Essays in International Macroeconomics

Inaugural-Dissertation
zur Erlangung des Grades eines Doktors
der Wirtschafts- und Gesellschaftswissenschaften
durch die
Rechts- und Staatswissenschaftliche Fakultät
der Rheinischen Friedrich-Wilhelms-Universität
Bonn

vorgelegt von
Almira Buzaushina
aus Astana, Kasachstan

Bonn 2011

Dekan:	Prof. Dr. Klaus Sandmann
Erstreferent:	Prof. Dr. Jürgen von Hagen
Zweitreferent:	Prof. Dr. Jörg Breitung

Tag der mündlichen Prüfung: 29.07.2011

посвящается моим родителям

Contents

List of Figures

List of Tables

Introduction

Ongoing theoretical research on issues of international macroeconomics draws heavily on new workhorse models known as New Open Economy Macroeconomic models. The new theoretical framework was introduced by the seminal contribution by Obstfeld and Rogoff (1995), while a previous study by Svensson and van Wijnbergen (1989) established some features that became distinguishing for New Open Economy Macroeconomics. The common characteristic of these models is the introduction of nominal rigidities and imperfect competition into a dynamic stochastic general equilibrium model, well-specified with microeconomic foundations. The comprehensive survey written by Lane (2001) provides a detailed literature review and a discussion of controversial modeling issues and their implications, while Corsetti (2007) presents a short literature survey of New Open Economy Macroeconomics with an emphasis on aspects of international transmission mechanisms and optimal policy designs.

New Open Economy Macroeconomics aims in its theoretical framework at offering an advancement to the traditional Mundell-Fleming approach, providing the analytical rationality and rigor adapted by modeling optimizing agents, utility-maximizing consumers and profit-maximizing firms. Furthermore, referring to the utility of the representative agent, a stringent welfare analysis with respect to policy design and evaluation can be directly conducted. Additionally, the optimizing behavior of economic agents make these models immune to the Lucas (1976) critique. Nominal rigidities and imperfect competition alter substantially transmission mechanisms of shocks, such that, e.g., short-run 'real' implications of monetary policy become relevant to explore. Imperfect competition, either in goods or production-inputs markets, allows researchers to investigate explicitly pricing decisions and, in combination with sticky prices, implies demand-driven output fluctuations or factor demand responses in the short run. Embedding the mentioned features into a general equilibrium context enriches the analysis with endogenous feedbacks from different sectors of the economy and from other countries.

The New Open Economy Macroeconomics literature has mainly explored two-country models, due to their convenience in investigating international transmission mechanisms. Recently even large-scale multi-country models have become prominent as a macroeconomic policy analysis tool in international organizations and central banks. However, their benefits in exploring international linkages come along with the disadvantages of model complexity. In order to analyze dynamics of small open economies, endogenous second-round feedback effects from abroad can be disregarded, such that researchers largely pass on rigorous modeling of foreign countries and stick to a small open economy version of New Open Economy Macroeconomic models, which is presented in the appendix of Obstfeld and Rogoff (1995).

As shown in detail in Lane (2001), international transmission and domestic propagation of macroeconomic shocks are highly sensitive and depend crucially on the precise specification of preferences, of nominal and real rigidities, and, to some extent, on the equilibrium characteristics. Therefore in order to use New Open Economy Macroeconomic models for quantitative policy analysis, it is important to fit these models to economic data, either via accurate calibration or estimation based on various econometric methods.

This dissertation aims at continuing the theoretical and empirical analysis in international macroeconomics with an emphasis on improving the quantitative performance of New Open Economy Macroeconomic models. Chapter 1 investigates empirically and theoretically how international financial shocks propagate into a small open and emerging economy of Latin America. A subset of structural parameters is estimated by matching empirical predictions gained from a vector-autoregressive analysis to the corresponding theoretical impulse responses. Chapter 2 reassesses a two-country version of the New Open Economy macroeconomic model in its ability to explain the US current account and exchange rate movements. Additional insights are gained regarding estimates of deep parameters that are controversial in the theoretical literature, obtained by applying the maximum likelihood procedure. Chapter 3 examines the trade balance implications of exchange rate movements for transition economies based on estimated import and export elasticities with respect to income and an international relative price. Trade elasticities with respect to international relative prices aim at providing further guidance on one of critical structural parameter in New Open Economy Macroeconomics, namely on the elasticity of substitution between home and foreign goods, which crucially affects international transmission of macroeconomic disturbances.

Even though the three chapters cover different aspects of international macroeconomics and undertake empirical analysis for different types of countries: emerging market, developed, and transition economies, they share the same underlying goal of bringing the theoretical New Open Economy Macroeconomic models closer to economic data. The results presented in this dissertation potentially help to improve the quantitative performance of New Open Economy macroeconomics models and therefore strengthen the credibility of these models as policy analysis tools.

Chapter 1, joint work with Michael Brei, investigates how an emerging market economy is affected when it suddenly faces a higher risk premium in international capital markets. By doing so, we focus on emerging market economies from Latin America, as over the last two decades these economies experienced deep economic crises that appeared to have been triggered largely by financial turmoils on international capital markets that were at least partially exogenous to these countries. The data on country risk premiums shows that financial spreads are highly correlated across Latin American countries and increased sharply during the major crises periods of 1994-95, 1998, and 2001-02. Even the recent financial crisis, which originated in industrial countries, resulted in a global financial turmoil and hit simultaneously many emerging markets economies in Latin America. The fact that risk premiums of Latin American economies increase recurrently and simultaneously across borders indicates that these countries are, from time to time, vulnerable to sudden and systemic deteriorations in external financial conditions and motivates us to model the financial crisis in these countries as an exogenous shock to country risk premiums.

First, we estimate the impact of adverse shocks to the country risk premium on fundamentals of major Latin American economies. As a framework serves a structural panel vector-autoregressive model including the gross domestic product, investment, the trade balance, domestic credits, and the country risk premium paid on external debt. We find that adverse financial shocks have been followed by persistent drops in investments, credits and gross domestic products in these countries and by an improvement in the trade balance. Second, we investigate the transmission mechanisms of risk premium shocks to the economy theoretically in a dynamic stochastic general equilibrium model of a small open economy, which reflects economic characteristics of emerging countries in Latin America. The small open economy borrows foreign-currency funds on international capital markets, subject to a debt-related risk premium. The theoretical literature on external financial shocks in EM economies typically incorporates financial market frictions in the form of a borrowing constraint on external debt (Arellano and Mendoza, 2003; Christiano et al., 2004; Mendoza, 2006) or in the form of a country risk premium that depends on an economy's net worth (Céspedes et al., 2004; Gertler et al., 2007; Cook and Devereux, 2005). The financial shock in our model is introduced as an exogenous rise in the risk premium of foreign-currency funds hold by the corporate sector and is amplified by a feed-back mechanism between the currency depreciation, the adverse balance sheet and risk premium effects. Our model is most related to the limited participation model of Christiano et al. (2004). Similar to Uribe and Yue (2006), however, we assume that not only the household's deposit decision is made prior to the shock as in classical limited participation models, but also the firm's decision on production and, therefore, finance. Finally we estimate a subset of the structural parameters by matching theoretical and empirical impulse responses. Although the number of estimated parameters is small, the theoretical model explains well the observed real adjustment and allows us to study different monetary policy responses. While expansive monetary policy tends to fuel inflation but mitigates the output drop, tight policies are associated with less inflation but more pronounced drops in output and employment. The estimated small open economy model provides further avenue to study optimal monetary policy responses for Latin American economies hit by the international financial turmoil.

Chapter 2 reexamines a standard two-country dynamic stochastic general equilibrium model, based on Bergin (2006), in order to analyze the ability of the model in explaining the US exchange rate and current account movements. In the case of two-country versions of New Open Economy Macroeconomic models, previous empirical literature has mainly considered the USA on one side and an aggregate of the remaining G-7 countries or the Euro Area on the other side. It thereby neglects China and Mexico, the two main trading partners of the USA after Canada. In contrast to previous literature, the estimation methods in this chapter are fitted to the data of the USA and its main trading partners, including China and Mexico. Therefore, we address the question how the inclusion of the main trading partners of the US into the data set changes the estimates of deep parameters and impacts the ability of the New Open Economy Macroeconomic model to explain the US current account and exchange rate movements.

Various deep parameters of the underlying theoretical model as well as statistical characteristics of five structural disturbances are estimated, using the maximum likelihood procedure. We use five data series: output, prices, and the interest rate (all in country differences), the multilateral exchange rate against the US dollar, and the US current account. The obtained results indicate that the estimated model matches surprisingly well a set of second moments considering that the estimation procedure is assigned to fit all moments of the data. For instance, the standard deviations of the data series for the current account, the exchange rate, price and output differentials are matched very well by simulated model variables.

The obtained estimates of the deep parameters bring some guiding light in the controversial debate on their values in the theoretical literature. In particular, one controversy regards the parameter which describes consumer preferences for home and foreign goods or, to be more precise, the degree of substitutability between home and foreign goods. Empirical studies based on micro-level evidence suggest high elasticities of around five (Harrigan, 1993), while the common assumption in the theoretical literature is an elasticity of substitution of one, supported also by the results of Bergin (2006). Our estimation results show, however, that the additional data from China and Mexico on the side of the foreign country pushes down the elasticity of substitution, achieving a significant estimate below one. Following different procedures, Corsetti et al. (2008) and Enders and Müller (2009) obtained even lower estimates of the trade elasticity. Another controversy deals with the currency in which prices are sticky. The traditional Keynesian approach assumes that prices are rigid only in exporter's currency (producer-currency pricing), so that nominal exchange rate changes induce demand shifts on the international goods market due to the expenditure-switching effect. However, Kollmann (1997), Chari et al. (1997), and Betts and Devereux (2000) show the potential of the local-currency pricing approach to replicate some controversial international business cycle regularities, such as the high variability of nominal and real exchange rates and the low comovements in international consumption levels. Our results do not provide, in contrast to Bergin (2006), an empirical support for local-currency pricing, estimating its share only at a low level.

Furthermore, the obtained estimation results help to understand the potential sources of the deviations from the uncovered interest parity condition. Risk premium shocks are estimated not to be closely related to monetary shocks, they rather are positively correlated with technology shocks and shifts in the marginal utility of consumption. Chapter 2 discusses in detail the propagation and transmission mechanisms of macroeconomic shocks, implied by the estimation results. Overall, we hope that the results in this chapter provide further avenues for critical research, e.g., current account determination and detection of potential sources for the positive correlation between the risk premium and technology shocks.

Chapter 3, joint work with Nicole Laframboise, endeavors to bring transition countries, namely those from Central and Eastern Europe and the Commonwealth of Independent States, into the universe of estimated price and activity elasticities of trade volumes in order to investigate trade balance implications of real exchange rate movements. As argued above, trade elasticities play a crucial role in translating economic analysis of external adjustment issues into macroeconomic policy. The most prominent example is the Consultative Group on Exchange Rate Issues at the International Monetary Fund, which measures exchange rate misalignments using three complimentary approaches within the course of exchange rate surveillance (International Monetary Fund, 2006b), the International Monetary Fund's core mandate. Within one of those methodologies, the so called 'macroeconomic balance approach', the Consultative Group on Exchange Rate Issues measures the exchange rate adjustment needed to eliminate a gap between the current account projected over the medium term at the prevailing exchange rates and the estimated equilibrium current account balance. By doing so, the Consultative Group on Exchange Rate Issues crucially relies on country-specific estimates of elasticities of the current account or the trade balance with respect to real exchange rates, which in turn are computed using elasticities of import and export volumes with respect to the real exchange rate. Certainly, trade elasticities are equally important for predicting current account or trade balance shifts implied by a given real exchange rate change.

Even though the empirical literature on trade elasticities is extensive, most of empirical studies have covered exclusively developed or emerging markets economies. Transition countries have been mostly excluded so far, in part because of the structural changes these economies have undergone since their independence, and also because of insufficient time series available for individual country estimates. The empirical research on trade demand elasticities for transition economies is therefore comparatively limited and uses exclusively time-series estimation techniques (e.g., Stučka, 2003; Hacker and Hatemi-J, 2004). To circumvent small sample handicaps that are associated with individual time-series analysis for transition countries, this chapter examines import and export volume elasticities with respect to a relative price variable, the real effective exchange rate, and to an income variable for transition countries applying different dynamic panel estimation techniques. The estimation procedure allows for discrepancies in trade elasticities between transition countries from Central and Eastern Europe and the Commonwealth of Independent States that could arise from different trade structures potentially implied by the distinct 'catching-up' processes.

The obtained significant results for trade elasticities indicate that increases in domestic and foreign income produce proportional or larger increases in imports and exports in the selected transition countries, with export elasticities being almost twice as high as those of import demand. Real effective exchange rates have a very small impact on trade volumes, which supports the baseline assumption for the estimation approach that goods produced by different countries are imperfect substitutes and is in line with price elasticities previously found for other countries in the macroeconomic literature. Moreover, estimated trade elasticities in this chapter correspond roughly to estimates obtained by differen econometric procedures based on international business-cycle models in chapter 1 and 2. Taking into consideration the highest price elasticities of export and import volumes which we obtained from our estimates, we find that the 'Marshall-Lerner' condition is not satisfied for transition countries as a whole, under the assumption of initially balanced external trade positions. Furthermore we observe that the long-run external trade flows in transition countries are largely driven by income changes; changes in real effective exchange rates do not have any significant impacts on exports and imports in the long run. The estimated price and income elasticities of export and import demands perform quite well in predicting out-of-sample changes in trade balance ratios for Armenia, Georgia, and Russia. Following the 'macroeconomic balance approach' and taking into account only relative price effects on trade volumes, actual changes in trade balances can be matched for a bigger set of countries, including in addition Estonia, Kazakhstan, the Slovak Republic, Slovenia, and Uzbekistan.

