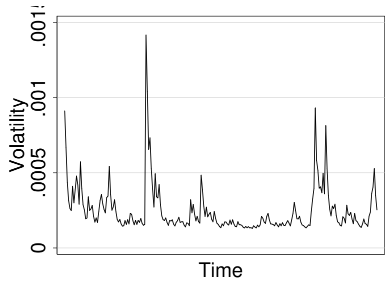
(xii) **Finland (1,1).**



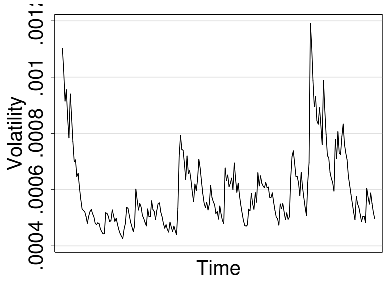
(xiii) **France (1,1).**



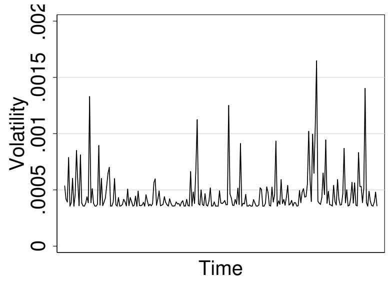
(xiv) **United Kingdom (1,1).**



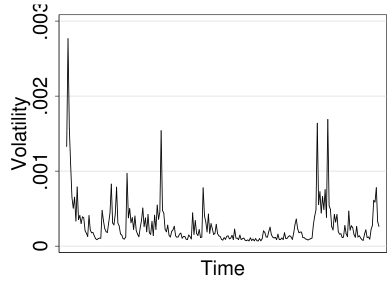
(xv) **Greece (1,1).**



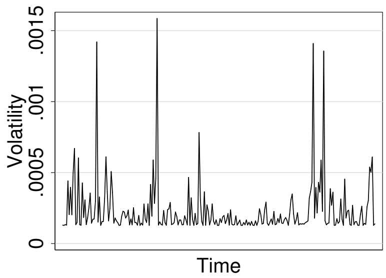
(xvi) **Hong Kong (1,1).**



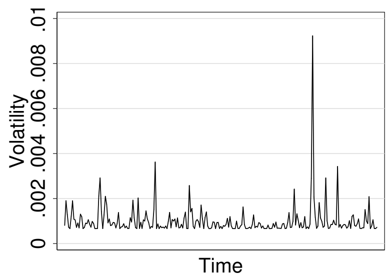
(xvii) **Hungary (1,0).**



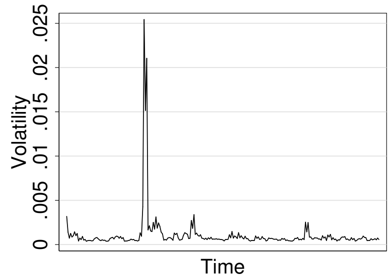
(xviii) **Ireland (1,2).**



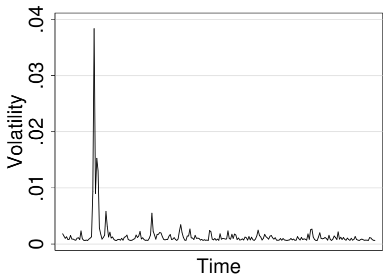
(xix) **Italy (1,0).**



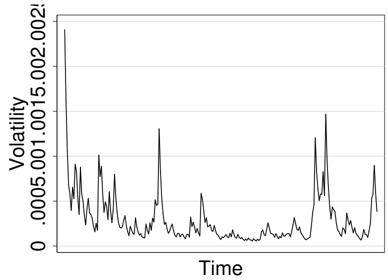
(xx) **Japan (1,0).**



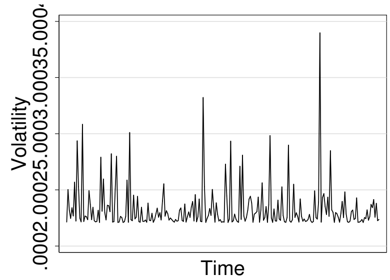
(xxi) **South Korea (3,0).**



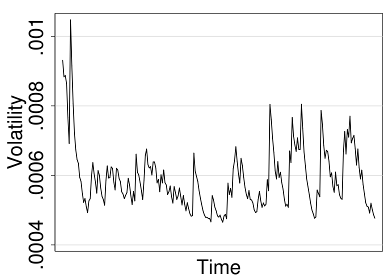
(xxii) **Mexico (1,1).**



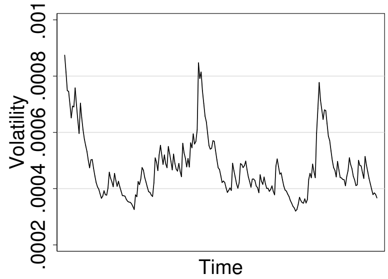
(xxiii) **the Netherlands (1,1).**



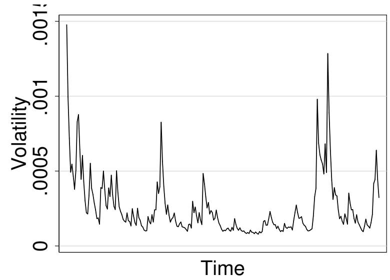
(xxiv) **Norway (1,0).**



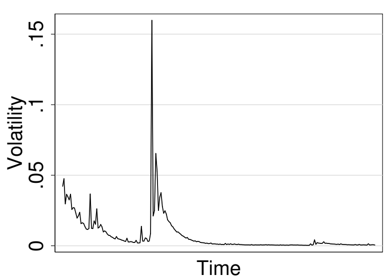
(xxv) **New Zealand (1,1).**



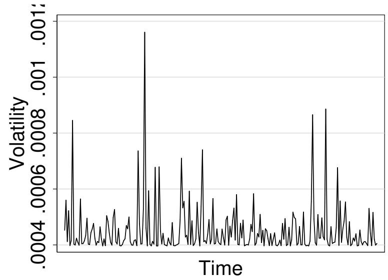
(xxvi) **Poland (1,1).**



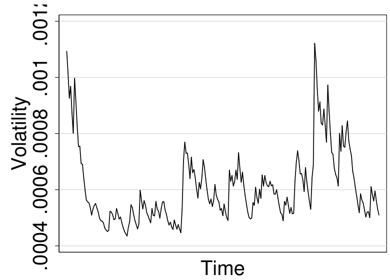
(xxvii) **Portugal (1,1).**



(xxviii) **Russia (1,4).**



(xxix) **Singapore (1,0).**



(xxx) **United States (1,1).**

Figure 4.4: **The volatility of the Swedish exchange rate to its partner countries with GARCH(p,q) specification.**

Source: Author's calculations

from the World Bank Indicators when necessary for China, Hong Kong, Russia, and Singapore. The data from both sources match each other closely and have the same adjustments: reference year 2005 and fixed PPPs.

I expect the estimation coefficient for GDP of home as well as GDP of host country to be positive since basic theory suggests that larger economies invest more in each other.

4.2.5 GDP per Capita

The data on GDP per capita is supplied from the OECD for most partner countries and supplemented with data from the World Bank Indicators for China, Hong Kong, Russia, and Singapore. The Data has the same adjustments from both sources with fixed PPPs and is denominated in 2005 US $.

$$GDP/capita_t^i = \frac{GDP_t^i}{Population_t^i} \tag{4.7}$$

I expect a positive coefficient estimate for GDP per capita because it indicates a higher sophistication of the firm, which is undertaking FDI. Furthermore, a more developed country is expected to attract more FDI (Head & Ries, 2008).

4.2.6 Squared Skill Difference

For all countries except China, the data on economically active population and occupation for the years 1991-2011 is taken from the International Labour Organization (ILO). In China's case, available observations were insufficient. To calculate the number of skilled to unskilled labour, I take the number of economically active people and multiply that by the percentage of people in the country with college and higher education levels, which is available through the National Bureau of Statistics of China (NBSC). I define skilled labour as labour engaged in managerial, professional, technical, and related workers, in line with Carr, Markusen, and Maskus (2001). The squared skill difference is then defined as the squared difference in the ratio of skilled to total labour between the parent and the host economy. Equation (4.8) shows this relationship at time t:

$$\left(skill\ difference_t^i\right)^2 = \left[\left(\frac{skilled}{total}\right)_t^{home} - \left(\frac{skilled}{total}\right)_t^{host}\right]^2, \tag{4.8}$$

where the squared skill difference between the parent and host economy at time t is equal to the squared difference in the ratio of skilled labour to total labour at time t. In order to supplement some missing observations, I take period averages where observations are missing.

I expect a positive coefficient estimate since one possible FDI motivation is to take advantage of different relative factor endowments – in this case the difference of the skilled labour endowments. Thus, the higher this difference is, the more firms should seek to take advantage of it through FDI – leading to increased FDI.

4.2.7 Regional Trade Agreements

The World Trade Organization (WTO) allows for countries to enter bilateral preferential trade agreements – also called regional trade agreements (RTA) – that allow for more favourable trading conditions between the partners than with other WTO members. Under WTO rules, a RTA can be categorised as one of the following types of bilateral agreement: a Free Trade Agreement, a Customs Union, an Economic Integration Act, or a Partial Scope Agreement (agreements that only cover certain products). At the beginning of the sample period, Sweden had active RTAs with 18 of the chosen partner countries, while it had active RTAs with 20 at the end of the sample period (WTO, 2013). I include a dummy variable that states whether the partner country is in a RTA with Sweden or not. Data on regional trade agreements are collected by the WTO and have been arranged by CEPII until 2006, after which I append the data with the most up-to-date data from the WTO. Equation (4.9) shows that the variable RTA_t^i is equal to 1 if a regional trade agreement is active in period t between the partner country i and Sweden, otherwise RTA_t^i is equal to 0.

$$RTA_t^i = 1, \tag{4.9}$$

otherwise

$$RTA_t^i = 0, \tag{4.10}$$

There are several aspects of regional trade agreements that can influence FDI flows. First, FDI that is export-substituting should be reduced by a regional trade agreement since such an agreement will remove barriers to trade. Second, FDI that seeks vertical integration will benefit from fewer trade restrictions since FDI and trade are compliments. Third, a side effect of countries belonging to a regional trade agreement is that these countries often make efforts to reduce other transaction costs (e.g. liberalizing capital flows), which would benefit FDI flows. Regional trade agreements can influence FDI flows either positively or negatively, depending on which feature dominates. Consequently, the question of which effect dominates should be answered empirically.

4.2.8 Descriptive Statistics

In this section, I present the descriptive statistics for all variables included in the empirical model. Table 4.3 shows the number of observations, mean, standard deviation, minimum, and maximum of all variables. RER differs depending on whether Sweden is the home or the host country, however, those variables are the same except the negative of them (i.e. $RER * -1$) which is thus excluded from the table below. The data for FDI are not available for all observations, and there is a more complete data set for outward FDI stock compared to inward FDI stock. The other variables have all observations available for all 29 countries for the entire period of 1993-2011 (19 years times 29 countries equals 551 observations) and the GDP variables have additional observations since data on Swedish GDP and GDP per capita is included (additional 19 observations).

Table 4.3: **Descriptive statistics: 1993-2011**

	Obs.	Mean	Standard deviation	Minimum	Maximum
Outward FDI Stock	482	6631.6	9739.6	-704.4	55609.5
Inward FDI Stock	418	6555.4	11627.0	-4433.7	65931.5
$\ln \sigma$	551	-7.784	0.836	-9.489	-3.402
$\ln RER$	551	2.168	2.257	-3.102	6.765
$\ln GDP^i$	570	13.20	1.228	11.11	16.44
$\ln GDP/capita$	570	10.09	0.541	7.318	10.89
RTA	551	0.642	0.480	0	1
$skill\ diff.^2$	551	0.0164	0.0307	$5.00e-10$	0.150

Source: Author's calculations

4.3 Diagnostics and Estimation Method

In this section, I present the reasoning for using the specific empirical method that I implement. The method used is as follows.