Chapter 1

International Financial Shocks in Latin America

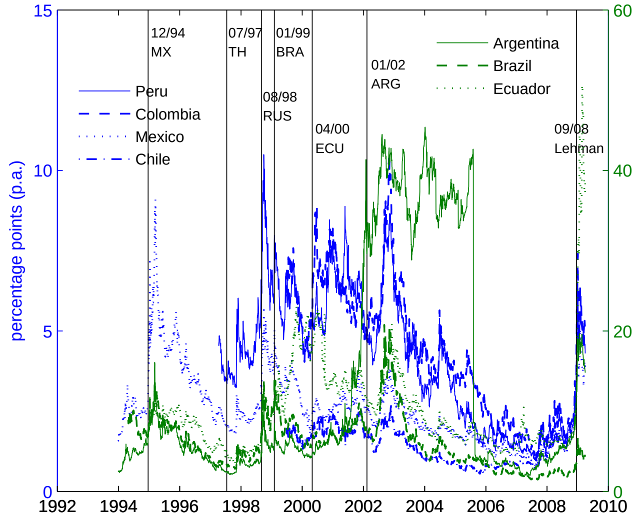
1.1 Introduction

Over the last two decades major emerging market (EM) economies have experienced deep economic crises. Many of them appear to have been triggered by financial turmoils on international capital markets, which affected a wide range of EM economies at approximately the same time. Figure 1.1 shows country risk premiums (EMBI+ spreads) for seven Latin American economies.[1] Remarkably, the financial spreads are highly correlated across countries and increase sharply during the major crisis periods of 1994-95, 1998, and 2001-02. Even the recent financial crisis, which originated in industrial countries, became a global financial turmoil and hit simultaneously many emerging markets economies in Latin America. The corresponding increase in the country risk premium was thereby extremely large in Ecuador, which has faced a risk premium of more than 40 percentage points.

The fact that country risks increase recurrently and simultaneously across borders indicates that these countries are, from time to time, vulnerable to sudden and systemic deteriorations in external financial conditions and motivates us to model the financial crisis in these countries as an exogenous shock to country risk premiums. The financial spreads reveal the unsettled nature of capital markets in which investors shy away from securities and investments in these countries. The amplitude of the effects of external financial shocks varies across countries, indicating that country fundamentals are crucial for the

[1]The countries include Argentina, Brazil, Chile, Colombia, Ecuador, Mexico, and Peru.

Figure 1.1: Country spreads in Latin America



transmission and amplification of the exogenously occurring financial turbulence. Calvo et al. (2006) emphasize that external shocks can be followed by a painful adjustment or become a minor recession. Domestic weaknesses such as currency mismatches and high levels of external short-term debt have been the major source of financial fragility in EM economies. Similar high levels of public debt have tied hands of many local governments to counteract crises by expansive fiscal policies. In countries where fundamentals are sound, as in Chile, country risk is much less volatile and dependent on external shocks.[2]

The theoretical literature on external financial shocks in EM economies typically incorporates financial market frictions in the form of a borrowing constraint on external debt (Arellano and Mendoza, 2003; Christiano et al., 2004; Mendoza, 2006) or in the form of a country risk premium that depends on an economy's net worth (Céspedes et al., 2004; Gertler et al., 2007; Cook and Devereux, 2005). In these models a crisis is set in motion when an adverse shock triggers binding borrowing constraints or directly increases risk premiums. In response, the economy is forced to repay parts of its external debt (financial deleveraging). When liabilities are largely denominated in units of tradables and assets in units of non-tradables, the deleveraging causes a real depreciation. The depreciation

[2] In our sample of countries, liability dollarization has been high relative to foreign-currency assets and exports in Argentina, Ecuador, Mexico, and Peru. These countries have experienced substantial deteriorations in economic conditions due to currency depreciations and higher risk premia than the other countries. It is natural that their debt maturity is shorter given their risk profile.

in turn increases economy's liabilities relative to assets (adverse balance sheet effect) and the associated reduction in net worth worsens the access to external finance (adverse cost effect). This mechanism tends to end up in a circle of amplification.[3]

In the present chapter we investigate empirically and theoretically the impact of such external financial shocks on emerging market economies of Latin America. Our contribution to the literature is twofold. First, we estimate the impact of adverse shocks to the country risk premium on fundamentals of major Latin American economies. As framework serves a structural panel vector-autoregressive (VAR) model of gross domestic product (GDP), investment, trade balance, domestic credits, and the country risk premium paid on external debt. We find that adverse financial shocks have been followed by persistent drops in investments, credits and GDP in these countries and by an improvement in the trade balance. Second, we investigate the transmission mechanisms of risk premium shocks to the economy in a dynamic stochastic general equilibrium model (DSGE) of a small open economy (SOE) which reflects economic characteristics of emerging countries in Latin America. The SOE borrows foreign-currency funds on international capital markets, subject to a debt-related risk premium. Our model is most related to the limited participation model of Christiano et al. (2004). There are, however, three important differences. We do not model the financial shock in form of a binding borrowing constraint, we rather incorporate the shock in the risk premium. Not only the household's deposit decision is made prior to the shock as in classical limited participation models, but also the firm's decision on production and, therefore, finance.[4] And finally we estimate a subset of the structural parameters by matching theoretical and empirical impulse responses. The results suggest that the proposed model fits the observed dynamics of economic fundamentals very well and that it may be applied to study optimal monetary policy responses for Latin American economies hit by the international financial turmoil.[5]

The remainder of this chapter is organized as follows. Section 1.2 presents estimation results of the VAR analysis and empirical impulse response functions. In Section 1.3 we discuss the theoretical model and present numerical simulations based on matching of impulse responses. Section 1.4 investigates model responses across expansive and tight

---

[3]The interaction of dollarized debts and net worth complicates an economy's response to external shocks, and it is not clear whether monetary policy should be loosened or tightened in response.

[4]This assumption is similar to Uribe and Yue (2006).

[5]Currently we are working on an extension to study optimal monetary policy responses using a welfare measure.

monetary policies and Section 1.5 across different levels of external leverage. The final section concludes.

1.2 Systemic Shocks in Latin America

In this section we investigate empirical impulse response functions (IRFs) of EM fundamentals, resulting from an adverse country risk shock in a structural panel VAR. As highlighted in Figure 1.1, Latin American country spreads have been highly volatile during the last two decades. While the Tequila crisis of 1994-95 has been followed by a temporary 10% increase in the Brazilian and Argentine country spread, the Russian crisis has been succeeded by financial distress in Argentina (increase by 8%), Brazil (10%), Ecuador (10%), and Peru (8%). The Argentine crisis of 2001-02 and the recent global financial crisis have most adversely affected Brazil (15%) in 2002, and Argentina (20%) and Ecuador (50%) in 2008. This highlights that financial shocks had different origins and impacts across countries. Most vulnerable to the financial contagion have been Argentina, Ecuador, and Brazil, while Chile has been most resilient.

In the following we analyze quantitatively the impact on the real economy. Due to the relatively small number of observations per country, we decided to work with a panel VAR including five Latin American economies (LA-5): Brazil, Colombia, Ecuador, Mexico, and Peru.[6] Within this model we identify structural shocks to the country risk premium by the assumption that real variables respond to financial shocks with a lag. The VAR system covers on a quarterly basis the period 1994-2007 and consists of 5 variables including GDP, investment, trade balance, domestic bank credits, and a measure of the country risk premium.[7]

[6] We also worked with data on Argentina and Chile but decided not to focus on these economies. Chile is an out-performer in Latin America, while Argentina has defaulted on external debt, which implies rather particular dynamics. In addition, we exclude Ecuador's period of dollarization.

[7] A more detailed description of data sources and definitions is provided in Table 1.1 in the appendix. Note that the VAR specification is similar to Uribe and Yue (2006) with the difference that we include domestic credits instead of the US interest rate.

The empirical model can be represented as follows:

$$\mathbf{A_0} x_t = \sum_{i=1}^{p} \mathbf{A_i} x_{t-i} + \varepsilon_t, \tag{1.1}$$

$$\mathbf{A_0} = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 & 0 \\ a_{31} & a_{32} & 1 & 0 & 0 \\ a_{41} & a_{42} & a_{43} & 1 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & 1 \end{pmatrix}, x_t = \begin{bmatrix} y_{jt} \\ i_{jt} \\ tb_{jt} \\ c_{jt} \\ r_{jt} \end{bmatrix}, \varepsilon_t = \begin{bmatrix} \varepsilon^y_{jt} \\ \varepsilon^i_{jt} \\ \varepsilon^{tb}_{jt} \\ \varepsilon^c_{jt} \\ \varepsilon^r_{jt} \end{bmatrix},$$

where t refers to the time dimension, j to countries and p to the lag length. Moreover, y_{jt} denotes real GDP, i_{jt} real investment, tb_{jt} the trade balance to GDP ratio, c_{jt} real domestic credits, and r_{jt} the country spread.[8] Output, investment, and domestic credits are expressed in log-deviations from a log-linear trend. All variables except for domestic credits and the country spread are seasonally adjusted. The included variables represent macroeconomic fundamentals that have been identified in the literature as being highly related to EM country spreads (Tornell and Westermann, 2002; Uribe and Yue, 2006).

The structural shock to the country risk premium is identified by imposing restrictions on the matrix $\mathbf{A_0}$ that determines contemporaneous effects of shocks. Our identification assumes that innovations in country risks affect real variables with one-period lag and that innovations in real variables affect country risks contemporaneously. These assumptions reflect that decisions on employment, consumption and investment take time to plan and to be implemented, while financial markets react more rapidly to changes in the state of the economy. Since we are only interested in identifying the structural shock to the country risk premium, the order of real variables is arbitrary. There are no restrictions on the coefficient matrices $\mathbf{A_i}, 1 \leq i \geq p$.

A difficulty that arises with this specification is the endogeneity associated with lags of dependent variables and error terms. For this reason the VAR is estimated equation-by-equation, using the Generalized Method of Moments (GMM) estimator for dynamic panel data (Arellano and Bover, 1995). The estimation results are reported in Table 1.2.[9] The AR(2) tests indicate that there is no incidence of autocorrelation of error terms, while the Sargan tests on overidentification indicate that instruments are valid, except for the GDP equation. The estimated coefficients show the expected signs. In particular

[8] Real variables are calculated by dividing the particular variable by the GDP deflator.

[9] Based on the Schwarz information criterion which is equal to $\{-34.69, -34.98, -34.68, -34.31\}$ for lag lengths $p = 1, 2, 3, 4$, we choose $p = 2$.

dependent variables are positively autocorrelated. Regarding adverse structural country risk shocks, real GDP and investment decrease significantly in response, while the trade balance ratio improves. Real domestic credits decrease, however, the coefficient is not statistically significant.

Based on the moving average representation we calculate the IRFs to a country spread shock of 5% per quarter or 22.5% per annum, reflecting average increases in LA-5 spreads during systemic crises. The graphs are shown in Figure 1.2.[10] In response to the structural financial shock, the country spread increases and reverses steadily toward zero. The half life of the response is approximately one year. The real economy is significantly affected in the following period and the financial shock results in a prolonged recession. The downturns in GDP and investments reach their trough after 3 quarters and domestic credits after 8 quarters. Real investments drop by 15% and real GDP by 5% from trend. The financial deleveraging is associated with an improvement of the trade balance by 4 percentage points of GDP. The international shock also affects the domestic financial market with a drop in domestic credits of 15% from trend. While the trade balance, domestic credits, and country risk recover after about 5 years, the recovery of GDP and investment takes much longer.

The empirical evidence suggests that adverse external shocks in LA-5 have been succeeded by long-lasting slowdowns in economic activity and deteriorations in domestic financial conditions. The involved transmission mechanism will be analyzed within the DSGE model in the next section.

1.3 The Theoretical Model

This section describes an economic environment that seems characteristic for emerging market economies: a small open economy (SOE) borrows on international capital markets in foreign currency subject to a risk premium that is related to its fundamentals. In our environment, unexpected financial shocks originating in international capital markets may occur and affect the real economy. To analyze the transmission mechanism of these shocks, we consider a SOE version of a cash-in-advance (CIA) model with limited participation

[10] The dotted lines indicate the 10% and 90% bootstrap intervals based on 1000 replications of estimation. In each replication we generated artificial data using the estimated coefficients and resampled residuals, reestimating the VAR and IRFs. The bootstrap intervals are the 10th and 90th percentile of the resulting distribution of IRFs.

augmented with a financial friction in form of a debt-elastic risk premium on external funds.[11] The SOE is inhabited by four types of agents: a representative household and firm, a financial intermediary, and a monetary authority.

1.3.1 Households

A representative household derives life-time utility from a composite consumption good C_t and disutility from labor L_t:

$$\mathbf{U} = E_t \sum_{j=0}^{\infty} \beta^j U(C_{t+j}, L_{t+j}), \tag{1.2}$$

where β denotes the household's time preference parameter. The instantaneous utility function takes the form:

$$U(C_t, L_t) = \frac{(C_t - \frac{L_t^{\mu}}{\mu} C_t^{\gamma})^{1-\sigma} - 1}{1-\sigma}, \ \mu > 0, \ \sigma > 0, \ \sigma \neq 1, \ \gamma \geq 0,$$

where σ denotes the intertemporal elasticity of substitution of consumption, μ the intertemporal elasticity of substitution of labor supply, and E_t the expectations operator conditional on time t information. Note that the preferences include as a special case, for $\gamma = 0$, the preferences proposed by Greenwood et al. (1988) which rule out wealth effects on the labor supply. We incorporate this type of preferences to control for the strength of the wealth effect by choosing γ. The composite consumption good consists of a domestic tradable and a non-tradable good:

$$C_t = (n^{\frac{1}{\lambda}} C_{Tt}^{\frac{\lambda-1}{\lambda}} + (1-n)^{\frac{1}{\lambda}} C_{Nt}^{\frac{\lambda-1}{\lambda}})^{\frac{\lambda}{\lambda-1}}, \ 0 < n < 1, \ \lambda > 0, \tag{1.3}$$

where n is the share of tradable goods in composite consumption and λ is the constant elasticity of substitution between the consumption of tradable and non-tradable goods.

At the beginning of period t, the household carries over its cash from the previous period M_{t-1}, gets prepaid paychecks $W_t L_t$, and deposits a cash amount D_t with the financial intermediary. The CIA constraint requires that all consumption expenditures must be paid with cash available at the beginning of period t:

$$P_t C_t \leq M_{t-1} - D_t + W_t L_t, \tag{1.4}$$

[11] For a detailed description of CIA models, see Christiano (1991), Christiano and Eichenbaum (1992), and Christiano et al. (1997).

where P_t denotes the price index for the composite consumption good given by:

$$P_t = (nP_{Tt}^{1-\lambda} + (1-n)P_{Nt}^{1-\lambda})^{\frac{1}{1-\lambda}}.$$

Maximizing composite consumption subject to total expenditures with respect to the consumption of tradable and non-tradable goods, we obtain the demand functions for tradables and non-tradables:

$$\begin{aligned} C_{Tt} &= n\left(\frac{P_{Tt}}{P_t}\right)^{-\lambda} C_t, \\ C_{Nt} &= (1-n)\left(\frac{P_{Nt}}{P_t}\right)^{-\lambda} C_t, \end{aligned}$$

both are decreasing in the ratio of the good's price to the overall price index.

The budget constraint of the household, who owns the firm and bank, reflects the evolution of its assets: cash at the beginning of period $t+1$ is equal to the sum of net dividends that it receives from the firm (π_t^F) and the financial intermediary (π_t^B), interest earnings and repaid deposits loaned to the financial intermediary at the beginning of the period ($R_{Dt}D_t$), and any cash that is left from financing consumption expenditures:

$$M_t = \pi_t^F + \pi_t^B + R_{Dt}D_t + (M_{t-1} - D_t + W_tL_t - P_tC_t). \tag{1.5}$$

The household maximizes its life-time utility (1.2) subject to the CIA (1.4) and budget (1.5) constraints. A period's deposit decision is made before the financial shock occurs, while the decisions on consumption and labor supply are made afterwards.

The first-order condition associated with the employment decision implies that in the optimum the consumer chooses consumption and labor such that the marginal rate of substitution between consumption and leisure is equal to their relative price:

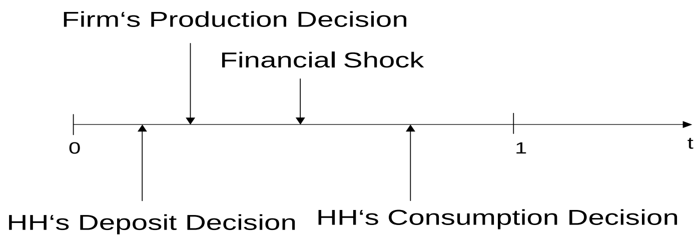
$$\frac{U_{C_t}}{U_{L_t}} = -\frac{P_t}{W_t}.$$

The intertemporal Euler equation associated with the deposit decision implies that marginal utility of consumption, or equivalently marginal utility of leisure, is equal between two consecutive periods, conditional on time $t-1$ information due to the assumption of limited participation:

$$E_{t-1}\beta\frac{U_{C_{t+1}}}{P_{t+1}} = E_{t-1}\frac{U_{C_t}}{R_{Dt}P_t}. \tag{1.6}$$

1.3.2 Firms

The international financial shock affects the economy through the corporate sector. The representative firm produces two types of goods, tradables and non-tradables, using labor L_t, capital K_t, and imported materials IM_t as input factors. We assume that the firm has access to three types of credits. It borrows at the beginning of period t domestic short-term credits, BL_t, from the financial intermediary to hire labor (bank loans), and foreign short-term credits, SF_t, on the global capital market to prepay imported materials (trade credits). The firm repays these loans including interest payments at the end of the period. In addition, we assume that the firm can borrow foreign long-term credits, FL_t, on the global capital market which have to be repaid in the next period. These credits are used to finance investment. We assume that external debt is denominated in foreign currency, which is in line with the original sin theory (Eichengreen et al., 2002), and subject to a risk premium which depends on the firm's level of debt. Opposed to Christiano et al. (2004), we assume that the firm decides on production at the beginning of period t, i.e., before the financial shock is realized, to capture that employment and investment decisions take time to plan. The timing in our model can be represented as follows:



It implies that the consumer decides on deposits and the firm on production before the financial shock occurs. After the financial shock is realized in the middle of period t, the household makes its consumption decision, and prices adjust such that all markets clear. Note that these timing assumptions ensure the consistency between the theoretical and empirical model discussed in Section 1.2.

The production functions of tradable and non-tradable goods are given by:

$$Y_{Tt} = A_{Tt} K_{Tt-1}^{\alpha_T} (IM_t^{\nu} L_{Tt}^{1-\nu})^{1-\alpha_T}, \; 0 < \alpha_T < 1, \; 0 < \nu < 1, \quad (1.7)$$

$$Y_{Nt} = A_{Nt} K_{Nt-1}^{\alpha_N} L_{Nt}^{1-\alpha_N}, \; 0 < \alpha_N < 1, \quad (1.8)$$

where A_{Tt} and A_{Nt} denote technology processes that are assumed to be constant. Note that α_i denotes the capital share in the production of each good and $\nu(1-\alpha_T)$ the import share in the production of tradable goods. The labor shares in the production of tradables and non-tradables are given by $(1-\nu)(1-\alpha_T)$ and $(1-\alpha_N)$, respectively. The firm accumulates two types of capital stocks:

$$K_{it} = I_{it} + (1-\delta)K_{it-1},\ i = T, N, \tag{1.9}$$

where I_{it} denotes investment in period t and $0 < \delta < 1$ the rate of capital depreciation. We assume that changes in the stock of capital are subject to quadratic capital adjustment costs:

$$AC(K_{it}, K_{it-1}) = \frac{\gamma_i}{2}\left(\frac{K_{it}-(1-\delta)K_{it-1}}{K_{it-1}}\right)^2 K_{it-1},\ i = T, N, \tag{1.10}$$

with an adjustment cost parameter denoted by $\gamma_i \geq 0$.

The firm starts each period with no cash, because all profits from the previous period are distributed to the household. Implied by the assumption of advance payments of labor and imports, the firm borrows domestic bank loans (BL_t) to hire labor, and foreign trade credits (SF_t) to prepay imported materials. In particular, the working capital constraints faced by the firm are given by:

$$BL_t \geq W_t L_{Tt} + W_t L_{Nt}, \tag{1.11}$$

$$SF_t \geq p^*_{IMt} IM_t, \tag{1.12}$$

where p^*_{IMt} denotes the price of imported materials expressed in foreign currency. Since domestic bank loans and foreign trade credits have to be repaid including interest payments at the end of each period, the effective costs of labor and imported materials in domestic currency are equal to $R_{Bt}W_tL_t$ and $e_tR_{St}p^*_{IMt}IM_t$, respectively. The nominal exchange rate e_t is denoted as the domestic price per unit of foreign currency. R_{Bt} denotes the gross interest rate on domestic bank loans and R_{St} that of trade credits. We assume that R_{St} is equal to the risk-free interest rate on external long-term credits, $1+r$. The gross interest rate on foreign long-term credits R_{Ft} is composed of a constant risk-free component and a variable risk premium:

$$R_{Ft} = (1+r) + \kappa \exp(e_t FL_t - \bar{e}\overline{FL}) + RP_t,\ \kappa \geq 0. \tag{1.13}$$

In particular, it is assumed that the risk premium consists of a debt-related component, which increases when external long-term credits measured in domestic currency rise above their steady-state level, and a stochastic component, RP_t, which is intended to capture aggregate risks. The stochastic component is assumed to follow a stationary AR(1) process $RP_t = \rho_{RP} RP_{t-1} + \epsilon_{RPt}$.

Note that we do not derive this risk premium explicitly from a debt contracting problem between borrowers and lenders, rather we use a reduced-form and assume that lenders charge additional interests when the firm's level of external debt expressed in domestic currency increases relative to its long-run average. We use this specification, because it summarizes the dynamics of the risk premium in two key variables (exchange rate and level of foreign currency debt) which have been highlighted in the empirical literature to be important determinants of emerging market risk premiums (Berganza et al., 2004). We believe that our choice is justified in the context of a general equilibrium model, however, other specifications of the risk premium could be introduced. Note that the strength of the financial friction can be controlled by the parameter κ. Moreover, our specification ensures stationarity of the equilibrium dynamics and is based on Schmitt-Grohé and Uribe (2003) with two modifications. First, it takes into account financial amplifier effects of exchange rate depreciations and, second, it prevents that the risk premium can turn negative during the equilibrium adjustment.[12] Note that we assume that the SOE is hit by the international financial shock in the form of an unexpected, adverse shock to RP_t.

The firm's optimization problem is to maximize the expected discounted sum of future profits by the choice of L_{Tt}, L_{Nt}, K_{Tt}, K_{Nt}, IM_t, BL_t, SF_t, and FL_t. Assuming that the firm is surprised by the financial shock, it solves the following optimization problem based on the information set of period $t-1$:

$$\max_{L_{Tt}, L_{Nt}, K_{Tt}, K_{Nt}, IM_t, BL_t, SF_t FL_t} E_{t-1} \sum_{j=0}^{\infty} \rho_{t,t+j} \pi^F_{t+j},$$

where

$$\begin{aligned}
\pi^F_t = \; & P_{Tt} Y_{Tt} + P_{Nt} Y_{Nt} - W_t L_{Tt} - W_t L_{Nt} - e_t p^*_{IMt} IM_t \\
& - P_{Tt} I_{Tt} - P_{Tt} AC(K_{Tt}, K_{Tt-1}) - P_{Nt} I_{Nt} \\
& - P_{Nt} AC(K_{Nt}, K_{Nt-1}) + BL_t - R_{Bt} BL_t \\
& + e_t SF_t - e_t R_{St} SF_t + e_t FL_t - e_t R_{Ft-1} FL_{t-1},
\end{aligned}$$

subject to the working capital constraints (1.11) and (1.12). We assume that goods and labor markets are perfectly competitive which implies that the firm acts as a price taker.

[12] The foreign interest rate with a debt-elastic risk premium as in Schmitt-Grohé and Uribe (2003) that incorporates an exchange rate would be: $R_{Ft} = (1+r) + \kappa(exp(e_t FL_t - \overline{eFL}) - 1)$. This specification, however, does not restrict the lower bound of the gross foreign interest rate to be larger than 1 for $\kappa > r$.

The optimality conditions with respect to labor in the production of tradable and non-tradable goods imply that expected effective marginal costs of labor are equal to their expected marginal products:

$$E_{t-1}R_{Bt}W_t = (1-\alpha_T)(1-\nu)E_{t-1}\frac{P_{Tt}Y_{Tt}}{L_{Tt}}, \qquad (1.14)$$

$$E_{t-1}R_{Bt}W_t = (1-\alpha_N)E_{t-1}\frac{P_{Nt}Y_{Nt}}{L_{Nt}}. \qquad (1.15)$$

The intertemporal optimality condition with respect to capital in the production of both types of goods equates the expected costs and expected benefits of an additional unit of capital:

$$E_{t-1}\left(1+\gamma\frac{I_{it}}{K_{it-1}}\right) = E_{t-1}\rho_{t,t+1}\left(\alpha_i\frac{Y_{it+1}}{K_{it}} + (1-\delta) - \gamma\frac{I_{it+1}}{K_{it}}\left[\frac{1}{2}\frac{I_{it+1}}{K_{it}} - \frac{K_{it+1}}{K_{it}}\right]\right),$$

for $i = T, N$. Expected benefits on the right side are equal to the expected marginal product of an additional unit of capital, its resale value after capital depreciation, and associated savings on future capital adjustment costs. The costs in the current period are given by the unit of investment and associated capital adjustment costs.

The optimality condition with respect to imported materials implies that expected effective marginal costs are equal to the expected marginal product:

$$E_{t-1}e_tR_{St}p^*_{IMt} = (1-\alpha_T)\nu E_{t-1}\frac{P_{Tt}Y_{Tt}}{IM_t}.$$

The intertemporal optimality condition with respect to external long-term credits equates expected benefits and expected costs of an additional unit of long-term foreign funds:

$$E_{t-1}e_t = E_{t-1}\rho_{t,t+1}e_{t+1}\left(R_{Ft} + \frac{\partial R_{Ft}}{\partial FL_t}FL_t\right), \qquad (1.16)$$

$$\frac{\partial R_{Ft}}{\partial FL_t} = \kappa exp(e_tFL_t - \bar{e}\overline{FL})e_t.$$

Expected costs on the right side are equal to the sum of the repayment including interests of an additional unit of foreign credits and its effect on the risk premium.