The panel is unbalanced, and the number of observations per panel for outward FDI stock range from 14 to 19 (19 being the full set) with an average of 16.6 observations, while the number of observations for inward FDI stock range from 7 to 19 with an average of 14.4 observations. A panel data analysis is appropriate since there is between as well as within country variation. See Figures A.1 and 4.4 to see variation between and within country for the dependent variable as well as for exchange rate volatility.

First of all, I inspect the data visually for normality using Q-Q plots (the variables quantiles plotted against a normal distributions quantiles) for the variables except regional trade agreements – which is binary and thus not normally distributed. The results can be found in the appendix in Figure A.2. The closer the plotted values lie to the line, the closer they are to being normally distributed. Not all the variables seem to follow a normal distributions very closely. The log transformed variables seem reasonably close to normally distributed, which does not entirely apply to the FDI variables (they seem to have skewed tails). This could be a potential source of bias.

Another possible concern is multicollinearity. To investigate this, I compile a correlation matrix which is shown in Table 4.4 for all control variables. The correlation coefficient for $\ln GDP/c$ and $skill\ diff^2$ is slightly higher than the rule of thumb of 0.6. This should not be an issue since the estimates for the effect of volatility would not be affected even if $\ln GDP/c$ and $skill\ diff^2$ are correlated. However, the variance in the coefficient estimates of the correlated variables may be large, resulting in insignificant estimates. The correlation coefficients for the variable of interest $\ln Vol$ are all low enough not to cause concern (Wooldridge, 2002b).

Table 4.4: **Matrix of estimated correlation coefficients**

	$\ln \sigma$	$\ln RER$	$\ln GDP^i$	$\ln GDP^{Swe}$	$\ln GDP/c^i$	RTA	$skill\ diff^2$
$\ln \sigma$	1.000						
$\ln RER$	−0.423	1.000					
$\ln GDP^i$	0.299	−0.158	1.000				
$\ln GDP^{Swe}$	−0.226	0.033	0.135	1.000			
$\ln GDP/c^i$	−0.494	0.513	−0.162	0.244	1.000		
RTA	−0.593	0.459	−0.318	0.036	0.165	1.000	
$skill\ diff^2$	0.491	−0.505	0.395	−0.011	−0.699	−0.347	1.000

rho coefficients

Source: Author's calculations

Since I am using panel data on 29 different countries over a 19-year time period, it is quite possible that there are unobservable individual μ_i and/or time-effects λ_t. When both effects are present, they can be modelled using so-called two-way error component models:

$$y_{it} = \alpha + \mathbf{X}_{it}\beta + u_{it} \qquad i = 1, \ldots, N;\ t = 1, \ldots, T$$

with

$$u_{it} = \mu_i + \lambda_t + v_{it},$$

where i denotes the individual (countries in this case), t denotes times, α is a scalar, β is $K \times 1$, X_{it}

is itth observation on K explanatory variables, μ_i is the unobservable individual-specific effect, λ_t is the unobservable time-specific effect, and v_{it} is the remainder disturbance. The individual effect is time-invariant and accounts for any individual-specific effect not included in the model, while the time effect is individual-invariant and accounts for any time-specific effect not included in the model. Depending on the underlying process, these models could be either fixed-effects FE or random-effects RE. In the case of the fixed-effects model, μ_i and λ_t are treated as unknown parameters that need to be estimated with a stochastic remainder disturbance. The random-effects model assumes that μ_i, λ_t, and v_{it} are random and independent of each other, as well as that $\mathbf{X}_{it}$ are independent of μ_i, λ_t, and v_{it} for all i and t (Baltagi, 2005). In order to investigate this possibility and other issues that potentially threaten the validity of the results, I first take a detailed look at the outward FDI model specification and then report the corresponding results for inward FDI.

The results for the hypothesis tests on the Swedish outward FDI stock regression can be found in Table 4.5. I begin by testing for individual-specific random and fixed-effects. Using the Breusch and Pagan Lagrangian multiplier $LM_{\mu\lambda}$ test for random-effects with $H_0 : \sigma^2_\mu = \sigma^2_\lambda = 0$, where σ^2_μ is the variance of the individual-effects and σ^2_λ is the variance of the time-effects. I reject the null hypothesis that the effects have a variance equal to zero, i.e. I find evidence for random individual or time-effects. Moreover, I find evidence for individual fixed-effects when performing an F-test F_μ with $H_0 : all\, \mu_i = 0$ on the fixed-effects regression, where I reject H_0. This means that random or fixed-effects are preferable to a standard OLS regressions. The question arises whether random-effects, which are more efficient than fixed-effects (if the random-effects assumptions are not violated), are more appropriate. Using Hausman's specification test H_{RE} with the null hypothesis $H_0 : E(u_{it}|X_{it}) = 0$ (the common effects are not correlated with the regressors), I reject the null (find that the common effects are correlated with the regressors). This suggests that random-effects would produce biased and inconsistent results and fixed-effects, which remove these common effects, are preferred. In addition, I test for time-specific effects using year dummies and testing their joint significance with a Breusch-Pagan Lagrangian multiplier (LM_λ) test with $H_0 : \sigma^2_\lambda = 0$, and do not reject the null hypothesis that they are jointly equal to zero, i.e. I do not find evidence for time-specific effects (Baltagi, 2005; Greene, 2012).

Since these tests suggest that a fixed-effects specification is preferable to random-effects or no individual-effects, I also consider a Hausman and Taylor (1981) instrumental variable estimator HT. The advantage of this technique is that it allows for some regressors to be correlated with the individual-effects in a random-effects specification. This could be preferable to a fixed-effects estimation since it allows for time-invariant regressors.[d]. In order to estimate the following model, Hausman and Taylor (1981) separate the explanatory variables according time-variance and correlated with μ_i:

$$y_{it} = \mathbf{X}_{1it}\beta_1 + \mathbf{X}_{2it}\beta_2 + \mathbf{Z}_{1i}\gamma_1 + \mathbf{Z}_{2i}\gamma_2 + \mu_i + v_{it},$$

where $\mathbf{X}_{1it}$ is a vector of time-varying exogenous variables (uncorrelated with μ_i and v_{it}), $\mathbf{X}_{2it}$ is a vector of time-varying endogenous variables (correlated with μ_i but not with v_{it}), $\mathbf{Z}_{1it}$ is a vector of time-invariant exogenous variables, and $\mathbf{Z}_{2it}$ is a vector of time-invariant endogenous variables. This equation is estimated with an instrumental variable approach using the within-panel mean of $\bar{\mathbf{X}}_{1it}$ and $\bar{\mathbf{X}}_{2it}$, the within transform of $\tilde{\mathbf{X}}_{1it}$ and $\tilde{\mathbf{X}}_{2it}$ (observations subtracted by the within-panel mean), and $\mathbf{Z}_{1i}$ as instruments. It is up to the econometrician to identify the variables that are likely correlated with the individual-effects through theory and over-identification tests. I suspect that the individual-effects are likely correlated with the GDP and GDP per capita of the partner country, squared skill difference, language proximity, and the volatility and level of the exchange rate as observed by Jeanneret (2006). Then, I compare the FE to the HT specification with another Hausman's specification test H_{HT}, where I do not reject the null hypothesis that there is a correlation between the included variables and the latent heterogeneity. This means I prefer the HT specification, which should be more efficient than FE. Next,

[d]I suspect that distance and language proximity are part of the appropriate model specification.

I test for other threats to validity (Baltagi, 2005; Greene, 2012).

Table 4.5: **Outward FDI stock: hypothesis tests**

	$LM_{\mu\lambda}$	F_{μ}	H_{RE}	LM_{λ}	H_{HT}	LR	CD	W
Test statistic	1428.054	33.489	24.634	0.778	0.198	1210.213	9.389	38.651
p-value	0.000	0.000	0.001	0.727	0.906	0.000	0.000	0.000

Source: Author's calculations

These model specifications assume that the regression errors are *homoskedastic* – normally distributed error terms with a constant mean – across time and panels. This is, however, not necessarily the case and can be an issue since assuming homoskedastic error terms, when they are in fact not i.e. *heteroskedastic*, will lead to inefficient estimates and biased standard errors. There are, however, strategies to deal with these problems (Baltagi, 2005). To test for panel-level heteroskedasticity in the form of non-constant conditional variance of the error terms across different groups of the sample at one point in time, I follow the test procedure outlined by Wiggins and Poi (2013) and conduct a likelihood-ratio (LR) test with the null hypothesis of no panel-level heteroskedasticity, in compliance with Schmidt and Broll (2009). The null hypothesis is rejected, indicating that cross-sectional heteroskedastic errors are present. Thereafter, I test for cross-sectional dependence of errors using the Pesaran (2004) cross-section dependence CD test with the null hypothesis that errors are uncorrelated between panels, and I find evidence for cross-sectional dependence. This means that the residuals are likely correlated across countries. Another aspect of heteroskedastic errors is possible serial correlation of the error term. An unobserved shock this period could affect the behavioural relationship for future periods. If serial correlation is ignored when present, it leads to inefficient estimate and biased standard errors (but still consistent estimates) (Baltagi, 2005). Following the procedure by Drukker (2003) for a serial correlation test in the idiosyncratic errors derived by Wooldridge (2002a) W with the null hypothesis of no first-order serial correlation. I reject the null hypothesis of no first order autocorrelation, suggesting the presence of serial correlation. In order to control for these forms of heteroskedasticity, I obtain standard errors for HT estimators that are robust to arbitrary autocorrelation and heteroskedasticity but not cross-sectional dependence – a source of inefficiency. I compare this to fixed-effects estimates obtained with Driscoll and Kraay (1998) standard errors DK that are robust to all observed irregularities of the error terms and naturally exclude time invariant variables. I compare these two estimates to check the robustness of the HT estimations and the results are presented in Table A.3 in the appendix. The estimated coefficients obtained with both methods are very similar, however, the estimated standard errors – and thus t-statistics – are not always close. It appears that cross-sectional dependence introduces a significant bias in the estimation of the standard errors for some variables. Because of this, I choose to estimate the model using pooled OLS with fixed-effects and Driscoll and Kraay (1998) adjusted standard errors. Unfortunately, this means that I cannot include time-invariant control variables (distance and language proximity). Their effects are now captured within the fixed-effects.

Similarly, I conduct the same test procedures on the specification with inward FDI stock. A summary of the hypothesis tests can be found in Table 4.6. In accordance with the same justifications as stated above, I choose the same estimation techniques for inward FDI stock (HT and DK). Comparing the estimates of the two estimation techniques (cf. Table A.3), I arrive at the same conclusion as for the outward FDI stock specification: a pooled OLS with fixed-effects and Driscoll and Kraay (1998) standard errors.

Table 4.6: **Inward FDI stock: hypothesis tests**

	$LM_{\mu\lambda}$	F_{μ}	H_{RE}	LM_{λ}	H_{HT}	LR	CD	W
Test statistic	853.265	18.690	18.777	0.884	1.761	1536.447	13.033	17.085
p-value	0.000	0.000	0.016	0.599	0.415	0.000	0.000	0.000

Source: Author's calculations

Thus, the estimated model for both specifications becomes:

$$FDI = \alpha\iota_{NT} + \mathbf{X}\beta + \mathbf{Z}_{\mu}\mu + v, \tag{4.11}$$

where α is a scalar, ι_{NT} is a vector of ones of dimension NT, $\mathbf{X}$ is the matrix of regressors, $\mathbf{Z}_{\mu}$ is the matrix of individual dummies, μ are the unobservable individual-specific effects, and v is the remainder disturbance (Baltagi, 2005).