Since firm profits are distributed to the household at the end of the period, the firm's discount factor is equal to the subjective discount factor of the household:

$$\rho_{t,t+j} = \beta^j\frac{P_t}{P_{t+j}}\frac{U_{C_{t+j}}}{U_{C_t}}. \qquad (1.17)$$

Using the expression for the firm's discount factor and combining the household's and firm's intertemporal optimality conditions (1.6) and (1.16), we obtain the model's uncovered interest parity (UIP) condition:

$$E_{t-1}R_{Dt} = E_{t-1}\frac{e_{t+1}}{e_t}\left(R_{Ft} + \frac{\partial R_{Ft}}{\partial FL_t}FL_t\right). \tag{1.18}$$

This condition differs from the usual UIP condition in two aspects: it includes a risk premium term (the second term on the right side) and it holds only in expectations conditioned on information at the end of period $t-1$. This is consistent with Lewis (1995) who finds empirical evidence for the existence of predicted interest rate differentials between home and foreign bonds which can be explained by differences in country risks. Moreover, realized and predicted interest rate differentials can deviate due to expectation errors. In our model, the actual and predicted interest rate differentials coincide as long as there are no unexpected shocks in periods t and $t+1$. If an unexpected shock occurs, the model's UIP condition deviates from the usual UIP condition in the initial period. The risk premium term stems from the fact that the interest rate on external long-term credits incorporates the debt-elastic risk premium. Note that with a positive level of foreign long-term debt, the domestic interest rate exceeds the foreign interest rate in the deterministic steady state and is given by:

$$\bar{R}_D = \bar{R}_F + \kappa\bar{e}\overline{FL}.$$

The associated level of foreign debt in steady state is then equal to $\bar{e}\overline{FL} = \frac{1/\beta-(1+r)}{\kappa} - 1$.

1.3.3 Financial Intermediary

The financial intermediary receives deposits D_t at the beginning of each period, and repays $R_{Dt}D_t$ at the end of each period. Moreover, the financial intermediary lends at the beginning of the period bank loans BL_t to the firm, and receives $R_{Bt}BL_t$ at the end of the same period. It is assumed that the financial intermediary has a second source of funds given by the change in domestic liquidity, $M_t - M_{t-1}$, which is controlled by the monetary authority. Note that the different monetary policy rules are described in Section 1.4. The financial intermediary solves the following problem:

$$\max_{D_t, BL_t} = E_t \sum_{j=0}^{\infty} \rho_{t,t+j}\pi^B_{t+j},$$

s.t.

$$\begin{aligned} \pi^B_t &= M_t - M_{t-1} + D_t - R_{Dt}D_t - BL_t + R_{Bt}BL_t, \\ BL_t &= D_t + M_t - M_{t-1}, \end{aligned} \tag{1.19}$$

where (1.19) represents the bank's balance sheet identity that requires that assets (bank loans) are equal to liabilities (deposits and cash).

In equilibrium, the intermediation margin between bank loans and deposits is zero:

$$R_{Bt} - R_{Dt} = 0.$$

1.3.4 Rest of the World

The rest of the world supplies imports which are employed in the production of tradable goods. We assume that imports are producer-currency priced and that the supply is increasing in the price of imports p^*_{IMt}:

$$IM_t = Z_{IM}(p^*_{IMt})^{\phi_{IM}},\ Z_{IM} > 0,\ \phi_{IM} > 0,$$

where Z_{IM} is a positive scaling parameter and ϕ_{IM} the price elasticity of supply.

Furthermore, the rest of the world imports tradable goods produced in the SOE. We assume that exports of the SOE are also producer-currency priced and that export demand is decreasing in the price of tradable goods:

$$C^*_t = Z_T \left(\frac{1}{e_t} p_{Tt}\right)^{-\phi_T},\ Z_T > 0,\ \phi_T > 0,$$

where Z_T, analogously, is a positive scaling parameter and $-\phi_T$ the price elasticity of the foreign demand for tradables.[13]

1.3.5 Market Clearing Conditions

The market clearing condition for non-tradable goods is given by:

$$Y_{Nt} = C_{Nt} + I_{Nt} + AC_{Nt},$$

and that for tradable goods by:

$$Y_{Tt} = C_{Tt} + I_{Tt} + AC_{Tt} + C^*_t.$$

These two conditions equate production and absorption.

[13] The assumption of producer-currency pricing implies that the firm sells tradable goods for the same price on the domestic and foreign market, and that foreign demand increases with an exchange rate depreciation depending on the demand elasticity.

The market clearing condition for labor is:

$$L_{Tt} + L_{Nt} = L_t.$$

Combining the household's and firm's cash constraints with the financial intermediary's balance sheet identity, the money market clearing condition corresponds to:

$$M_t \geq P_t C_t. \tag{1.20}$$

This condition requires that actual cash balances equal desired cash balances.

The consolidated budget constraint of the whole economy results from combining the household's budget constraint with those of the firm and the financial intermediary:

$$\begin{aligned}(P_{Tt}Y_{Tt} - P_{Tt}C_{Tt} - P_{Tt}I_{Tt} - P_{Tt}AC_{Tt}) + (P_{Nt}Y_{Nt} - P_{Nt}C_{Nt}\\ -P_{Nt}I_{Nt} - P_{Nt}AC_{Nt}) + (W_tL_t - W_tL_{Tt} - W_tL_{Nt})\\ -e_t p^*_{IMt} IM_t - e_t(R_{St} - 1)SF_t - e_t(R_{Ft-1} - 1)FL_{t-1} = -e_t(FL_t - FL_{t-1}).\end{aligned}$$

Using the market clearing conditions for goods and labor, the consolidated budget constraint reduces to:

$$P_{Tt}C^*_{Tt} - e_t p^*_{IMt} IM_t - e_t(R_{St} - 1)SF_t - e_t(R_{Ft-1} - 1)FL_{t-1} = -e_t(FL_t - FL_{t-1}).$$

The economy's trade balance is given by:

$$TB_t = \underbrace{P_{Tt}C^*_{Tt}}_{\text{Exports}} - \underbrace{e_t p^*_{IMt} IM_t}_{\text{Imports}}.$$

Using the definition of the trade balance, the consolidated budget constraint can be expressed as:

$$\underbrace{TB_t - e_t(R_{St} - 1)SF_t - e_t(R_{Ft-1} - 1)FL_{t-1}}_{\text{Current Account}} = \underbrace{-e_t(FL_t - FL_{t-1})}_{-\text{Capital Account}}.$$

This condition represents the economy's balance of payments condition, which requires that the current account (sum of the trade balance and net foreign interest payments) is equal to the negative of the capital account (change in net foreign assets).

1.3.6 Equilibrium

A rational expectations equilibrium of the whole economy is a set of processes for $\{C_t, C_{Tt}, C_{Nt}, L_{Tt}, L_{Nt}, L_t, IM_t, K_{Tt}, K_{Nt}, I_{Tt}, I_{Nt}, Y_{Tt}, Y_{Nt}, \rho_{t,t+1}, P_{Tt}, P_{Nt}, P_t, p^*_{IMt}, W_t, C^*_t,$

D_t,BL_t,SF_t,FL_t,R_{Dt},R_{Bt},R_{St},$R_{Ft}\}_{t=0}^{\infty}$, having the following properties: (1) for each time period and given prices, the quantities solve the optimization problems of the household, firm, and the financial intermediary, and (2) all markets clear. We solve the model by linearizing the equilibrium conditions around the deterministic steady state and solve numerically the linearized system.

1.3.7 Estimation

In this section theoretical response functions are matched with their empirical counterparts, as a function of particular structural parameters. While the first set of parameters is fixed to determine the economic and financial conditions of the model economy in steady state, the parameters of the second set are estimated with impulse response matching.

The structural parameters of the first group determine the economy's long-run characteristics. These parameters are either provided by averages over the LA-5 economies or are in line with related literature. The parameters $\{n, \alpha_T, \nu, \alpha_N, \delta\}$ determine the relative size of the tradable goods sector, capital, import and labor shares in production, and capital depreciation rate. Table 1.3 shows the parameter values. Our assumptions imply that tradable production makes up 38% of total production, the tradable sector employs more capital than the non-tradable sector, and that imports make up 7% of production costs.[14] The implied wage costs are 54% of total costs. The intertemporal elasticity of substitution of consumption is set to $\sigma = 1.001$ and the intertemporal elasticity of substitution of labor to 2, implied by $\mu = 1.455$ (Mendoza, 1991; Uribe and Yue, 2006). The risk-free foreign interest rate is set to 4% (p.a.) and the stock of external corporate debt to 20% of annual GDP.[15] The sensitivity parameter κ in the risk premium is set to 0.04. Given these assumptions, the steady state relation $\bar{e}\overline{FL} = \frac{1/\beta-(1+r)}{\kappa} - 1$ implies that the economy's time preference parameter β has to be fixed to 0.92. This makes the economy more impacient than the capital market and implies that it is a net borrower on international capital markets. The model's balance of payments condition implies then a trade balance to GDP ratio of 4% (p.a.). For estimation we abstract from monetary policy and assume that domestic liquidity remains constant $\Delta M_t = 0$.

The second group of parameters consists of the remaining structural and stochastic parameters that are to be estimated. We restrict these parameters to intervals that are in

[14] See Arellano and Mendoza (2003), Christiano et al. (2004), and Kehoe and Ruhl (2007).

[15] In Section 1.5 we analyze country dynamics by varying levels of leverage.

line with empirical evidence. Export and import elasticities are restricted to the interval $\phi_{IM} = \phi_T = [0.4, 1.5]$, capital adjustment cost parameters to $\gamma_T = \gamma_N = [0, 20]$, the elasticity of substitution between tradables and non-tradables to $\lambda = [0.1, 0.5]$, and the wealth parameter to $\gamma = [0, 0.5]$.[16] Based on the VAR estimation, the stochastic parameters governing the financial shock process are restricted to $\rho_{RP} = [0.5, 0.9]$ and $\sigma_{RP} = [0.001, 0.05]$.

Empirical and theoretical IRFs are estimated by minimizing a weighted distance between empirical IRFs, IR^e, and theoretical IRFs, IR^t.[17] Five years of impulse responses are matched by minimizing the following distance:

$$\min_{\xi}[IR^e - IR^t(\xi)]'W[IR^e - IR^t(\xi)],$$
$$\xi = (\phi_{IM}, \phi_T, \gamma_T, \gamma_N, \lambda, \gamma, \rho_{RP}, \sigma_{RP})$$

subject to $\underline{\xi} \leq \xi \leq \bar{\xi}$. The positive-definite weighting matrix W is calculated by the inverse of the covariance matrix of the IRFs, determined in the bootstrap replications in Section 1.2.

Table 1.3 shows starting values, interval bands and resulting parameters. The estimated parameters lie inside the interval band, except for the wealth parameter that converges to $\gamma = 0$, implying that changes in wealth do not affect labor supply consistent with Greenwood et al. (1988). Figure 1.3 highlights that most of the points belonging to the theoretical IRFs lie inside the bootstrapped confidence intervals. Although only 8 parameters are estimated to match 100 points of impulse responses, the theoretical model reproduces the empirical evidence very well: output, investment, and domestic credits drop, and the trade balance improves. The initial response of investment is slightly overestimated, while output and domestic credits do not react as much as in reality. Over time theoretical and empirical IRFs get closer.

Figure 1.4 shows the theoretical responses of other model variables.[18] In response to the exogenous financial shock, the interest rate on external debt R_{Ft} increases to 2.5% (p.q.) in the second quarter, driven by the debt-related component. The associated currency depreciation amounts to 40% and external long-term credits decrease by 1.2%. The

[16] See Goldstein and Khan (1981), Bahmani-Oskooee and Kara (2005), Arellano and Mendoza (2003) and Christiano et al. (2004).

[17] The theoretical counterparts of the VAR variables are log-deviations from steady state of real output $(P_TY_T + P_NY_N)/P$, real investment $(P_TI_T + P_NI_N)/P$, real domestic bank loans BL/P and of the risk premium of foreign long-term credits as well as trade balance over production TB/PY.

[18] Interest rates are shown in percentage points and the other variables in percentage deviations from steady state.

trade balance improves in response, driven by a drop in imports (12%) and an increase in exports (30%). Capital stocks in the tradable and non-tradable sector drop by 4% and 3%, respectively, and labor is shifted from the non-tradable (8%) to the tradable goods sector (10%). Overall the financial shock causes a drop in output of 2%. This is explained by an important contraction in the non-tradable goods sector (6%) that is partly offset by an expansion in the tradable goods sector (3%). Total consumption drops by 5.5%, dominated by a more pronounced decrease in the consumption of tradable goods (6%).

1.3.8 The qualitative adjustment

In the following, the discussion is based on the estimated parameters in Table 1.3. Due to the variable interest rate on external funds, the firm faces an unexpected increase in the costs of borrowing by the magnitude of the exogenous shock. The assumption that the household's deposit and the firm's production and financing decisions are made prior to the shock implies that other model variables do not change in the initial period. The domestic interest rate remains constant, because the household's deposit decision and the firm's demand for domestic bank loans are predetermined. Moreover, because the model's UIP condition holds only in expectations, see (1.18), there is no predicted interest rate differential and no currency depreciation. In the initial period, only the foreign interest rate changes; other prices and quantities are not affected.

In the next period the firm reduces external borrowing. Given that the domestic interest rate rises by less than the foreign interest rate, the UIP condition implies a currency depreciation that is followed by an expected appreciation. The depreciation results in an adverse balance sheet effect by increasing the domestic-currency stock of external debt. For a given level of external debt the depreciation causes an increase in the risk premium and amplifies the reduction in foreign borrowing. The firm faces opposite effects on operating profits in form of increasing import costs and export earnings. In combination with the increased costs of investment implied by rising interest rates, this translates into a higher labor demand in the tradable good sector, and the firm reallocates resources from the non-tradable to the tradable good sector. For the household, the financial shock translates into a negative wealth effect, because dividend and wage payments decrease. In response, the household reduces consumption. Overall the financial shock is amplified by currency depreciation and adverse balance sheet and cost effects, resulting in persistent drops in economic activity and domestic absorption.

1.4 The Role of Monetary Policy

In this section we compare theoretical IRFs for different responses of monetary policy. It is assumed that the monetary authority, as the rest of the economy, is surprised by the exogenous financial shock in the initial period. In our model, the monetary authority has two possibilities to respond. On the one hand, it can provide additional liquidity to the financial intermediary by increasing the domestic money supply. This tends to reduce the domestic interest rate and effective wage costs, but it increases the currency depreciation which then amplifies adverse balance sheet and cost effects. On the other hand, the monetary authority can reduce the domestic money supply which would increase effective wage costs, but counteract the currency depreciation and financial amplification.

Figure 1.5 shows theoretical responses for expansionary and contractionary monetary policy, along the baseline case of passive monetary policy. It is assumed that the monetary authority increases/decreases domestic liquidity by 10%, following an AR(1) process.[19] In the expansionary case the currency depreciation reaches 55%, opposed to 40% in the baseline case. The associated adverse balance sheet effect sets in motion a stronger financial amplification. The foreign interest rate increases to 3% (p.q.), external long-term credits decrease by 2%, and investment drops by slightly less than in the baseline case (-13%). The slowdown in output is mitigated due to the improvement in the international price competitiveness of domestic tradable goods and the lower effective wage costs. When monetary policy is tightened, the currency depreciation is lower (23%) which mitigates adverse balance sheet and risk premium effects. The foreign interest rate increases by less (2%), while external long-term credits drop by 0.5%. Investments drop by 11%. The output collapse, however, is more pronounced, as the improvement in the international price competitiveness of domestic tradable goods is smaller and effective wage costs are higher. This contractionary monetary policy is, however, accompanied by a modest deflation.

This analysis suggests that monetary authorities face a trade-off between inflation and output stabilization. While expansive monetary policy tends to fuel inflation but mitigates the output drop, tight policies are associated with less inflation but more pronounced drops in output and employment. A monetary authority that targets output and employment stabilization would have to follow expansionary policies, while an authority that targets

[19] We could analyze more sophisticated monetary policy rules, but for presentation reasons we focus on this simple specification, as we are interested in the qualitative policy responses rather than in optimal monetary policy responses.

inflation would follow contractionary policies.

1.5 The Role of Leverage

In this section we compare theoretical IRFs across different levels of external debt. For this purpose we vary the time preference parameter β which determines the economy's impatience and, therefore, its willingness to borrow. Figure 1.6 shows the results for $\beta = 0.92$ and 0.94 which are associated with external corporate debt to annual GDP ratios in steady state of 25% and 10%, respectively. In the high-debt economy the financial amplification leads to a rise in the foreign interest rate of 3.5% (p.q.), opposed to 2% (p.q.) in the low-debt economy. The recession in the highly leveraged economy is deeper and more persistent. For instance, the exchange rate depreciates by 60% and output drops by 3% in the high-debt economy, compared to a depreciation of 20% and output drop of 1% in the low-debt economy.

The intuition is the following. Given the same magnitude of the initial exogenous financial shock, interest payments of the high-debt economy increase by more than in the low-debt economy which results in a higher reduction in wealth. In order to compensate the adverse wealth effect, the high-debt economy finds it optimal to reduce external borrowing by more than the low-debt economy. This implies that the associated currency depreciation and improvement in the trade balance are higher in the high-debt economy. The feed-back mechanism between depreciation, adverse balance sheet and risk premium effects sets in motion a vicious circle of financial amplification in the high-debt economy.

1.6 Conclusions

The present paper investigates how an emerging market economy is affected when it suddenly faces a higher risk premium in international financial markets. We study this question empirically for five Latin American economies within a structural panel VAR model and analyze theoretically the transmission to the real economy, using a dynamic general equilibrium model. In our theoretical framework the financial shock hits initially the corporate sector. The financial shock is modeled as a rise in the risk premium of foreign-currency funds and it is amplified by a feed-back mechanism between currency depreciation, adverse balance sheet and country risk effects.

In our model the economy responds to the financial shock by reducing external borrowing. The economy is forced to run a current account surplus. During the transition, the debt-elastic risk premium limits the economy's ability to smooth out adverse effects on output and employment. The currency depreciates in response and overshoots. Our framework highlights that initially small shocks can culminate in prolonged recessions, depending on an economy's real and financial structure; i.e., most importantly, on the stock of foreign-currency debt, the size of the tradable goods sector, and the share of imports in production.

By calibration and estimation of the structural parameters, the theoretical model is able to reproduce quantitatively empirical impulse responses of GDP, investment, trade balance and domestic credits, triggered by an adverse shock to the country risk premium of five Latin American economies. Regarding policy implications, we find that monetary authorities face a trade-off between higher inflation associated with expansive policies and higher output costs associated with monetary tightening. Based on our sample of countries, monetary authorities that target output stabilization should follow expansionary policies, while authorities that target inflation stabilization should implement contractionary policies.