5 Results and Analysis

In this paper, I empirically test the effect of exchange rate volatility on Swedish direct investment stock abroad and foreign direct investment stock in Sweden over the period 1993-2011 for 29 partner countries using Stata (StataCorp, 2011a). I estimate this effect by using a panel data fixed-effects approach with Driscoll and Kraay (1998) corrected standard errors implemented by Hoechle (2007).

Tables 5.1 and 5.2 show the results of the benchmark specification (1), including a time trend-volatility interaction term (2), including a time trend (3), and including both time trend and interaction term (4) for Swedish direct investment stock abroad and FDI stock in Sweden, respectively. The estimated coefficients are reported with t-statistics in parentheses and significance level indicated by one to three stars. The reported $R^2\,Within$ is obtained by fitting the mean deviated model where the effects of the groups are assumed to be fixed quantities. This means that the reported R^2 does not include the effect of the individual fixed-effects on the fit of the model but only that of the reported control variables. The number of panels (in this case countries) and number of observations are also reported.

I use a specification with a linear dependent variable and logged and linear independent variables. How the coefficient estimates can be interpreted depends on the type of variable. For a 1% increase in one of the logged variables, the difference in the expected mean FDI stock will be equal to $\beta * \ln(1.01)$. The dummy variable for regional trade agreements raises or lowers the intercept by the amount of its coefficient when its value is equal to one. A one unit increase of the squared control variable X at the mean $\bar{X}$ has an effect on FDI stock of $2 * \beta * \bar{X}$. The time trend coefficient can be interpreted as the amount of FDI stock that increased (decreased) at the absolute rate of $\beta * million\,US\$$. The interpretation of variables by themselves as well as in interaction terms (i.e. $\beta_1 X_1 + \beta_2 (X_1 * X_2)$) is less straightforward. Here the effect of X_1 is equal to $\beta_1 + \beta_2 * X_2$, i.e. the effect of X_1 varies with X_2. This means that a value for X_2 needs to be chosen in order to evaluate X_1. This could be either a value of interest or the mean of X_2 (Balli & Sorensen, 2012; Greene, 2012; Gujarati & Porter, 2009).

The reported R^2 of 0.38 indicates a relatively good fit for the model overall. The effect of exchange rate volatility is positive and significant in all specifications and the estimated coefficient of the benchmark specification of 1348.3 is significant at the 5% level. A 10% increase in the volatility is expected to increase the mean FDI stock by $1348.3 * \ln(1.10) = 128.5$. This means that the FDI stock evaluated at the mean will be approximately \$129 million higher, given a 10% increase in volatility. The effect of the real exchange is estimated to be negative but insignificant even at the 10% level, the negative result suggests that a depreciation ($RER \uparrow$) results in a reduction of FDI. Since the estimated result is insignificant, the evidence for this relationship is not very strong.[e] The estimated signs of the other control variables do not always match my expectations, however, they are mostly significant with the exception of squared skill differences. The GDP of the partner country has a negative and highly statistically significant effect on outward FDI. The size of the estimated effect indicates that with a 1% increase in GDP mean FDI stock is expected to decrease by \$219 million. The estimated signs of Swedish GDP and partner country GDP per capita exhibit the expected positive signs and are significant. A 1% increase in Swedish GDP is associated with an increase of \$365 million in mean FDI stock and a 1% increase in partner country GDP per capita is associated with a \$157 million increase. I also included Swedish GDP per capita as a control variable, however, the correlation between Swedish GDP and Swedish GDP per capita is very large, resulting in large standard errors. Both variables have positive coefficient estimates and, when included without the other, produce highly significant coefficient estimates. I include Swedish GDP in the specification and not Swedish GDP per capita on the account of the fact that the fit of the model, measured by $R^2 Within$, is better with Swedish GDP than GDP per capita. The estimation results for the

[e] Other measure of the exchange rate, such as nominal exchange rates ER, ΔRER, and ΔER, have also been tested with no change in the results.

Table 5.1: **Results of the regressions on outward FDI stock**

	(1)	(2)	(3)	(4)
$\ln \sigma$	1348.3**	1754.4***	897.2*	1900.7**
	(2.62)	(4.70)	(1.98)	(2.21)
$Trend * \ln \sigma$		−76.81**		−88.42
		(−2.22)		(−0.91)
$\ln RER$	−726.3	−1004.0	−817.6	−1028.7
	(−0.96)	(−1.51)	(−1.11)	(−1.66)
$\ln GDP^i$	−21979.3***	−26111.6***	−25538.9***	−26065.4***
	(−4.53)	(−4.05)	(−4.46)	(−4.16)
$\ln GDP^{SWE}$	36780.4***	15228.4	19263.1***	15272.0
	(18.34)	(1.61)	(3.64)	(1.63)
$\ln GDP/capita^i$	15874.9***	20639.6***	18950.5***	20780.1**
	(3.07)	(3.06)	(3.26)	(2.83)
$Skill\ Diff.^2$	−67419.8	−55270.3	−60101.9	−54813.1
	(−1.76)	(−1.62)	(−1.59)	(−1.67)
RTA	−3772.4***	−3400.7**	−3883.6***	−3323.6*
	(−3.35)	(−2.71)	(−3.38)	(−2.07)
$Time\ Trend$			510.9***	−96.28
			(3.24)	(−0.17)
R^2 *Within*	0.381	0.390	0.388	0.390
Countries	29	29	29	29
Observations	482	482	482	482

t statistics in parentheses
$^* \ p < 0.1$, $^{**} \ p < 0.05$, $^{***} \ p < 0.01$

Source: Author's calculations

other variables are not altered by this and the overall value of R^2 is only reduced by a negligible amount because of the exclusion of Swedish GDP per capita. The size of the effect of volatility is found to be of comparable size to the traditional FDI determinants included in this thesis. During the period of study, the average absolute percentage change per year of the exchange rate volatility measure was 46.5%, while partner country GDP changed on average by 3.6%, Swedish GDP by 3.4% and per capita GDP by 3.1%. Compared to the effects on mean FDI stock mentioned previously, this illustrates that volatility seems to have a significant impact. Squared skill difference has a negative sign and is insignificant. Regional trade agreements have a highly significant negative effect. This suggests that Swedish outward FDI is characterized by being a substitute and not a complement to trade. This could be the case when Swedish FDI is mainly export-substituting. This could also indicate market-seeking FDI which is expected to be partly motivated by high barriers to trade, which regional trade agreements aim to reduce. The size of this effect is approximately \$3.8 billion. In the other specifications, the coefficients of the control variables do not vary significantly (with the exception of squared skill difference, which becomes insignificant), suggesting that the benchmark specification is fairly robust.

The regression on inward FDI stock has a slightly higher R^2 of 0.4 and uses fewer observations due to fewer available data. The results of the coefficient estimates resemble the previous ones: the signs are unchanged and the significance levels are also similar. Exchange rate volatility has a positive and highly significant coefficient estimate of a similar size compared to outward FDI stock. A 10% increase in volatility is expected to result in an increase of the mean of inward FDI stock by approximately \$220 million. The real exchange rate has a negative but insignificant effect. The natural logarithm of the

Table 5.2: **Results of the regressions on inward FDI stock**

	(1)	(2)	(3)	(4)
$\ln \sigma$	2309.1***	2620.2***	2117.3**	4415.5**
	(3.10)	(3.81)	(2.87)	(2.52)
$Trend * \ln \sigma$		−61.63		−203.6
		(−1.64)		(−1.68)
$\ln RER$	−782.4	−523.9	−715.9	−302.4
	(−0.58)	(−0.39)	(−0.53)	(−0.22)
$\ln GDP^i$	−29603.7***	−33817.1***	−31545.1***	−32603.9***
	(−4.90)	(−4.41)	(−4.30)	(−4.23)
$\ln GDP^{SWE}$	56712.6***	39602.4***	49601.7***	40182.7***
	(19.35)	(3.82)	(5.92)	(3.44)
$\ln GDP/capita^i$	16674.7**	21035.2**	18189.0**	22563.0**
	(2.38)	(2.85)	(2.49)	(2.93)
Skill Diff.^{2}	−127695.9	−119233.3	−126464.7	−106664.2
	(−1.31)	(−1.22)	(−1.29)	(−1.09)
RTA	−4265.8***	−4113.9***	−4311.5***	−3506.8**
	(−4.26)	(−4.13)	(−4.28)	(−2.89)
Time Trend			211.0	−1186.9
			(0.83)	(−1.41)
R^2 *Within*	0.400	0.403	0.401	0.405
Countries	29	29	29	29
Observations	418	418	418	418

t statistics in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Source: Author's calculations

partner country's GDP has a negative and significant effect of a slightly larger size than for outward stock (a 1% increase in GDP decreases mean FDI stock by $295 million), Swedish GDP has a stronger positive and highly significant effect (a 1% increase is associated with a $564 million increased mean FDI stock), partner country GDP per capita is positive and statistically significant (a 1% increase leads to an increase of $165 million in mean stock), squared skill differences have an insignificant and negative impact, and regional trade agreements have a negative and significant effect (being in a trade agreement with Sweden is associated with a $4.3 billion lower FDI stock). The inclusion of a time trend and an interactive term with σ also do not change the estimates significantly, suggesting the specification is fairly robust. In Section 5.1, I take a deeper look at the robustness of the estimation and observe how sensitive the results are to the specific sample that I have chosen.

The positive effects of exchange rate volatility seem to suggest that real options model by Campa (1993) is not able to accurately describe the decision-making process of firm with regards to Swedish FDI. A possible explanation for this could be that not all the assumptions in the model are met. It is for example possible that the entry cost into the foreign market is not strictly sunk and firms are able to either sell it on exit or benefit from abroad. An example of sunk cost that are difficult to recover are marketing expenditures. If a firm continues to serve a market through exports after it has exited it, these would still be of value. Of course, this depends on the type of industry of the firm and the type of FDI motive. The framework provided by Lin et al. (2010) allows for the observed results. According to their model, I expect that Swedish FDI is dominated by export-substituting FDI or similar FDI motivations. This would also fit with the results obtained for regional trade agreements. It might also explain the insignificant impact of skill differences. Export-substituting FDI is not established in order to take advantage of lower production costs abroad but in order to be closer to the market that is being served.

The time trend and interaction term ($trend * \ln \sigma$) are included due to the possibility of trends, which have been present over the last two decades. Looking at Figures A.3 and A.4, two clear trends are apparent: average FDI stocks have a clear upwards trend and the average exchange rate volatilities have a downwards trend. This trend does not match up with the results on the effect of exchange rate volatility on FDI stocks. Moreover, it is unlikely that the increase in FDI stocks is only due to the positive trend in GDP and GDP per capita. Thus, there may be a time trend present that could influence the estimation of the effect of volatility. It seems unlikely that the effect of exchange rate volatility is constant over the whole period: MNEs have many tools for dealing with exchange rate uncertainty (i.e. hedging and other methods) and it stands to reason that the sophistication and availability of these tools increases over time as well as with the total amount of FDI. A way of testing for this possibly dynamic effect is to include an interaction term between exchange rate volatility and the time trend (Jeanneret, 2006).