Appendix to Chapter 1

Figure 1.2: Empirical impulse responses to country spread shocks

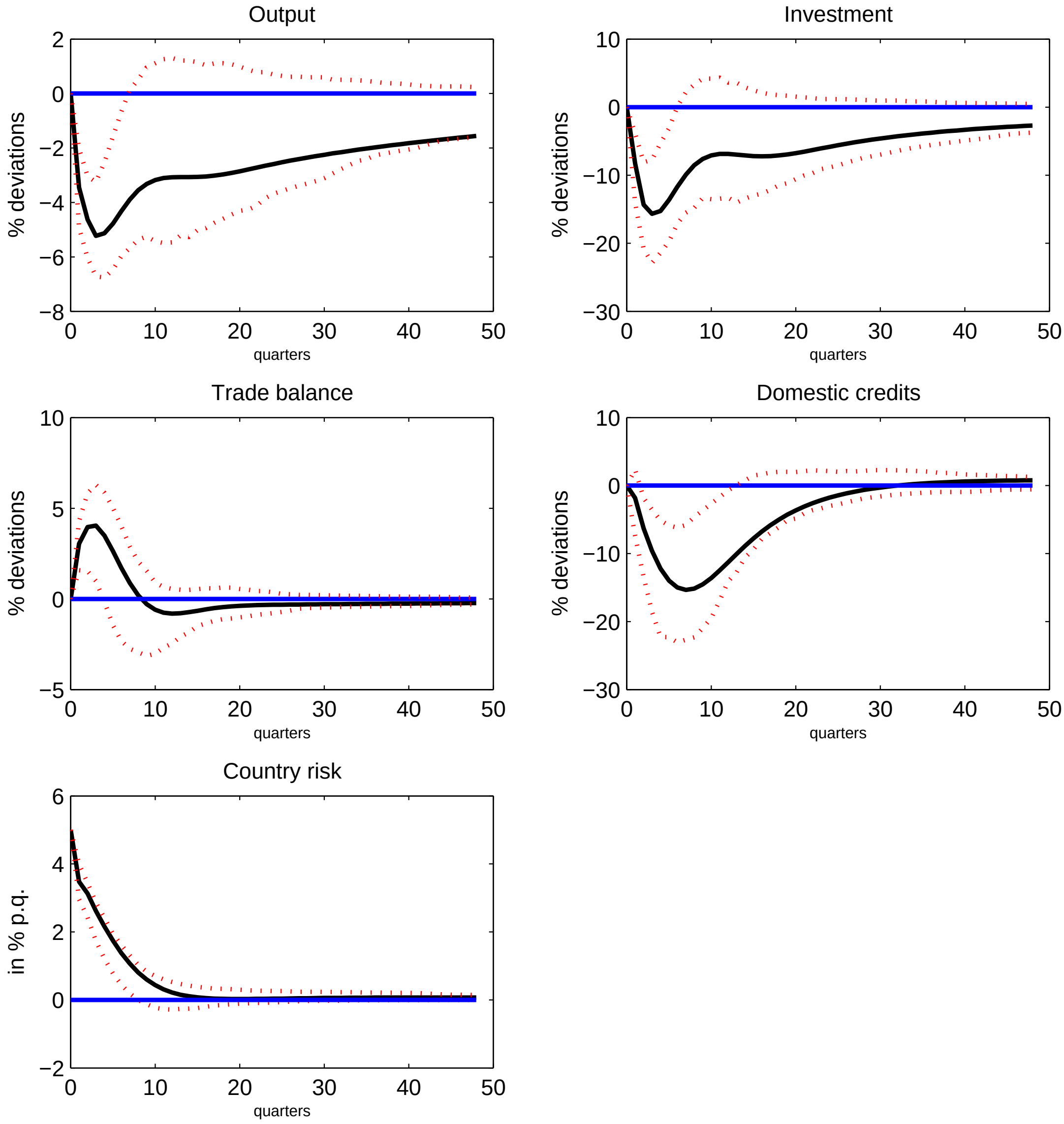


Figure 1.3: Empirical and theoretical impulse responses

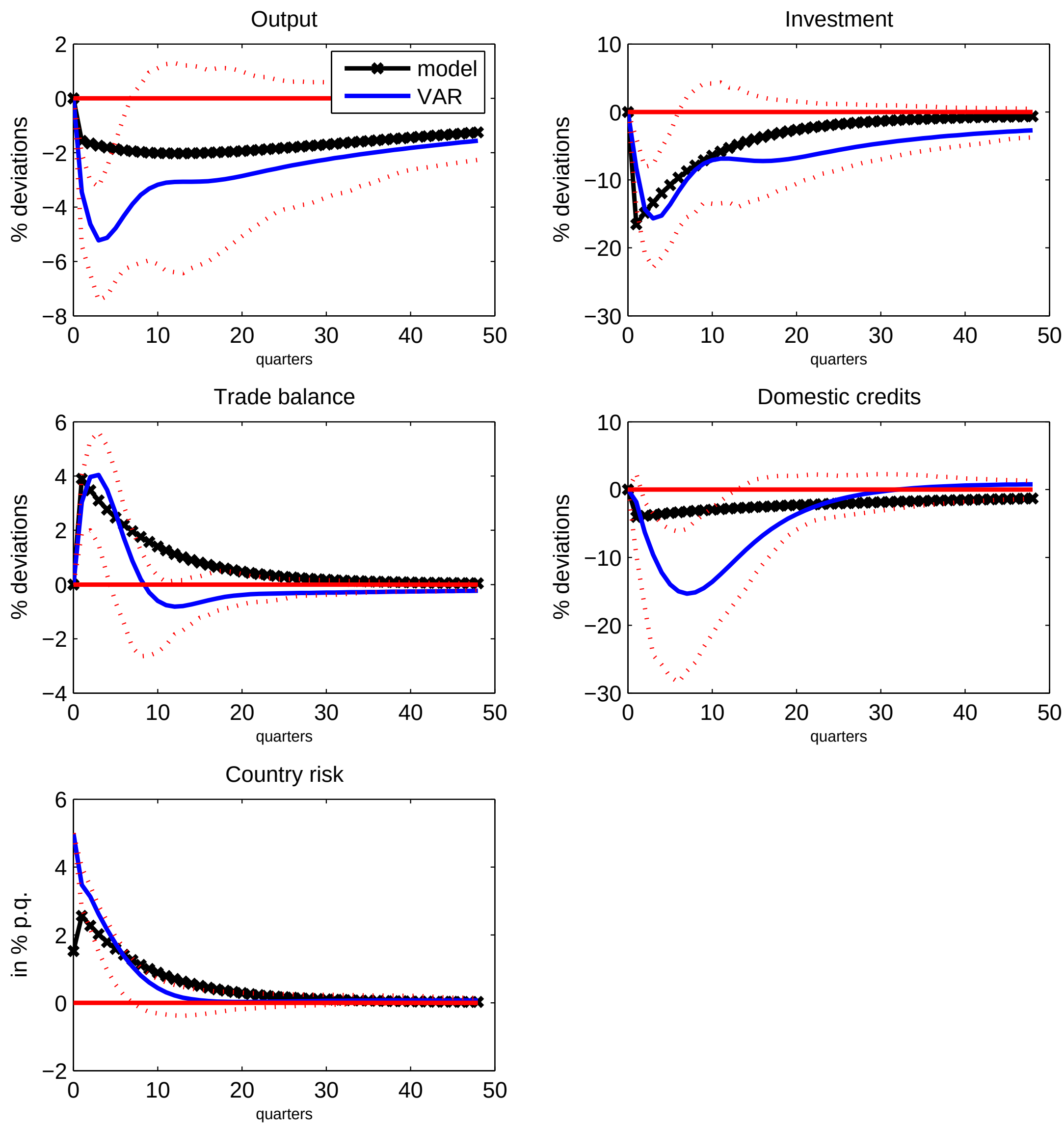


Figure 1.4: Theoretical impulse responses

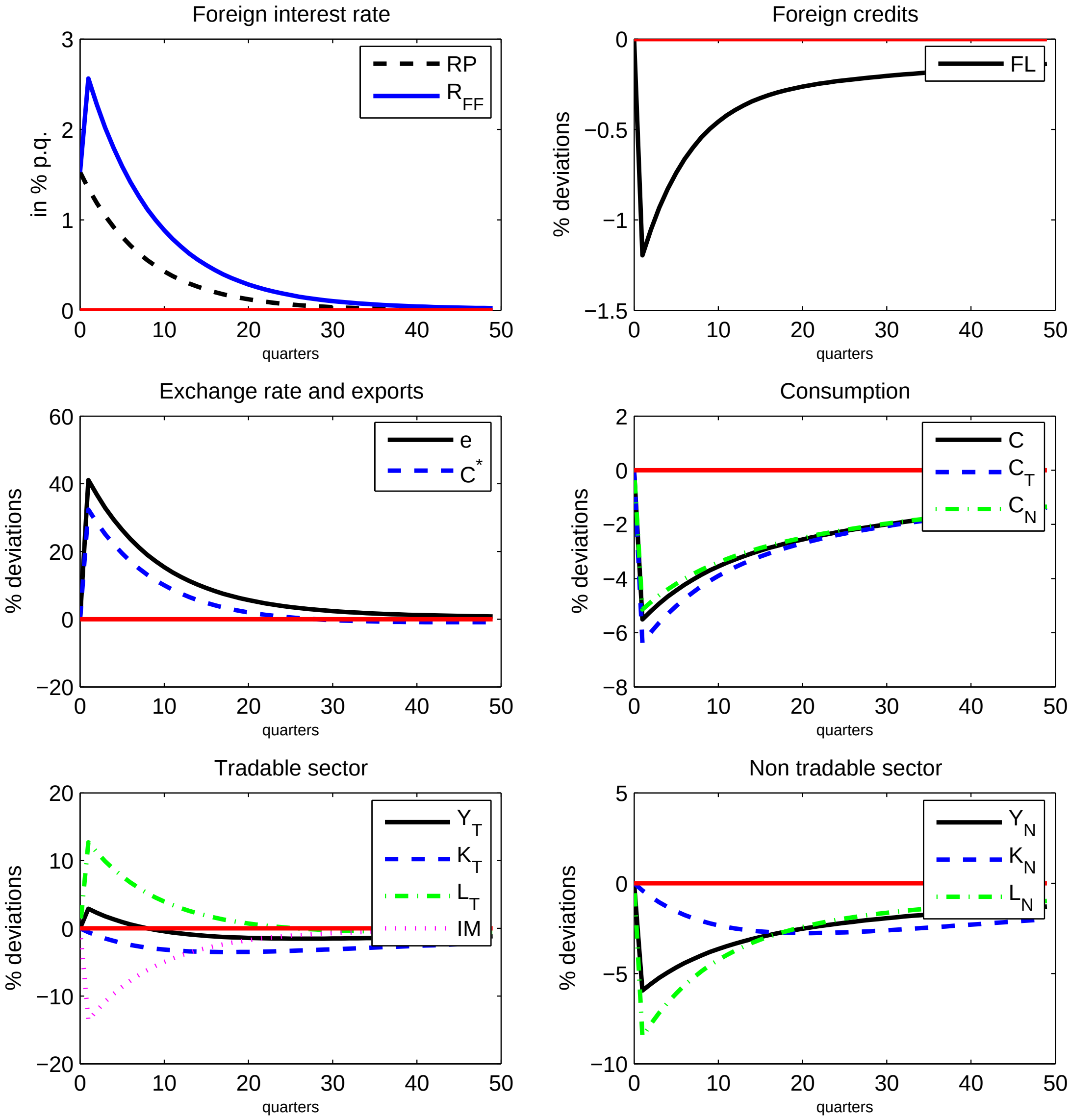


Figure 1.5: Monetary tightening versus monetary loosening

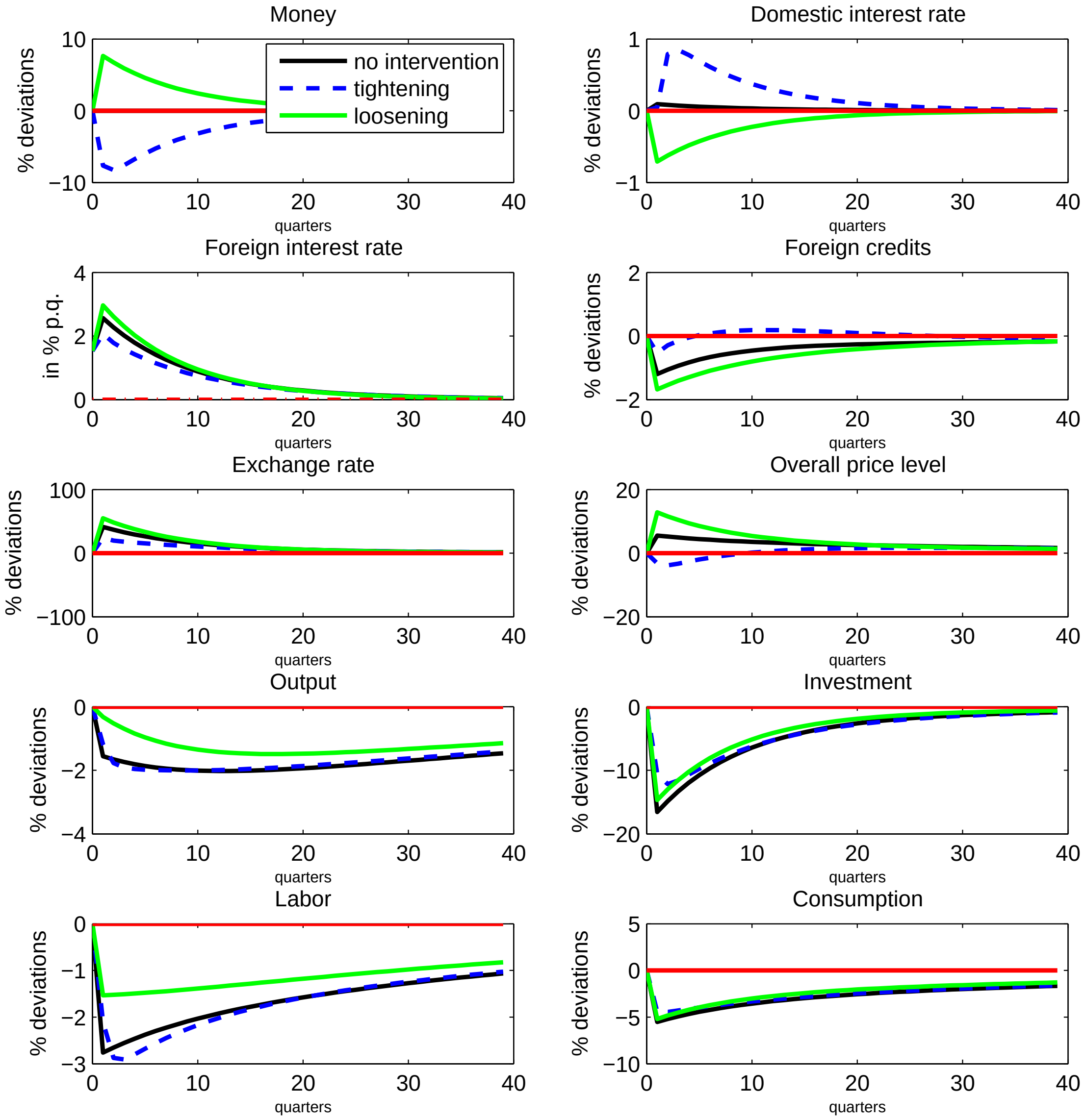


Figure 1.6: Theoretical impulse responses for different debt levels

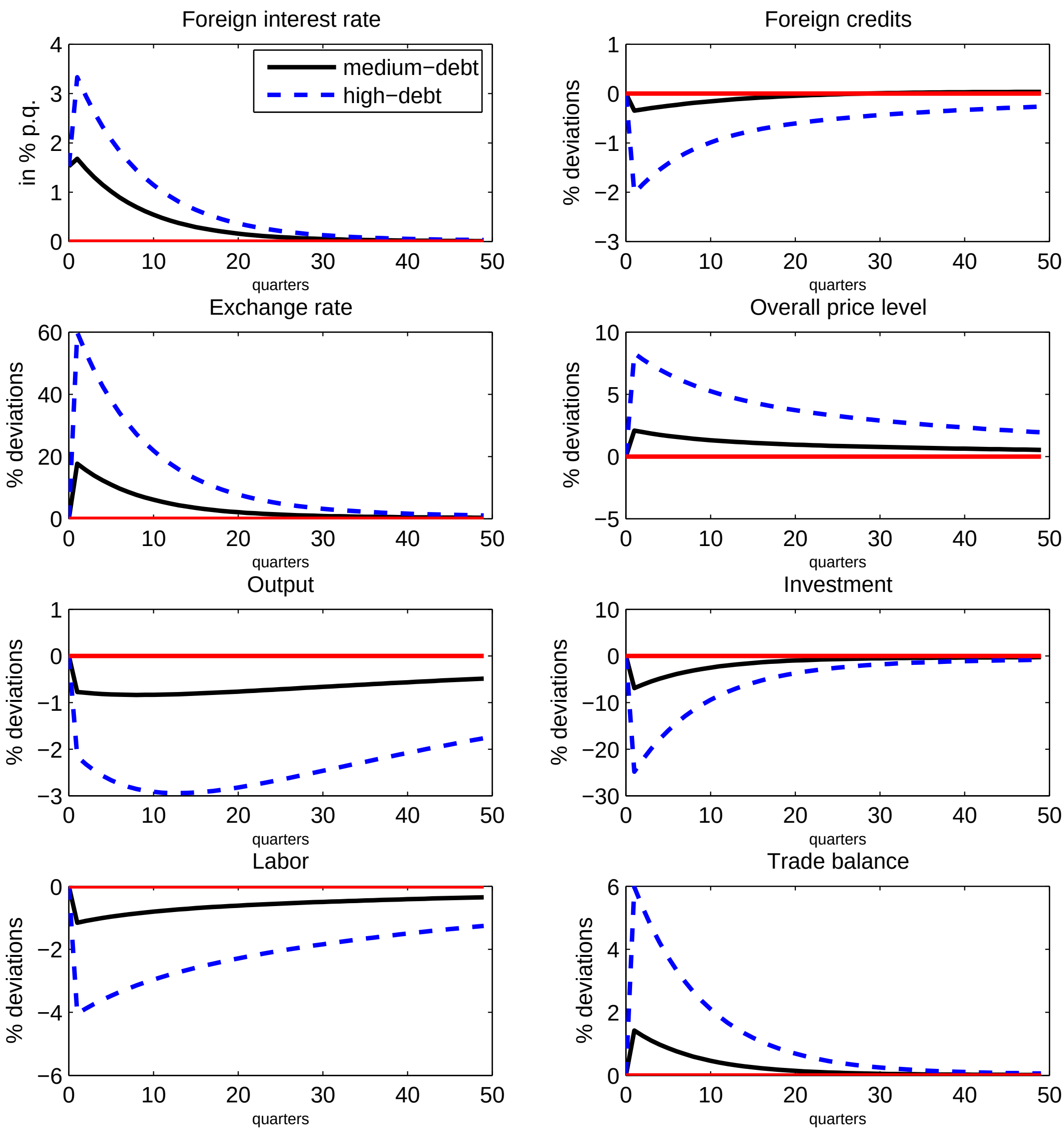


Table 1.1: Description of the data

The data consists of quarterly data for 5 Latin American economies: Brazil, Colombia, Ecuador, Mexico, and Peru. The sample periods vary from country to country: Brazil 1995:1-2007:4, Colombia 1994:1-2007:4, Ecuador 1995:2-2002:1, Mexico 1994:1-2007:4, and Peru 1994:1-2007:4. In total, the data set includes 198 observations. Quarterly series for GDP (series 99B), gross domestic investment (series 93E), trade balance (series 90C minus series 98C), and domestic credits (series 52 and 32) are from IMF's International Financial Statistics. GDP, investment, and the trade balance are seasonally adjusted. GDP, investment, and domestic credits are deflated using the GDP deflator (series 99BIP). Because the GDP deflator for Brazil is not available, we use the consumer price index (series 64). As a measure for the country spread, we use J.P. Morgan EMBI+ stripped spread from the database Datastream. The EMBI+ is a composite index of different liquid dollar-denominated debt instruments such as Brady bonds, Eurobonds, and traded loans by sovereign entities. We express GDP, investment, and domestic credits as log deviations from a log-linear trend, and the trade balance as a ratio of the nominal trade balance to nominal GDP.

Table 1.2: Estimation results for the structural panel VAR

Estimation method: System GMM					
Independent variables	Dependent variables				
	y_t	i_t	tb_t	c_t	r_t
y_t	–	1.43***	0.09	0.19	-0.29***
y_{t-1}	0.69***	-0.47**	0.03	-0.43**	0.20***
y_{t-2}	0.13	-0.76***	-0.06*	-0.09	0.08
i_t	–	–	-0.12***	-0.06	0.04
i_{t-1}	0.07*	0.73***	0.09***	0.08	-0.05
i_{t-2}	-0.01	0.14	0.01	0.09	0.00
tb_t	–	–	–	0.45	0.32**
tb_{t-1}	-0.06	-0.90**	1.28***	-0.57	-0.35
tb_{t-2}	0.36**	0.99**	-0.41***	0.26	0.10
c_t	–	–	–	–	0.07
c_{t-1}	0.02	-0.03	-0.01	1.01***	-0.03
c_{t-2}	-0.03	0.05	0.01	-0.12***	-0.01
r_t	–	–	–	–	–
r_{t-1}	-0.16**	-0.15**	0.11**	-0.14	0.62***
r_{t-2}	0.04	0.08	-0.10***	-0.15	0.17
Observations	198	198	198	198	198
AR(2) test	0.700	0.117	0.535	0.186	0.212
Sargan test	0.011	0.808	0.914	0.899	0.791

Note: The included countries are Brazil, Colombia, Ecuador, Mexico and Peru.