The results of the inclusion of time effects suggest that the benchmark specification is quite robust as none of the results change drastically. Specification (3) shows evidence of a statistically significant positive time trend on outward FDI stock. The estimation results implies that about \$511 million of outward FDI stock are accumulated per year due to the time trend. The time trend-volatility interaction term $trend * \ln \sigma$ in specification (2) is significant and negative for outward FDI stocks. The effect of volatility now has to be interpreted in combination with time. Since the time trend is equal to zero in 1990 and increases one unit interval per year, in the initial period of the regression (1993) the effect of σ thus becomes $1754.4 - (76.81 * 3) = 1523.97$ (an increase of \$145 million at the mean of FDI stock for a 10% increase in σ), while in the last period (2011) the effect becomes $1754.4 - (76.81 * 21) = 141.39$ (an increase of \$13.5 million) significantly lower to the point where it is almost zero. Figure A.5 in the appendix illustrates this development. The effect of exchange rate volatility on outward FDI has drastically decreased over the sample period. This could indicate several things: a shift in the nature of Swedish direct investment, firms becoming more adapt at dealing with volatility, or that low-level volatility is less influential than high levels (although a squared volatility term did not produce significant results). There are no such trends observed for inward FDI stock. Specification (4) may seem suspect at first glance because of the change in the estimated sign of the time trend when it is included with the interaction term. However, the effect of the time trend depends on volatility in this specification and the estimated effect of the time trend is still positive when it is evaluated at the mean of $\ln \sigma$ -7.784. The time trend and interacted effects become insignificant for both regressions (Balli & Sorensen, 2012).

I also consider lags and leads of the exchange rate volatility, as well as the exchange rate volatility of other major currencies.[f] The interesting results from these experiments are shown in Table 5.3. For inward FDI stock, a lead of volatility for one year is positive and statistically significant, without altering the effects of exchange rate volatility in the current year significantly. This implies perfect forecast expectations of the economic agents of the level of volatility. The ability of economic agents to perfectly forecast the level of volatility is not assumed and is not necessary to interpret the estimated results. Forecasts only need to be accurate enough to be similar to the realized volatility. Interestingly, this effect is only significant for inward FDI stock. This could suggest that either foreign firms are able to forecast volatility more accurately or that they are interested in a longer-term engagement in Sweden compared to the interests of Swedish firms abroad. Similarly, Campa (1993) finds evidence that perfectly forecast volatility is related to current behaviour. Specifications (2) and (3) of Table 5.3 show the volatility of the krona-pound and krona-dollar exchange rate, respectively. Both have a more significantly positive – and larger – effect than the volatility with the given partner country on outward FDI. Swedish firms seem to allocate a higher amount of FDI in non-US and non-UK countries as a response to an increase in the krona-dollar and

[f] I also test for effects of the volatility of krona with US dollar, British pound, and euro, while excluding the corresponding countries (USA, GBR, Eurozone) from the regression.

Table 5.3: **Results of the regressions with other interesting variables**

	Inward	Outward	
	(1)	(2)	(3)
$\ln \sigma$	1908.3**	799.2	643.2*
	(2.37)	(1.80)	(2.01)
$\ln \sigma_{1\ year\ lead}$	992.1***		
	(3.66)		
σ_{USD}			2792.3*
			(2.11)
σ_{GBP}		1602.9*	
		(1.88)	
$\ln RER^{home}$		−1038.0	404.3
		(−1.31)	(0.77)
$\ln RER^{host}$	−700.7		
	(−0.49)		
$\ln GDP^{i}$	−30357.7***	−20921.6***	−35267.5***
	(−5.26)	(−4.02)	(−5.10)
$\ln GDP^{SWE}$	56376.4***	35831.1***	32466.5***
	(20.55)	(17.50)	(16.76)
$\ln GDP/capita^{i}$	17863.2**	14060.3**	30554.9***
	(2.69)	(2.63)	(3.98)
$Skill\ Diff.^2$	−122055.3	−59114.6	−100243.6**
	(−1.23)	(−1.60)	(−2.63)
RTA	−4228.0***	−3704.6***	−2066.3*
	(−4.12)	(−3.25)	(−2.12)
R^2 *Within*	0.402	0.359	0.386
Countries	29	28	28
Observations	418	463	463

t statistics in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Source: Author's calculations

krona-pound volatility, respectively. This effect is less certain with the krona-pound volatility because of the reduced significance in $\ln \sigma$. This could indicate that Swedish firms view locating in other markets as a substitute for locating in the US or the UK. Since the US is the largest economy (and the largest recipient of Swedish direct investment) and the dollar is the dominant currency in the world, it is not very surprising that the krona-dollar volatility affects other markets as well. This coefficient could also capture some effects from the volatility in the price of dollar-priced raw materials.

I find strong evidence for a positive effect of volatility on FDI stock in the Swedish case, although there is some evidence that the effect on Swedish outward FDI might not persist. These results are contradictory to the theoretical model outlined by Campa (1993) but can be explained within the framework set up by Lin et al. (2010). A positive relationship is expected when export-substituting firms dominate Swedish FDI. Are these results desirable from a Swedish policy point of view? To give a thorough answer to this is beyond the scope of this thesis, however, it is not pointless to briefly consider it. If the goal is to reduce outward FDI in order to keep Swedish capital and production on Swedish soil, it might be possible to enact policies that accomplish this (Stevens & Lipsey, 1992). This would naturally also affect inward FDI, which might be desirable in order to keep the control of Swedish firms in Swedish hands.

Possibilities are monetary policies that reduce fluctuations in the fundamentals, which determine the exchange rate, and regulations that reduce fluctuations arising from financial markets. Alternatively, the exchange rate could be fixed against a basket of international currencies (Galí & Monacelli, 2005). Such policies are likely to have further reaching implications and how well they would work to reduce exchange rate volatility is questionable. Moreover, there is no clear reasoning that outward FDI necessarily means less investment and production in Sweden. Herzer (2008) establishes empirical evidence that outward FDI actually benefits the home economy in the long run. The alternative (promoting FDI by inducing a higher exchange rate volatility) seems inadvisable. The positive effect could be interpreted as an argument that policy makers do not need to worry about the effects of exchange rate volatility in regards to Swedish MNEs and foreign MNEs in Sweden. It appears that volatility is not a hindrance to FDI and that investing abroad is one technique to cope with it.

A remaining concern is the very significant and negative estimated effect of partner country GDP in the regressions on both inward and outward FDI. It is contrary to both theory and expectation, however, there are several possible explanations for this. Outward FDI could be influenced by firms' FDI motives, which cannot be argued for foreign MNEs in the same way. A likely reason for the negative estimate for both inward and outward FDI lies in the nature of the unbalanced data set and the chosen sample. Omitted variable bias is also a possibility as well as possible endogeneity. Swedish MNEs might be attracted to markets with lower GDP due to the factors that are correlated with GDP and incentivize certain types of FDI e.g. vertical integration. Lowered GDP could be correlated with lower wages, lower inflation, and lower capital costs. Considering the sample mostly consisting of developed – and EU member – countries, it could be that Swedish firms enter countries when GDP is relatively low to take advantage of the low prices and to be able to serve a bigger market regardless of the size of the host country. However, this argumentation does not seem applicable to the case of inward FDI and I suspect an econometric explanation. The following section deals with the robustness of the regression to changes in the sampled countries and time period. It also gives some idea how the effect of partner country GDP could obtain an implausible significant estimate.

5.1 Robustness and Sensitivity Analysis

Due to the fact that a significant amount of observations is missing over the period – especially for inward FDI stock – and that the regression results do not entirely conform to theory, it is important to see whether the results are only valid for the chosen sample and period or if they are robust to some specification changes. I report the results of four robustness checks in Tables A.4 and A.5 for outward and inward FDI stock, respectively. Specification (1) is the benchmark model, (2) only spans the period between 1993 and 2000, (3) only spans the period between 2000 and 2011, (4) only includes high-income countries defined by a GDP per capita of more than $20,000,[g] and (5) only includes countries that have at least 75% of observations (15) per panel.[h]

These tests shed light on some possible explanations for the sign of partner country GDP coefficient. The coefficient is not consistent across the different specifications and becomes positive in specification (2) for outward FDI and in (2) and (5) for inward FDI. This suggest that there are indeed problems in estimating the appropriate effect of partner country GDP. In the case of inward FDI, this suggests that the nature of the censored unbalanced panel is responsible for the unexpected result. What is encouraging is, however,

[g]The lower income countries are China, Czech Republic, Greece (1993-1999) Hungary, Ireland (1993-1994), Mexico, New Zealand (1993-1994), Poland, Portugal (1993-1998), Russia, and South Korea (1993-2001).

[h]The data scarce countries for outward FDI are Czech Republic, Greece, Hong Kong, Hungary, South Korea, New Zealand, Russia. For inward FDI, the data scarce countries are Australia, Austria, Canada, China, Czech Republic, Greece, Hong Kong, Hungary, Ireland, Italy, Japan, Mexico, New Zealand, Poland, Portugal, Russia, Singapore, South Korea, and Spain.

that this seems to only affect partner country GDP and not exchange rate volatility. The size of the effect of volatility is drastically increased in specification (5) for inward FDI but this does not change the conclusions of the previous analysis.

In specification (2) and (3), I test how robust the results are by limiting the period to the 1990s and 2000s, respectively. For outward FDI stock, this supports the inference from the volatility-time interaction term. In the 1990s, the effect is positive and significant, while it is insignificant in the 2000s. Moreover, the coefficient estimate for $\ln GDP/capita^i$ becomes insignificant. This could be due to the fewer observations available, raising standard errors. The results for $\ln RER$ and $skill\ diff.^2$ are not consistent and this could suggest that their relationship changes over time. For inward stocks, neither coefficient estimates nor standard errors change significantly. The other robustness test (using only high income countries with a GDP per capita higher than \$20,000 (4), and only countries with at least 75% of observations (5)) do not result in surprising results for either outward or inward stocks. Specification (5) for inward FDI excludes RTA from the regression because the variable has become time-invariant. The main reassuring result of the sensitivity analysis is that the estimation of the σ coefficient and its standard errors seem robust.

6 Conclusions

In this thesis, I empirically test the effect of exchange rate volatility on Swedish direct investment abroad as well as foreign direct investment in Sweden with 29 partner countries using annual data for the period 1993-2011. I obtain strong evidence for a positive effect of exchange rate volatility on both inward and outward FDI. In the case of outward FDI, there is evidence that this effect is becoming weaker and less significant. The regressions prove robust to a variety of experimentation, even though the negative and significant estimate for partner country GDP is unexpected and likely due to censoring of the data.

The result that exchange rate volatility encourages FDI may seem counter-intuitive in light of the fact that multinationals in general would certainly prefer less uncertainty in their business. However, this reflects that motivations to engage in FDI are diverse and FDI is often used to deal with the imperfections and barriers present in international markets.

This either suggests that firms with different FDI motives were similarly (positively) affected over the investigated period, or that, on an aggregate level, firms that expand FDI in response to increased exchange rate volatility dominate Swedish bilateral FDI relationships.

I also find some evidence that future exchange rate volatility affects foreign firms considering direct investments in Sweden and that Swedish firms consider the volatility between the krona and other currencies (the dollar and weaker evidence for the pound) when making investment decisions.

Sweden is a small open economy, heavily integrated into international markets through foreign direct investment relationships, which could influence the way aggregate FDI stocks develop. This also makes it more important for Sweden, in comparison to other countries, to understand the processes underlying FDI developments since they can have a substantial impact on the Swedish economy. The results of this thesis do not lend themselves to a clear policy recommendation as it is important to consider in which way FDI and the Swedish economy interact. Does outward FDI replace economic activity within Sweden or does it act as a complement?