***,**, and * indicate significance at the 1%, 5%, and 10% level.

y_t denotes GDP, i_t investment, tb_t the trade balance, c_t domestic credits and r_t country risk.

For the Arellano-Bond test for autocorrelation in residuals (AR(2)) and the Sargan test of overidentifying restrictions. P-values are reported. The constant is not reported.

Table 1.3: Structural parameters

Parameter	Starting Value	Interval	Estimation Result	Description
β	0.92			time preference
μ	1.455			intertemporal EoS of labor
σ	1.001			intertemporal EoS of consumption
n	0.3			share of C_T in C
λ	0.14	[0.1,0.5]	0.12	EoS between C_N and C_T
γ	0	[0,0.5]	0	disutility of labor
α_T	0.3			capital share in Y_T
α_N	0.4			capital share in Y_N
δ	0.026			capital depreciation
r	0.01			risk-free interest rate
κ	0.04			risk premium parameter
ν	0.3			share of imports in Y_T
γ_T	0	[0,20]	13.11	K_T adjustment costs
γ_N	0	[0,20]	11.79	K_N adjustment costs
Z_{IM}	0.1			import supply parameter
Z_T	0.1			export demand parameter
ϕ_{IM}	0.7	[0.4,1.5]	1.31	price elasticity of import supply
ϕ_T	0.8	[0.5,1.5]	1.20	price elasticity of export demand
σ_{RP}	0.03	[0.001,0.05]	0.015	std. deviation of ε_{RP}
ρ_{RP}	0.7	[0.5,0.9]	0.88	persistence of ε_{RP}

Chapter 2

How important is China for the US exchange rate and current account?

2.1 Introduction

Since the seminal contribution by Obstfeld and Rogoff (1995), there has been a growing research in theoretical international macroeconomics on new workhorse models known as New Open Economy Macroeconomic (NOEM) models. The common feature of these models is the introduction of nominal rigidities and imperfect competition into a dynamic stochastic general equilibrium (DSGE) model, specified with microeconomic foundations.[1] Furthermore, these models have become a fixture in most applied academic and policy work in international macroeconomics. However, while the theoretical work has developed rapidly, there are less contributions on the empirical dimensions which prove and verify the accuracy of these models. For example, Bergin (2003) and Bergin (2006) extend the NOEM into an empirical direction estimating and testing a small open economy and a two-country model, respectively, by adapting maximum likelihood procedure. Lubik and Schorfheide (2006) employ Bayesian techniques to study a two-country model following the NOEM paradigm. In the case of two-country models, previous literature has mostly considered the USA on one side and an aggregate of the remaining G-7 countries or the Euro Area on the other side. It thereby neglects China and Mexico, the two main trading partners of the USA after Canada. As for the policy analysis and applied work it is important to trust on

[1] There is a comprehensive survey on the NOEM literature written by Lane (2001).

NOEM models, this chapter reexamines and extends a standard two-country DSGE model empirically, considering data of the USA on the home-country side and data of its main trading partners, including China and Mexico, on the foreign-country side. The estimation results show that the consideration of data for China and Mexico on the opposite side of the US current account is important for explaining the US current account and exchange rate movements, as well as for getting confident estimates for some deep parameters which are controversial in the theoretical literature.

In the present chapter we assess a standard two-country DSGE model, based on Bergin (2006), featuring monopolistic competition, nominal rigidities, capital accumulation subject to adjustment costs, a debt-elastic country risk premium, and monetary policy specified in the form of an interest rate targeting rule. For this purpose, we estimate various structural parameters of the underlying theoretical model using the maximum likelihood procedure. There are five shocks to the economy: technology, monetary, taste, home bias, and UIP shocks. The estimation procedure will also estimate the correlation coefficients between the UIP and other structural shocks, in order to examine the potential sources of deviations from the UIP condition. We use five data series: output, prices, and the interest rate (all in country differences), the bilateral exchange rate against the US dollar, and the US current account. As China and Mexico are the main trading partners of the US and hold substantial amounts of US dollar assets, the empirical analysis whose interest lies, amongst others, in explaining the US current account and exchange rate movements, cannot be complete passing on data from these countries. Therefore, this chapter addresses the question how the consideration of the main trading partners of the US in the data set changes the estimates of deep parameters and impacts the ability of the NOEM model to explain current account and exchange rate movements.

The obtained results indicate that the estimated model matches surprisingly well a small set of second moments considering that the estimation procedure is assigned to fit all moments of the data. The standard deviations of the data series for the current account, the exchange rate, price and output differentials are matched very well by simulated model variables. Furthermore, the contemporaneous correlation between the current account and output is fitted exactly by the model. Regarding other correlation coefficients, the model performs well in fitting the correlations between the exchange rate and prices, the interest rate and output, and prices and output.

The estimates of the deep parameters are expected to bring some guiding light in the controversial debate on their values in the theoretical literature. In particular, one controversy regards the parameter which describes consumer preferences for home and foreign goods or, to be more precise, the degree of substitutability between home and foreign goods. Empirical studies based on micro-level evidence suggest high elasticities of around five (Harrigan, 1993), while the common assumption in the theoretical literature is an elasticity of substitution of one, which makes NOEM models extremely tractable. Bergin (2006) furthermore provides a statistical significant estimate for this elasticity which is somewhat higher than unity (1.130), estimating the described NOEM model on data from the US and the remaining G-7 countries, and he therefore advocates a unit elasticity of substitution between home and foreign goods. In the present study, the additional data from China and Mexico on the side of the foreign country pushes down the elasticity of substitution, achieving a significant estimate below one. Following different procedures, Corsetti et al. (2008) and Enders and Müller (2009) obtained even lower estimates of the trade elasticity. The other controversy deals with the currency in which prices are sticky. The traditional Keynesian approach assumes that prices are rigid only in exporter's currency (producer-currency pricing), so that nominal exchange rate changes induce demand shifts on the international goods market due to the expenditure-switching effect. Obstfeld and Rogoff (2000) provided empirical evidence supporting the assumption that nominal exchange rate changes play a key role in the short run in shifting world demand between countries. However, Kollmann (1997), Chari et al. (1997), and Betts and Devereux (2000) show the potential of local-currency pricing approach to replicate some controversial international business cycle regularities, such as the high variability of nominal and real exchange rates and the low comovements in international consumption levels. In the underlying theoretical model both types of price rigidities are allowed to coexist, where the share of the local-currency pricing is a parameter which can be estimated. Our results do not provide, in contrast to Bergin (2006), an empirical support for local-currency pricing, estimating its share only at a low level. Furthermore, we estimate the sensitivity of the reaction of the country risk premium to changes in country's net foreign debt positions, as the debt-elastic country risk premium has become a common instrument for imposing stationarity on the net wealth positions. Therefore, we hope that this estimate will be useful for future theoretical work.

Furthermore, the econometric analysis here provides some insights into the nature of the UIP shocks, showing that the deviations from the UIP condition are not closely related to monetary shocks, they rather are positively correlated with technology shocks and shifts in the marginal utility of consumption. Moreover, we support the finding that UIP shocks are especially helpful in explaining fluctuations in the current account, pointing out that the movements on the capital account side of the balance-of-payments condition are important for the current account determination. However, exchange rate movements are mainly explained by the technology shock and its common distribution with the UIP shock. Overall, we hope that the underlying study provides many avenues for critical future research, e.g., current account determination and detection of potential sources for the positive correlation between UIP and technology shocks.

The remainder of the chapter is organized as follows. In Section 2.2 we describe the theoretical model. In Section 2.3 we present the estimation results from the maximum likelihood procedure and discuss their cyclical implications, impulse responses, and forecast error variance decompositions. The final section draws some conclusions.

2.2 The Model

The theoretical framework referred to in the following is based on Bergin (2006). Consider a two-country world, where the countries are called home and foreign. The population of the home country is a fraction n of the world population. Each country is inhabited by a representative household and a representative firm which produces a continuum of intermediate goods. Intermediate goods produced in the home country are indicated by an H subscript, and intermediate goods produced in the foreign country by an F. Variables which describe the foreign country, e.g., goods consumed by the foreign country, are expressed with an asterisk. All variables are written in per capita terms. Steady-state levels are indicated by overbars, while tildes indicate percentage deviations from steady state. The following description focuses on the home country.

2.2.1 Market Structure

Final goods in the economy (Y_t) are produced by aggregating over a continuum of intermediate home goods, produced by the representative home firm and indexed by $i \in [0, 1]$, and over a continuum of imported foreign goods, produced by the representative foreign firm and indexed by $j \in [0, 1]$. The technology for producing final goods is given by:

$$Y_t = \left[\theta_t^{\frac{1}{\mu}} Y_{Ht}^{\frac{\mu-1}{\mu}} + (1-\theta_t)^{\frac{1}{\mu}} Y_{Ft}^{\frac{\mu-1}{\mu}}\right]^{\frac{\mu}{\mu-1}}, \mu > 0, \tag{2.1}$$

where

$$Y_{Ht} = \left(\int_0^1 y_{Ht}(i)^{\frac{1}{1+\nu}} di\right)^{1+\nu}, \nu > 0,$$
$$Y_{Ft} = \left(\int_0^1 y_{Ft}(j)^{\frac{1}{1+\nu}} dj\right)^{1+\nu}.$$

Here Y_{Ht} represents an aggregate of the home intermediate goods sold in the home country and Y_{Ft} an aggregate of the foreign intermediate goods imported by the home country, while lower case counterparts denote outputs of the individual firms. The share of home intermediate goods in the production of final goods is denoted by θ_t, the so called home bias parameter, which is assumed to be subject to stochastic shocks.[2] The parameter μ denotes the elasticity of substitution between home and foreign goods in the production of final goods, while the parameter ν governs the elasticity of substitution between individual intermediate goods in the aggregation function which is given by $(1 + \nu)/\nu$.

Final good producers behave perfectly competitive and solve each period the following optimization problem:

$$\pi_t = \max_{Y_{Ht}, Y_{Ft}} P_t Y_t - P_{Ht} Y_{Ht} - P_{Ft} Y_{Ft},$$

where P_t is the overall price index of the final good, P_{Ht} (P_{Ft}) is the price index of home (foreign) goods, all denominated in the home currency. It is assumed that a fraction η of firms producing intermediate goods (indexed by $i = 0, ..., \eta$) exhibits local-currency pricing, i.e. they set their prices in the currency of the buyer. The remaining fraction of firms ($1 - \eta$, indexed by $i = \eta, ..., 1$) exhibits producer-currency pricing, i.e., they set their prices in their own currency.

The price indexes are defined as:[3]

$$P_t = \left[\theta_t P_{Ht}^{1-\mu} + (1 - \theta_t) P_{Ft}^{1-\mu}\right]^{\frac{1}{1-\mu}},$$

where

$$P_{Ht} = \left(\int_0^\eta p_{Ht}(i)^{-\frac{1}{\nu}} di + \int_\eta^1 p_{Ht}(i)^{-\frac{1}{\nu}} di\right)^{-\nu},$$
$$P_{Ft} = \left(\int_0^\eta p_{Ft}(j)^{-\frac{1}{\nu}} dj + \int_\eta^1 (s_t p_{Ft}(j))^{-\frac{1}{\nu}} dj\right)^{-\nu}.$$

The lower case counterparts of price indexes represent the prices set by individual firms. The nominal exchange rate (s_t) is the home-currency price of one unit of foreign currency.

[2]All stochastic shock processes are presented in Section 2.2.6.

[3]See the appendix for a formal derivation of the price indexes.

The price index of home exports denominated in the foreign currency can be expressed as:

$$P_{Ht}^{*} = \left(\int_{0}^{\eta} p_{Ht}^{*}(i)^{-\frac{1}{\nu}} di + \int_{\eta}^{1} \left(\frac{1}{s_t} p_{Ht}^{*}(i) \right)^{-\frac{1}{\nu}} di \right)^{-\nu}.$$

Given the aggregation technology (2.1), the profit maximization by the final goods producers leads to the following demand functions for home and foreign goods:

$$Y_{Ht} = \theta_t Y_t \left(\frac{P_t}{P_{Ht}} \right)^{\mu}, \tag{2.2}$$

$$Y_{Ft} = (1-\theta_t) Y_t \left(\frac{P_t}{P_{Ft}} \right)^{\mu}, \tag{2.3}$$

with the following demand functions for individual home and foreign goods:[4]

$$\begin{aligned} y_{Ht}(i) &= Y_{Ht} \left(\frac{p_{Ht}(i)}{P_{Ht}} \right)^{-(1+\nu)/\nu} \quad \text{for } i = 0, ..., 1, \\ y_{Ft}(j) &= Y_{Ft} \left(\frac{p_{Ft}(j)}{P_{Ft}} \right)^{-(1+\nu)/\nu} \quad \text{for } j = 0, ..., \eta, \\ y_{Ft}(j) &= Y_{Ft} \left(\frac{s_t p_{Ft}(j)}{P_{Ft}} \right)^{-(1+\nu)/\nu} \quad \text{for } j = \eta, ..., 1. \end{aligned}$$

Analogous conditions apply for the foreign country.

2.2.2 Firm

To produce intermediate goods firms rent capital (K_{t-1}) at the real rental rate (r_t), and hire labor (L_t) at the nominal wage rate (W_t). The assumption of price stickiness is introduced here by quadratic menu costs.