Some caveats remain to be kept in mind when interpreting my results. Firstly, despite the effort to control for the most important and consistently good predictors of FDI, the chosen set of control variables do not perform as well as hoped. Thus, it is still possible that the results are driven by a factor correlated with the exchange rate volatility. Secondly, the unbalanced and censored nature of the data is likely an issue resulting in the unexpected result for partner country GDP. The not entirely normal distributed FDI variables could also introduce some bias. Even though it does not seem to affect the estimates on exchange rate volatility, it is, nevertheless a possibility. Thirdly, it could be problematic to aggregate data for the whole economy when theoretical approaches deal with firm incentives. It is plausible that different sectors of the economy respond differently to exchange rate volatility, which is one possible source of the ambiguous results of empirical studies (Phillips & Ahmadi-Esfahani, 2008). Fourthly, the chosen proxy for exchange rate uncertainty models volatility conditional on past a series' past behaviours and it should be kept in mind that this is based on assumptions about the memory and foresight of the agents in the economy. It is not certain whether surveys on the perception of uncertainty and volatility of the exchange rate match the volatility measures used in the empirical work. These caveats provide a jumping off point for further analysis.

6.1 Suggestions for Further Studies

Future research should analyse the relationship between aggregate and disaggregate firm behaviour in light of exchange rate volatility. This should become increasingly possible with the establishment of better and more comparable FDI statistics, which will also serve to reduce influences from censored and unbalanced data sets. In addition, these type of studies should be complemented by investigation into how accurate the underlying assumptions about firm behaviour are. How do firms perceive exchange rate volatility and the underlying uncertainty? How good are they at predicting future levels of volatility and do they take these predictions into account in the present? What is the extent and impact of hedging?

Another interesting aspect is the question whether the influence of volatility changes over time and, if so, due to what factors. The effect could change due to changes in the composition of FDI or because firms are changing how they view or deal with volatility. It is also of interest to further expand the research on interdependent FDI decisions between different destinations. Depending on the FDI motive this could further reveal how MNEs react to volatility. Exchange rate developments of other currencies could have an impact as well.

Another important aspect that is part of theoretical models but is difficult to study in practice is the trade-off between engaging in international transactions through trade and FDI. In this thesis, I gather some evidence that suggests an export-substituting motive for a significant amount of Swedish FDI. It could be a useful addition to include trade into models of FDI determinants in order to better understand what the trade-offs between trade and FDI with respect to volatility are.

The importance and scope of foreign direct investment is likely to increase even further in the near future and this makes it important for policy makers to increase their knowledge about them. To be able to shape the development of FDI through policy it is of interest how it acts on an aggregate level.

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Appendix: Background

Table A.1: **Summary of previous empirical studies**

Author/s (Year)	Period	Type	Countries	Dependent Var.	ER σ Proxy	ER σ	Other Variables: RER	ER	Expected ER	GDP	ΔGDP	GDP σ	GDP Host	Inflation	Trend	Trade Openness	Interest Rate	Labour Cost	Distance
Amuedo-Dorantes and Pozo (2001)	1976:1-1998:3	Quarterly, panel	into USA	Δ in $\frac{FDI}{GDP}$	GARCH & MASD	$-^*$ & $+$	$-$												
Bénassy-Quéré et al. (2001)	1984-1996	Annual, bilateral, panel	17 OECD countries to 42 developing countries	log of stock of FDI	CV of quarterly ER	$-^*$	$+^*$									$+^*$			$-^*$
Campa (1993)	1981-1987	Annual, panel, industry	USA from countries	# of firms entering the market	MASD of monthly Δ log ER	$-^*$		$+^*$							$-$			$-$	
Crowley and Lee (2003)	1980-1998	Quarterly, bilateral, time-series & panel	USA to AUS, AUT, BEL, CAN, DEU, DNK, ESP, FIN, FRA, GBR, ITA, JPN, KOR, MEX, NLD, NZL, PRT, and SWE	Δ log of FDI	GARCH	$-^*$ (8/18)		$-$			$+^*$	$\pm^*$							
Cushman (1985)	1963-1978	Annual, bilateral, panel	USA to GBR, FRA, DEU, CAN, and JPN	Δ in DI	MASD of quarterly RER	$+^*$	$\pm$		$-^*$								$\pm$		

Author/s (Year)	Period	Type	Countries	Dependent Var.	ER σ Proxy	ER σ	Other Variables: RER	ER	Expected ER	GDP	ΔGDP	GDP σ	GDP Host	Inflation	Trend	Trade Openness	Interest Rate	Labour Cost	Distance
Cushman (1988)	1963-1986	Annual, bilateral, panel	Into USA from GBR, FRA, DEU, CAN, and JPN	Δ in DI	MASD of quarterly ER	$+^*$			$-^*$				$+^*$				$\pm$		
de Ménil (1999)	1984-1994	Quarterly, bilateral	OECD member countries	FDI flows	MASD of annual ΔRER	$+^*$				$+^*$			$+^*$						$-^*$
De Vita and Abbott (2007)	1975-2001	Annual, bilateral, sector	GBR from AUS, CHF, DEU, FRA, JPN, NLD, and USA	log of net FDI	GARCH	$-^*$	$+^*$				$+^*$					$\pm$	$+^+$		$+^*$
di Giovanni (2005)	1990-1999	Annual, bilateral, panel	Panel data set consisting of 193 countries	log of M&A	MASD of monthly ΔER	$+^*$	$-^*$			$+$						$\pm$			
Goldberg (1993)	1970:1-1989:4	Quarterly, sectoral	31 industries in USA	log of investment	MASD of quarterly RER	$\pm$	$\pm^*$			$+^*$	$-$						$\pm$		
Goldberg and Kolstad (1995)	1978:1-1991:4	Quarterly, bilateral	USA flows to CAN, GBR, and JPN	FDI/total investment	MASD of of quarterly RER	$+^*$	$-$				$+$	$\pm$	$\pm^*$						
Görg and Wakelin (2002)	1983-1995	Annual, bilateral, panel	USA to/from CAN, CHF, DEU, ESP, FRA, GBR, HKG, ITA, JPN, KOR, SGP, and SWE	Sales by multinationals in the host country	MASD of monthly Δ log ER	$+$		$-^*$		$+^*$			$+^*$		$\pm$		$-^*$	$-$	$-$

Author/s (Year)	Period	Type	Countries	Dependent Var.	ER σ Proxy	ER σ	Other Variables: RER	ER	Expected ER	GDP	ΔGDP	GDP σ	GDP Host	Inflation	Trend	Trade Openness	Interest Rate	Labour Cost	Distance
Jeanneret (2006)	1982-2002	Annual, bilateral, panel	28 OECD countries	log of FDI flow	MASD of Δ ER	$-$				$+^*$			$+^*$			$+^*$			$-$
Kiyota and Urata (2004)	1990-2000	Annual, bilateral & industry, panel	JPN to 127 countries.	log of $\frac{FDI}{GDP}$	Variance of unexplained RER	$-^*$	$+^*$								$-^*$				
Kumarasamy and Velan (2011)	1996:2-2010:1	Quarterly, panel	IND from unspecified	FDI	GARCH, MASD, and HP	$-^*$	$-$			$+^*$				$-^*$		$-^*$			
Lin et al. (2010)	1987-2002	Annual, firm	TWN to CHN	rate of investment of MNE	GARCH	$\pm^+$	$-^*$												
Pain and Van Welsum (2003)	1972-2000	Annual, bilateral, panel	CAN, DEU, FRA, GBR, ITA, and USA	Δ in $\frac{FDI}{GDP}$	Δ SD of quarterly RER	$+^*$	$-$												
Ricci (2006)	1977-1997	Annual, panel	17 OECD countries	$\frac{FDI}{GDP}$	MASD of Δ ER	$\pm^*$										$+$		$-$	
Russ (2012)	1986-2005	Annual, bilateral, panel	28 OECD countries	log of # new M&As	MASD of Δ short-term interest	$\pm^+$													

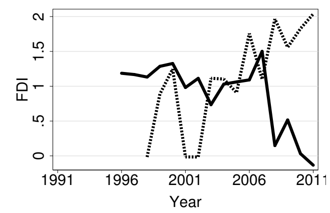
Author/s (Year)	Period	Type	Countries	Dependent Var.	ER σ Proxy	ER σ	Other Variables: RER	ER	Expected ER	GDP	ΔGDP	GDP σ	GDP Host	Inflation	Trend	Trade Openness	Interest Rate	Labour Cost	Distance
Schmidt and Broll (2009)	1983-2004	Annual, industry	USA to CAN, DEU, FRA, GBR, ITA, and JPN	$\frac{FDI}{GDP}$	MASD of annual ΔRER & Variance of unexplained RER	$-^{*}$ & $\pm^{*}$	$+^{*}$		$\pm$						$+^{*}$		$-^{*}$	$+^{*}$	
Urata and Kawai (2000)	1980-1994	Annual, industry	JPN to 117 countries	# of firms	CV of ER	$-^{*}$		$\pm$					$+^{*}$	$-$					

* indicates statistic significance in the majority of specifications reported in the paper, country codes can be found in Table A.2

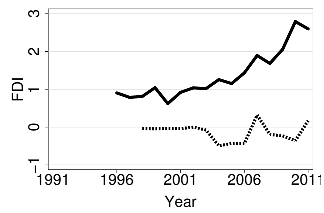
Table A.2: **ISO-3166-1 alpha-3 code for each country**

ISO	Name	ISO	Name	ISO	Name
ABW	Aruba	GIB	Gibraltar	NLD	Netherlands
AFG	Afghanistan	GIN	Guinea	NOR	Norway
AGO	Angola	GLP	Guadeloupe	NPL	Nepal
AIA	Anguilla	GMB	Gambia	NRU	Nauru
ALA	Aland Islands	GNB	Guinea-Bissau	NZL	New Zealand
ALB	Albania	GNQ	Equatorial Guinea	OMN	Oman
AND	Andorra	GRC	Greece	PAK	Pakistan
ARE	United Arab Emirates	GRD	Grenada	PAN	Panama
ARG	Argentina	GRL	Greenland	PCN	Pitcairn
ARM	Armenia	GTM	Guatemala	PER	Peru
ASM	American Samoa	GUF	French Guiana	PHL	Philippines
ATA	Antarctica	GUM	Guam	PLW	Palau
ATF	French Southern Territories	GUY	Guyana	PNG	Papua New Guinea
ATG	Antigua and Barbuda	HKG	Hong Kong	POL	Poland
AUS	Australia	HMD	Heard Island and McDonald Islands	PRI	Puerto Rico
AUT	Austria	HND	Honduras	PRK	Korea, Democratic People's Republic of
AZE	Azerbaijan	HRV	Croatia	PRT	Portugal
BDI	Burundi	HTI	Haiti	PRY	Paraguay
BEL	Belgium	HUN	Hungary	PSE	Palestine, State of
BEN	Benin	IDN	Indonesia	PYF	French Polynesia
BES	Bonaire, Sint Eustatius and Saba	IMN	Isle of Man	QAT	Qatar
BFA	Burkina Faso	IND	India	REU	RÈunion
BGD	Bangladesh	IOT	British Indian Ocean Territory	ROU	Romania
BGR	Bulgaria	IRL	Ireland	RUS	Russian Federation
BHR	Bahrain	IRN	Iran, Islamic Republic of	RWA	Rwanda
BHS	Bahamas	IRQ	Iraq	SAU	Saudi Arabia
BIH	Bosnia and Herzegovina	ISL	Iceland	SDN	Sudan
BLM	Saint BarthÈlemy	ISR	Israel	SEN	Senegal
BLR	Belarus	ITA	Italy	SGP	Singapore
BLZ	Belize	JAM	Jamaica	SGS	South Georgia and the South Sandwich Islands
BMU	Bermuda	JEY	Jersey	SHN	Saint Helena, Ascension and Tristan da Cunha
BOL	Bolivia, Plurinational State of	JOR	Jordan	SJM	Svalbard and Jan Mayen
BRA	Brazil	JPN	Japan	SLB	Solomon Islands
BRB	Barbados	KAZ	Kazakhstan	SLE	Sierra Leone
BRN	Brunei Darussalam	KEN	Kenya	SLV	El Salvador
BTN	Bhutan	KGZ	Kyrgyzstan	SMR	San Marino
BVT	Bouvet Island	KHM	Cambodia	SOM	Somalia
BWA	Botswana	KIR	Kiribati	SPM	Saint Pierre and Miquelon
CAF	Central African Republic	KNA	Saint Kitts and Nevis	SRB	Serbia
CAN	Canada	KOR	Korea, Republic of	SSD	South Sudan
CCK	Cocos (Keeling) Islands	KWT	Kuwait	STP	Sao Tome and Principe
CHE	Switzerland	LAO	Lao People's Democratic Republic	SUR	Suriname
CHL	Chile	LBN	Lebanon	SVK	Slovakia
CHN	China	LBR	Liberia	SVN	Slovenia
CIV	Cote d'Ivoire	LBY	Libya	SWE	Sweden
CMR	Cameroon	LCA	Saint Lucia	SWZ	Swaziland
COD	Congo, the Democratic Republic of the	LIE	Liechtenstein	SXM	Sint Maarten (Dutch part)
COG	Congo	LKA	Sri Lanka	SYC	Seychelles
COK	Cook Islands	LSO	Lesotho	SYR	Syrian Arab Republic
COL	Colombia	LTU	Lithuania	TCA	Turks and Caicos Islands
COM	Comoros	LUX	Luxembourg	TCD	Chad
CPV	Cape Verde	LVA	Latvia	TGO	Togo
CRI	Costa Rica	MAC	Macao	THA	Thailand
CUB	Cuba	MAF	Saint Martin (French part)	TJK	Tajikistan
CUW	CuraÁao	MAR	Morocco	TKL	Tokelau
CXR	Christmas Island	MCO	Monaco	TKM	Turkmenistan
CYM	Cayman Islands	MDA	Moldova, Republic of	TLS	Timor-Leste
CYP	Cyprus	MDG	Madagascar	TON	Tonga
CZE	Czech Republic	MDV	Maldives	TTO	Trinidad and Tobago
DEU	Germany	MEX	Mexico	TUN	Tunisia
DJI	Djibouti	MHL	Marshall Islands	TUR	Turkey
DMA	Dominica	MKD	Macedonia, the former Yugoslav Republic of	TUV	Tuvalu
DNK	Denmark	MLI	Mali	TWN	Taiwan, Province of China
DOM	Dominican Republic	MLT	Malta	TZA	Tanzania, United Republic of
DZA	Algeria	MMR	Myanmar	UGA	Uganda
ECU	Ecuador	MNE	Montenegro	UKR	Ukraine
EGY	Egypt	MNG	Mongolia	UMI	United States Minor Outlying Islands
ERI	Eritrea	MNP	Northern Mariana Islands	URY	Uruguay
ESH	Western Sahara	MOZ	Mozambique	USA	United States
ESP	Spain	MRT	Mauritania	UZB	Uzbekistan
EST	Estonia	MSR	Montserrat	VAT	Holy See (Vatican City State)
ETH	Ethiopia	MTQ	Martinique	VCT	Saint Vincent and the Grenadines
FIN	Finland	MUS	Mauritius	VEN	Venezuela, Bolivarian Republic of
FJI	Fiji	MWI	Malawi	VGB	Virgin Islands, British
FLK	Falkland Islands (Malvinas)	MYS	Malaysia	VIR	Virgin Islands, U.S.
FRA	France	MYT	Mayotte	VNM	Viet Nam
FRO	Faroe Islands	NAM	Namibia	VUT	Vanuatu
FSM	Micronesia, Federated States of	NCL	New Caledonia	WLF	Wallis and Futuna
GAB	Gabon	NER	Niger	WSM	Samoa
GBR	United Kingdom	NFK	Norfolk Island	YEM	Yemen
GEO	Georgia	NGA	Nigeria	ZAF	South Africa
GGY	Guernsey	NIC	Nicaragua	ZMB	Zambia
GHA	Ghana	NIU	Niue	ZWE	Zimbabwe

Appendix: Empirical Model, Data, and Method



(i) **Austria.**



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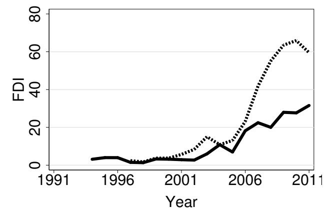
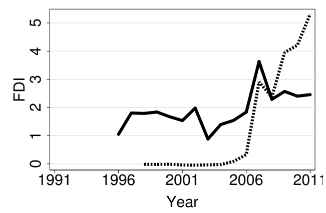
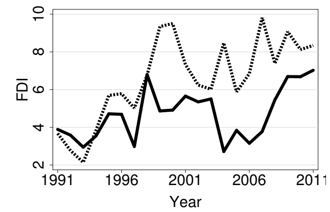


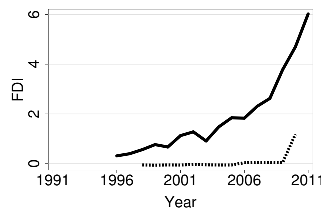
(iii) **Bel. & Lux..**



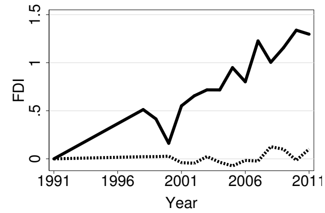
(iv) **Canada.**



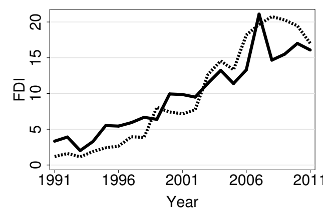
(v) **Switzerland.**



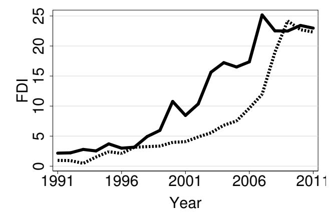
(vi) **China.**



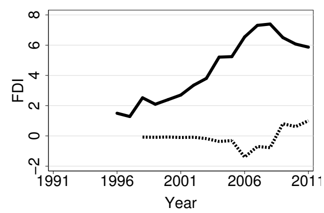
(vii) **Czech Republic.**



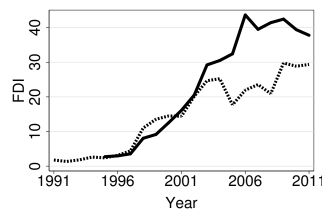
(viii) **Germany.**



(ix) **Denmark.**



(x) **Spain.**



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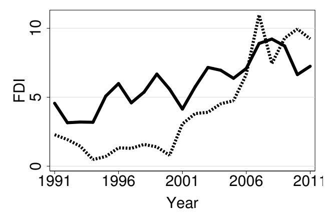

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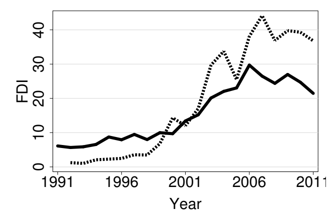

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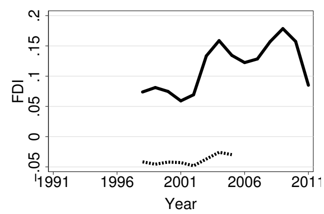
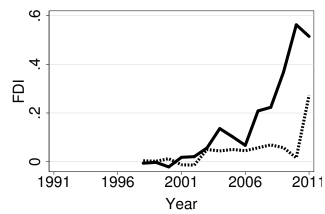
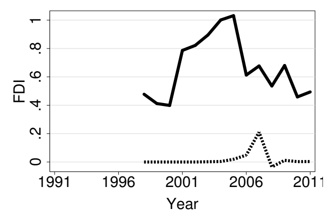


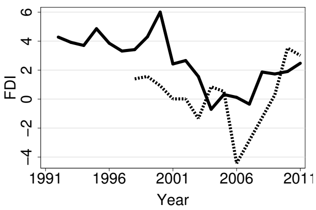
(xiv) **Greece.**



(xv) **Hong Kong.**



(xvi) **Hungary.**



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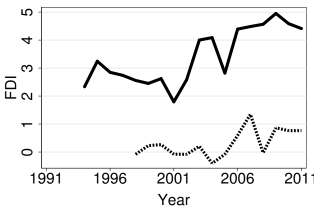
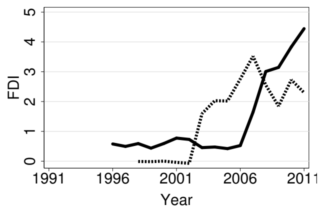
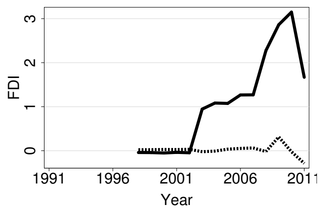


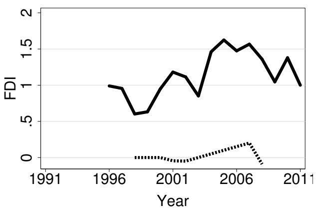
(xviii) **Italy.**



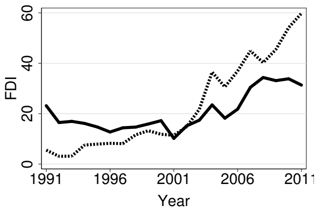
(xix) **Japan.**



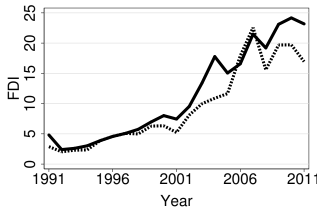
(xx) **South Korea.**



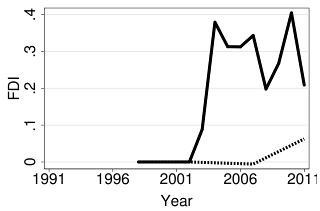
(xxi) **Mexico.**



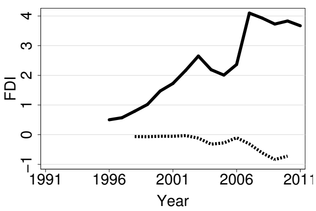
(xxii) **Netherlands.**



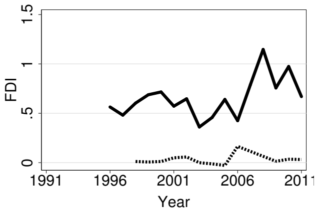
(xxiii) **Norway.**



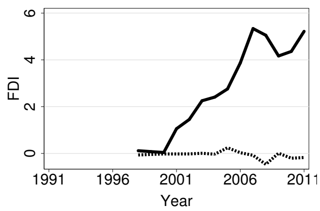
(xxiv) **New Zealand.**



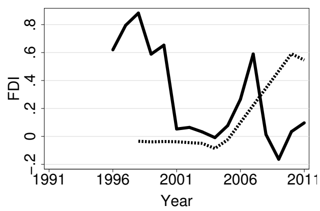
(xxv) **Poland.**



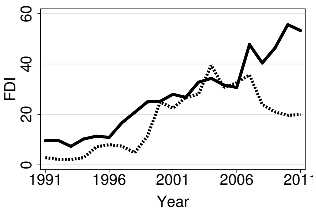
(xxvi) **Portugal.**



(xxvii) **Russia.**



(xxviii) **Singapore.**



(xxix) **United States.**

Figure A.1: **Swedish inward (- -) & outward (–) FDI stock by country in billion US$.**

Source: Author's illustration based on data by OECD statistics

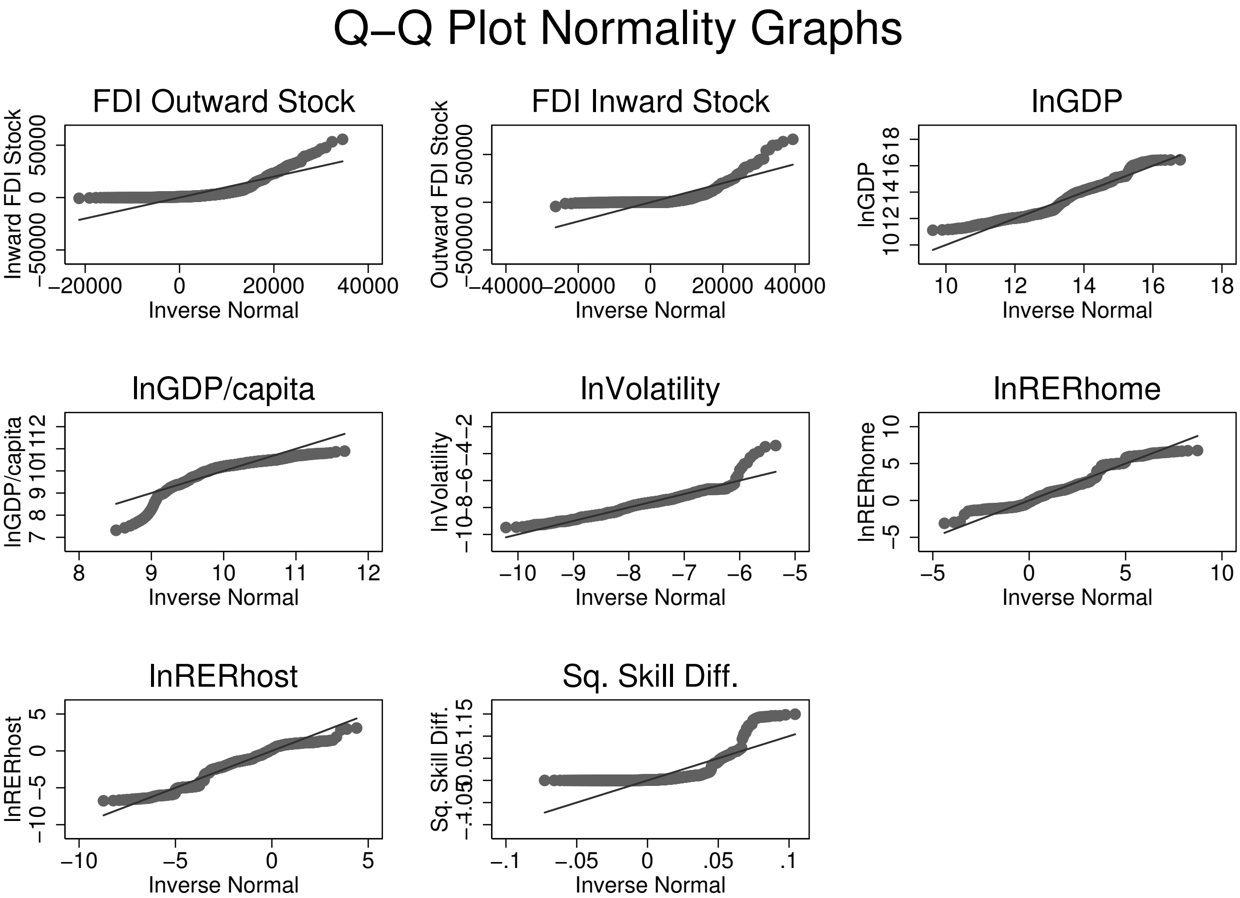


Figure A.2: **Quantiles of the variables against quantiles of a normal distribution.**

Source: Author's calculations

Table A.3: **Comparing estimation techniques: in- & outward FDI stock**

	Inward		Outward	
	DK	*HT*	*DK*	*HT*
$\ln \sigma$	2309.1***	2309.1**	1348.3**	1338.4*
	(2.99)	(2.09)	(2.53)	(1.92)
$\ln RER^{home}$			−726.3	−720.7
			(−0.92)	(−0.38)
$\ln RERhost$	−782.4	−782.4		
	(−0.56)	(−0.38)		
$\ln GDP^{i}$	−29603.7***	−29603.7	−21979.3***	−21142.9***
	(−4.73)	(−1.49)	(−4.38)	(−1.04)
$\ln GDP^{SWE}$	56712.6***	56712.6***	36780.4***	36610.0***
	(18.67)	(4.40)	(17.72)	(3.89)
$\ln GDP/capita^{i}$	16674.7**	16674.7	15874.9***	15014.9
	(2.30)	(0.76)	(2.96)	(0.71)
$Skill\ Diff.^{2}$	−127695.9	−127695.9	−67419.8	−67609.8
	(−1.26)	(−0.93)	(−1.70)	(−1.16)
RTA	−4265.8***	−4265.8***	−3772.4***	−3869.3*
	(−4.11)	(−4.49)	(−3.24)	(−2.05)
$\ln Dist.$		106042.7		13229.5
		(0.41)		(1.05)
LP		159087.7		17717.3
		(0.39)		(1.99)
Observations	418	418	482	482

z statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Source: Author's calculations

Appendix: Results and Analysis

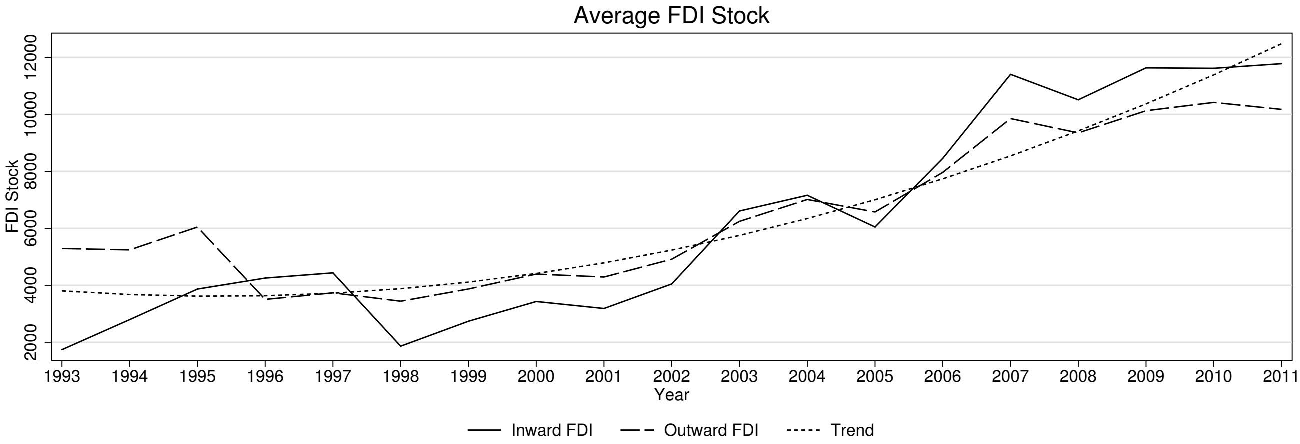


Figure A.3: **Trend of the average FDI stocks.**

Source: Author's illustration based on data by OECD statistics

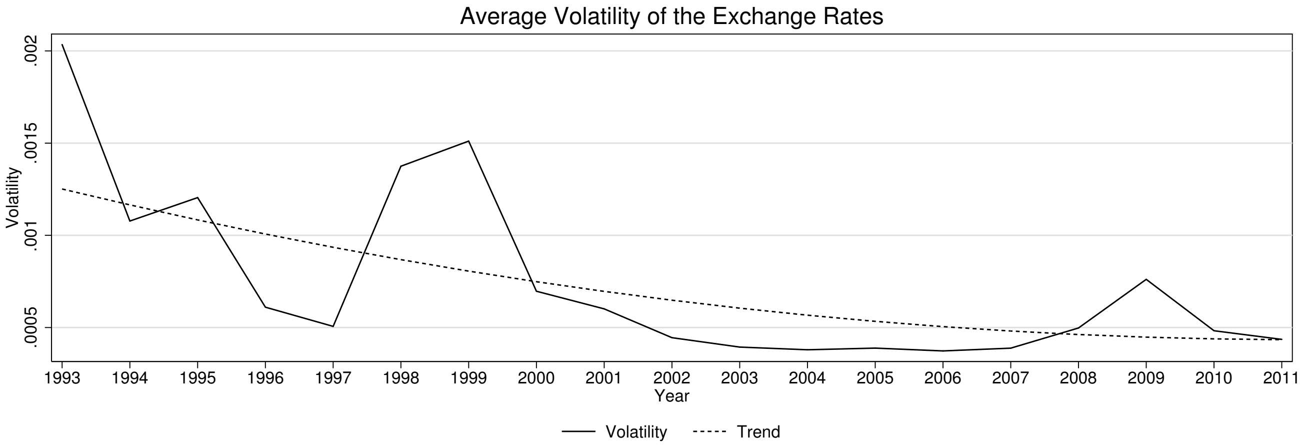


Figure A.4: **Trend of the average of the logged exchange rate volatility.**

Source: Author's calculations

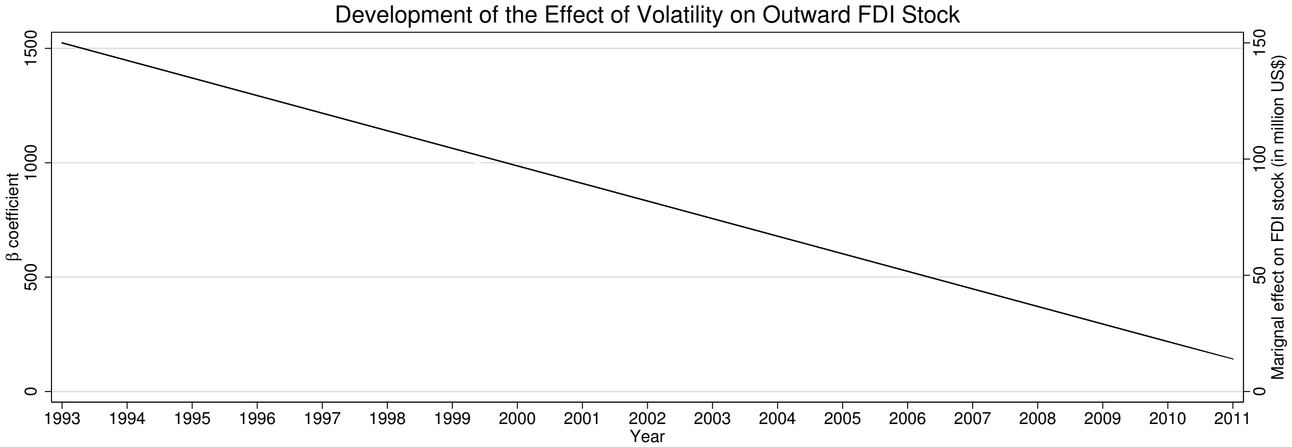


Figure A.5: **The development of the effect of exchange rate volatility over time in terms of a β coefficient as well as the effect on outward FDI stock at the mean.**

Source: Author's calculations

Table A.4: **Sensitivity analysis: outward FDI stock**

	(1) Benchmark	(2) 1993-2000	(3) 2000-2011	(4) High Income	(5) 75% Data
$\ln \sigma$	1348.3**	228.5	1311.3*	2050.6***	2129.2***
	(2.62)	(1.83)	(1.92)	(3.87)	(4.24)
$\ln RER$	−726.3	695.5	248.5	402.1	−793.7
	(−0.96)	(1.44)	(0.35)	(0.27)	(−0.59)
$\ln GDP^i$	−21979.3***	41306.2	−15963.7*	−42198.1***	−30668.8***
	(−4.53)	(1.64)	(−1.90)	(−3.94)	(−5.66)
$\ln GDP^{SWE}$	36780.4***	15298.8***	35091.3***	38400.0***	40664.4***
	(18.34)	(11.07)	(6.75)	(14.17)	(20.79)
$\ln GDP/capita^i$	15874.9***	−45711.2	10189.2	46220.1***	26490.7***
	(3.07)	(−1.62)	(1.67)	(3.00)	(4.48)
$Skill\ Diff.^2$	−67419.8	−53012.3***	6866.5	−1894.5	−78236.9
	(−1.76)	(−5.20)	(0.25)	(−0.04)	(−1.53)
RTA	−3772.4***	0	−2601.5***	−3164.3***	−4134.7**
	(−3.35)	(.)	(−5.33)	(−4.12)	(−2.24)
R^2 *Within*	0.381	0.342	0.288	0.428	0.420
Countries	29	29	29	24	22
Observations	482	163	348	388	384

t statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Source: Author's calculations

Table A.5: **Sensitivity analysis: inward FDI stock**

	(1) Benchmark	(2) 1993-2000	(3) 2000-2011	(4) High Income	(5) 75% Data
$\ln \sigma$	2309.1***	1099.8*	3077.1**	3110.4***	4611.8***
	(3.10)	(2.09)	(2.99)	(4.24)	(3.49)
$\ln RER$	−782.4	−1464.9	−1395.3	−5071.3**	−4731.9
	(−0.58)	(−1.79)	(−1.51)	(−2.89)	(−1.33)
$\ln GDP^i$	−29603.7***	44453.7*	−31924.6***	−70127.8***	32422.9
	(−4.90)	(2.25)	(−3.32)	(−7.88)	(1.71)
$\ln GDP^{SWE}$	56712.6***	20312.6***	52777.2***	54946.3***	33306.5**
	(19.35)	(6.19)	(7.98)	(10.58)	(2.78)
$\ln GDP/capita^i$	16674.7**	−35881.0	16953.6**	81104.8***	6623.4
	(2.38)	(−1.87)	(2.36)	(6.06)	(0.34)
$Skill\ Diff.^2$	−127695.9	−65025.8	10200.0	−9347.0	−971440.4*
	(−1.31)	(−1.74)	(0.17)	(−0.11)	(−1.97)
RTA	−4265.8***	0	−2604.0***	−4568.9**	
	(−4.26)	(.)	(−5.66)	(−2.86)	
R^2 *Within*	0.400	0.528	0.238	0.459	0.596
Countries	29	29	29	24	10
Observations	418	133	314	344	186

t statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Source: Author's calculations

Appendix: Stata Code

Garch.do

```
// This .do file shows how the GARCH specifications for the different exchange rates are created

//arch() specifies the ARCH terms included, garch() specifies the GARCH terms included
//ar() specifies the AR terms included, ma() specifies the MA terms included
//create GARCH id=1 AUSTRIA
arch dlnxrate if id==1 & time>=tm(1991m1), arch(1/3) ar(1) ma(1 3 4)
predict volaut if id==1 & time>=tm(1991m1), variance
//create GARCH id=2 Australia
arch dlnxrate if id==2 & time>=tm(1991m1), arch(1) garch(1) ma(1)
predict volaus if id==2 & time>=tm(1991m1), variance
//create GARCH id=3 BELGIUM
arch dlnxrate if id==3 & time>=tm(1991m1), arch(1) garch(1/2) ar(1) ma(1)
predict volbel if id==3 & time>=tm(1991m1), variance
//create GARCH id=4 CANADA
arch dlnxrate if id==4 & time>=tm(1991m1), arch(1) garch(2) ar(1) ma(1)
predict volcan if id==4 & time>=tm(1991m1), variance
//create GARCH id=5 SWITZERLAND
arch dlnxrate if id==5 & time>=tm(1991m1), arch(1/2) ar(1) ma(1)
predict volswz if id==5 & time>=tm(1991m1), variance
//create GARCH id=6 CHINA
arch dlnxrate if id==6 & time>=tm(1991m1), arch(1) ar(1) ma(1)
predict volchn if id==6 & time>=tm(1991m1), variance
//create GARCH id=7 CZECH REPUBLIC
arch dlnxrate if id==7 & time>=tm(1991m1), arch(1) garch(1)  ar(1)
predict volczk if id==7 & time>=tm(1991m1), variance
//create GARCH id=8 GERMANY
arch dlnxrate if id==8 & time>=tm(1991m1), arch(1/2) garch(1) ar(1) ma(1 3 4)
predict voldeu if id==8 & time>=tm(1991m1), variance
//create GARCH id=9 DENMARK
arch dlnxrate if id==9 & time>=tm(1991m1), arch(1) garch(1) ar(1 3) ma(1 3)
predict voldnk if id==9 & time>=tm(1991m1), variance
//create GARCH id=10 SPAIN
arch dlnxrate if id==10 & time>=tm(1991m1), arch(1) garch(2) ma(1 4) ar(4)
predict volesp if id==10 & time>=tm(1991m1), variance
//create GARCH for EUR/SEK: id=11
arch d.lnxrate if id==11 & time>=tm(1991m1), arch(1) garch(1) ar(1) ma(1)
predict voleur if id==11 & time>=tm(1991m1), variance
//create GARCH id=12 FINLAND
arch dlnxrate if id==12 & time>=tm(1991m1), arch(1) garch(1) ar(1) ma(1)
predict volfin if id==12 & time>=tm(1991m1), variance
//create GARCH id=13 FRANCE
arch dlnxrate if id==13 & time>=tm(1991m1), arch(1) garch(1) ar(1 3) ma(1 3)
predict volfra if id==13 & time>=tm(1991m1), variance
//create GARCH id=14 UNITED KINGDOM
arch d.lnxrate if id==14 & time>=tm(1991m1), arch(1) garch(1) ar(1) ma(1)
predict volgbp if id==14 & time>=tm(1991m1), variance
//create GARCH id=15 GREECE
arch dlnxrate if id==15 & time>=tm(1991m1), arch(1) garch(1) ar(1) ma(1)
predict volgre if id==15 & time>=tm(1991m1), variance
//create GARCH id=16 HONG KONG
```

```
arch dlnxrate if id==16 & time>=tm(1991m1), arch(1) garch(1) ar(1) ma(1)
predict volhkg if id==16 & time>=tm(1991m1), variance
//create GARCH id=17 HUNGARY
arch dlnxrate if id==17 & time>=tm(1991m1), arch(1) ar(1) ma(1)
predict volhuf if id==17 & time>=tm(1991m1), variance
//create GARCH id=18 IRELAND
arch dlnxrate if id==18 & time>=tm(1991m1), arch(1) garch(1/2) ar(1) ma(1)
predict volirl if id==18 & time>=tm(1991m1), variance
//create GARCH id=20 ITALY
arch dlnxrate if id==20 & time>=tm(1991m1), arch(1) ar(1) ma(1)
predict volitl if id==20 & time>=tm(1991m1), variance
//create GARCH id=21 JAPAN
arch dlnxrate if id==21 & time>=tm(1991m1), arch(1) ar(1) ma(1)
predict voljpn if id==21 & time>=tm(1991m1), variance
//create GARCH id=22 SOUTH KOREA
arch dlnxrate if id==22 & time>=tm(1991m1), arch(1/3) ma(1) ar(1)
predict volkor if id==22 & time>=tm(1991m1), variance
//create GARCH id=23 MEXICO
arch dlnxrate if id==23 & time>=tm(1991m1), arch(1) garch(1)  ar(1 8 10) ma(1 8 10)
predict volmxn if id==23 & time>=tm(1991m1), variance
//create GARCH id=24 NETHERLANDS
arch dlnxrate if id==24 & time>=tm(1991m1), arch(1) garch(1) ar(1 3) ma(1 3)
predict volnlg if id==24 & time>=tm(1991m1), variance
//create GARCH id=25 NORWAY
arch dlnxrate if id==25 & time>=tm(1991m1), arch(1) ar(1) ma(1)
predict volnor if id==25 & time>=tm(1991m1), variance
//create GARCH id=26 NEW ZELAND
arch dlnxrate if id==26 & time>=tm(1991m1), arch(1) garch(1) ar(1) ma(1)
predict volnzd if id==26 & time>=tm(1991m1), variance
//create GARCH id=27 POLAND
arch dlnxrate if id==27 & time>=tm(1991m1), arch(1) garch(1) ar(1) ma(1)
predict volpln if id==27 & time>=tm(1991m1), variance
//create GARCH id=28 PORTUGAL
arch dlnxrate if id==28 & time>=tm(1991m1), arch(1) garch(1) ar(4 5) ma(1)
predict volpor if id==28 & time>=tm(1991m1), variance
//create GARCH id=29 RUSSIA
//fix outlier from re-evalution
estpost summarize dlnxrate if id==29, detail
matrix p99= e(p99)
replace dlnxrate=p99[1,1] if id==29 & time==tm(1998m1)
arch dlnxrate if id==29 & time>=tm(1991m1), arch(1) garch(1/4) ar(1)
predict volrus if id==29 & time>=tm(1991m1), variance
//create GARCH id=30 SINGAPORE
arch dlnxrate if id==30 & time>=tm(1991m1), arch(1) ma(1)
predict volsgp if id==30 & time>=tm(1991m1), variance
//create GARCH id=31 UNITED STATES
arch dlnxrate if id==31 & time>=tm(1991m1), arch(1) garch(1) ar(1) ma(1)
predict volusd if id==31 & time>=tm(1991m1), variance
```

Regression.do

```
// This .do file shows with which commands the regressions in the reported tables were performed

//Tabel 5.1
//(1)
xtscc fdistockout lnvol lnRERhome lngdp lngdpc lngdpswe skilldiffsq rta if year>=1993, fe
//(2)
xtscc fdistockout lnvol trlnvol lnRERhome lngdp lngdpswe lngdpc skilldiffsq rta if year>=1993, fe
//(3)
xtscc fdistockout lnvol lnRERhome lngdp lngdpswe lngdpc skilldiffsq rta trend if year>=1993, fe
//(4)
xtscc fdistockout lnvol trlnvol lnRERhome lngdp lngdpswe lngdpc skilldiffsq rta trend if year>=1993, fe

//Table 5.2
//(1)
xtscc fdistockin lnvol lnRERhost lngdp lngdpswe  lngdpc skilldiffsq rta if year>=1993, fe
//(2)
xtscc fdistockin lnvol trlnvol lnRERhost lngdp lngdpswe  lngdpc skilldiffsq rta if year>=1993, fe
//(3)
xtscc fdistockin lnvol lnRERhost lngdp lngdpswe  lngdpc skilldiffsq rta trend if year>=1993, fe
//(4)
xtscc fdistockin lnvol trlnvol lnRERhost lngdp lngdpswe  lngdpc skilldiffsq rta trend if year>=1993, fe

//Table 5.3
//(1)
xtscc fdistockin lnvol Flnvol lnRERhost lngdp lngdpswe lngdpc skilldiffsq rta if year>=1993, fe
//(2)
xtscc fdistockin lnvol Flnvol F2lnvol lnRERhost lngdp lngdpswe lngdpc skilldiffsq rta if year>=1993, fe
//(3)
xtscc fdistockout lnvol lnvolusd lnRERhome lngdp lngdpswe lngdpc skilldiffsq rta if year>=1993 & id!=31, fe
```