The optimization problem for local-currency pricing firms at home ($i = 1, ..., \eta$) can be summarized by:

$$\max E_t \sum_{\kappa=0}^{\infty} \rho_{t,t+\kappa} \pi_{Ht+\kappa}(i),$$

where

$$\begin{aligned} \pi_{Ht}(i) = {} & p_{Ht}(i) y_{Ht}(i) + s_t p_{Ht}^{*}(i) \left(\frac{1-n}{n} \right) y_{Ht}^{*}(i) \\ & - P_t r_t K_{t-1}(i) - W_t L_t(i) - P_t AC_{Ht}(i) - s_t P_t AC_{Ht}^{*}(i), \end{aligned} \tag{2.4}$$

[4]See the appendix for a formal derivation of the demand functions for individual goods.

subject to

$$
\begin{aligned}
AC_{Ht}(i) &= \frac{\psi_P}{2}\frac{(p_{Ht}(i)-p_{Ht-1}(i))^2}{P_t p_{Ht-1}(i)} y_{Ht}(i), \\
AC^*_{Ht}(i) &= \frac{\psi_P}{2}\frac{(p^*_{Ht}(i)-p^*_{Ht-1}(i))^2}{P_t p^*_{Ht-1}(i)} \left(\frac{1-n}{n}\right) y^*_{Ht}(i), \\
z_t(i) &= A_t K^{\alpha}_{t-1}(i) L^{1-\alpha}_t(i), \qquad (2.5) \\
z_t(i) &= y_{Ht}(i) + \left(\frac{1-n}{n}\right) y^*_{Ht}(i), \qquad (2.6)
\end{aligned}
$$

and subject to the demand functions for $y_{Ht}(i)$ and $y^*_{Ht}(i)$ described in Section 2.2.1. AC_{Ht} represents quadratic price adjustment costs, where $\psi_P \geq 0$ is the price adjustment parameter. The production function is represented in (2.5), where z_t indicates the overall production. Here A_t represents technology common to all production firms in the country, and is subject to stochastic shocks. The parameter α denotes the capital share in the production of each good, and the labor share is given by $(1-\alpha)$. The discount factor $\rho_{t,t+\kappa}$ is used to derive the present value of the date $t+\kappa$ payoffs. Because the firms are assumed to be owned by the households, the future payoffs from production will be evaluated according to the household's intertemporal marginal rate of substitution in consumption, $\rho_{t,t+\kappa} = \beta^{\kappa}\frac{P_t}{P_{t+\kappa}}\frac{U_{C,t+\kappa}}{U_{C,t}}$, where $U_{C,t+\kappa}$ is the household's marginal utility of consumption in period $t+\kappa$. E_t is the expectations parameter conditional on time t information.

The optimization problem for the producer-currency pricing firms $(i = \eta, ..., 1)$ is the same, except that the price p^*_{Ht} is denominated in the home currency and (2.4) is replaced by:

$$
\begin{aligned}
\pi_{Ht}(i) &= p_{Ht}(i) y_{Ht}(i) + p^*_{Ht}(i)\left(\frac{1-n}{n}\right) y^*_{Ht}(i) \\
&\quad - P_t r_t K_{t-1}(i) - W_t L_t(i) - P_t AC_{Ht}(i) - P_t AC^*_{Ht}(i).
\end{aligned}
$$

The optimal trade-off between labor and capital inputs depends on their relative costs:

$$
P_t r_t K_{t-1}(i) = \frac{\alpha}{1-\alpha} W_t L_t(i). \qquad (2.7)
$$

The firms's marginal costs are:

$$
MC_t = \frac{1}{A_t}\alpha^{-\alpha}(1-\alpha)^{\alpha-1}(P_t r_t)^{\alpha} W_t^{1-\alpha}.
$$

Optimal price setting rules for firms can be derived by the maximization of the expected discounted sum of future profits with respect to the individual price under the constraints illustrated earlier in the text and using the optimal trade-off between labor and capital.

The optimal price setting rule for domestic sales of all home firms ($i = 0, ..., 1$) is:

$$\frac{1+\nu}{\nu}\left(\frac{P_t r_t}{P_{Ht}\alpha A_t(L_t(i)/K_{t-1}(i))^{1-\alpha}} + \frac{\psi_P}{2}\frac{(p_{Ht}(i) - p_{Ht-1}(i))^2}{P_{Ht}p_{Ht-1}(i)} - \frac{p_{Ht}(i)}{P_{Ht}}\right)$$
$$\times\left(\frac{Y_{Ht}}{y_{Ht}(i)}\right)\left(\frac{p_{Ht}(i)}{P_{Ht}}\right)^{-\frac{1+2\nu}{\nu}} + \frac{\psi_P}{2}E_t\left[\rho_{t,t+1}\left(\frac{p^2_{Ht+1}(i)}{p^2_{Ht}(i)} - 1\right)\frac{y_{Ht+1}(i)}{y_{Ht}(i)}\right]$$
$$-\psi_P\left(\frac{p_{Ht}(i)}{p_{Ht-1}(i)} - 1\right) + 1 = 0. \quad (2.8)$$

The optimal price setting rule for exports of local-currency pricing firms ($i = 0, ..., \eta$) is:

$$\frac{1+\nu}{\nu}\left(\frac{P_t r_t}{s_t P^*_{Ht}\alpha A_t(L_t(i)/K_{t-1}(i))^{1-\alpha}} + \frac{\psi_P}{2}\frac{(p^*_{Ht}(i) - p^*_{Ht-1}(i))^2}{P^*_{Ht}p^*_{Ht-1}(i)} - \frac{p^*_{Ht}(i)}{P^*_{Ht}}\right)$$
$$\times\left(\frac{Y^*_{Ht}}{y^*_{Ht}(i)}\right)\left(\frac{p^*_{Ht}(i)}{P^*_{Ht}}\right)^{-\frac{1+2\nu}{\nu}} + \frac{\psi_P}{2}E_t\left[\rho_{t,t+1}\left(\frac{p^{*2}_{Ht+1}(i)}{p^{*2}_{Ht}(i)} - 1\right)\frac{s_{t+1}}{s_t}\frac{y^*_{Ht+1}(i)}{y^*_{Ht}(i)}\right]$$
$$-\psi_P\left(\frac{p^*_{Ht}(i)}{p^*_{Ht-1}(i)} - 1\right) + 1 = 0. \quad (2.9)$$

The optimal price setting rule for exports of producer-currency pricing firms ($i = \eta, ..., 1$) is:

$$\frac{1+\nu}{\nu}\left(\frac{P_t r_t}{s_t P^*_{Ht}\alpha A_t(L_t(i)/K_{t-1}(i))^{1-\alpha}} + \frac{\psi_P}{2}\frac{(p^*_{Ht}(i) - p^*_{Ht-1}(i))^2}{s_t P^*_{Ht}p^*_{Ht-1}(i)} - \frac{p^*_{Ht}(i)}{s_t P^*_{Ht}}\right)$$
$$\times\left(\frac{Y^*_{Ht}}{y^*_{Ht}(i)}\right)\left(\frac{p^*_{Ht}(i)}{s_t P^*_{Ht}}\right)^{-\frac{1+2\nu}{\nu}} + \frac{\psi_P}{2}E_t\left[\rho_{t,t+1}\left(\frac{p^{*2}_{Ht+1}(i)}{p^{*2}_{Ht}(i)} - 1\right)\frac{y^*_{Ht+1}(i)}{y^*_{Ht}(i)}\right]$$
$$-\psi_P\left(\frac{p^*_{Ht}(i)}{p^*_{Ht-1}(i)} - 1\right) + 1 = 0. \quad (2.10)$$

2.2.3 Household

The household derives utility from consumption (C_t) of the final good and disutility from supplying labor (L_t). For simplicity, real cash balances (M_t/P_t) used for facilitating transactions are also directly introduced in the utility function, where M_t is the economy's money stock. The household's preferences can be described by:

$$E_t\sum_{\kappa=0}^{\infty}\beta^{\kappa}U\left(C_{t+\kappa}, \frac{M_{t+\kappa}}{P_{t+\kappa}}, L_{t+\kappa}\right), \quad (2.11)$$

where β denotes the household's time preference parameter. The instantaneous utility function takes the form:

$$U\left(C_t, \frac{M_t}{P_t}, L_t\right) = \frac{\tau_t}{1-\sigma_1}(C_t)^{1-\sigma_1} + \frac{1}{1-\sigma_2}\left(\frac{M_t}{P_t}\right)^{1-\sigma_2} - \frac{\sigma_3}{1+\sigma_3}(L_t)^{\frac{1+\sigma_3}{\sigma_3}}, \quad (2.12)$$

where τ_t is the consumption preference or taste parameter which is subject to stochastic shocks. The parameters σ_i for $i = 1, 2$, and 3 denote the intertemporal elasticity terms for consumption, money demand, and labor supply, respectively, where $\sigma_i > 0$ for $i = 1, 2, 3$.

The household derives its income by supplying labor at the nominal wage rate, renting capital to firms at the real rental rate, and receiving nominal profits from the two types of firm (local- and producer-currency firms) and government transfers (T_t). In addition to money, the household holds two types of noncontingent nominal bonds, one denominated in home currency (B_t) and paying return i_t, and one denominated in foreign currency ($-B_t^*$) paying return i_t^*. Furthermore, the household accumulates the capital stock:

$$K_t = (1 - \delta)K_{t-1} + I_t, \tag{2.13}$$

where I_t denotes investment in period t and $0 < \delta < 1$ the constant rate of capital depreciation. It is assumed that changes in the stock of capital are subject to quadratic capital adjustment costs:

$$AC_{It} = \frac{\psi_I}{2} \frac{(K_t - K_{t-1})^2}{K_{t-1}}, \tag{2.14}$$

where $\psi_I \geq 0$ is the capital adjustment cost parameter.

The optimization problem faced by the household is to maximize its life-time utility (2.11) with respect to C_t, M_t, L_t, K_t, B_t, and B_t^*, subject to the budget constraint:

$$CA_t = \frac{B_t - B_{t-1}}{P_t} - \frac{s_t(B_t^* - B_{t-1}^*)}{P_t}, \tag{2.15}$$

where

$$\begin{aligned} CA_t \quad &= \quad \frac{W_t}{P_t}L_t + r_t K_{t-1} + \frac{1}{P_t}\int_0^1 \pi_{Ht}(i)di + T_t + \frac{i_{t-1}B_{t-1}}{P_t} - \frac{s_t i_{t-1}^* B_{t-1}^*}{P_t} \\ &\quad -C_t - I_t - AC_{It} - \left(\frac{M_t}{P_t} - \frac{M_{t-1}}{P_t}\right). \end{aligned} \tag{2.16}$$

Here CA_t denotes the economy's current account in real terms.

The household's optimization problem implies the following optimality conditions. The intertemporal Euler equation associated with the home-currency bond decision implies that the marginal utility of one cash unit hold in home-currency bonds in time t is equal to the discounted expected marginal utility of the returns from this bond at the time $t + 1$:

$$\frac{\tau_t C_t^{-\sigma_1}}{P_t} = \beta(1 + i_t)E_t\left[\frac{\tau_{t+1}C_{t+1}^{-\sigma_1}}{P_{t+1}}\right]. \tag{2.17}$$

This condition implies that the household prefers expected marginal utilities to be constant across the periods, unless the rate of return on savings exceeds the time preference parameter which would induce the household to lower its consumption today relative to the future. The first-order condition associated with cash holdings (M_t) implies the money demand equation:

$$\left(\frac{M_t}{P_t}\right)^{-\sigma_2} = \tau_t C_t^{-\sigma_1} \frac{i_t}{1+i_t}. \tag{2.18}$$

The first-order condition associated with the labor supply decision implies that at the optimum the household chooses consumption and labor such that the marginal rate of substitution between consumption and leisure is equal to their relative price:

$$\frac{L_t^{\frac{1}{\sigma_3}}}{\tau_t C_t^{-\sigma_1}} = \frac{W_t}{P_t}. \tag{2.19}$$

The intertemporal optimality condition with respect to capital equates the costs and expected benefits of an additional unit of capital:

$$\begin{aligned}\left(1 + \frac{\psi_I(K_t - K_{t-1})}{K_{t-1}}\right) &= \\ &\beta E_t\left[\left(\frac{\tau_{t+1}C_{t+1}^{-\sigma_1}}{\tau_t C_t^{-\sigma_1}}\right)\left(r_{t+1} + (1-\delta) + \frac{\psi_I}{2}\left(\frac{K_{t+1}^2 - K_t^2}{K_t^2}\right)\right)\right].\end{aligned} \tag{2.20}$$

Expected benefits on the right hand side are equal to the return from the rental of capital, its resale value after depreciation, and associated savings on future capital adjustment costs. The costs in the current period are given by the unit of investment and associated capital adjustment costs. The optimal portfolio choice can be derived by equating the intertemporal Euler equations with respect to home and foreign bonds:

$$E_t\left[\frac{U_{Ct+1}}{U_{Ct}}\frac{s_{t+1}}{s_t}\frac{P_t}{P_{t+1}}(1+i_t^*)\right] = E_t\left[\frac{U_{Ct+1}}{U_{Ct}}\frac{P_t}{P_{t+1}}(1+i_t)\right].$$

Up to a first-order approximation, this condition implies that the model's uncovered interest parity (UIP) condition is as follows:

$$E_t\left[\frac{s_{t+1}}{s_t}(1+i_t^*)\right] = (1+i_t). \tag{2.21}$$

It is well known that this form of the UIP condition is strongly rejected by the data (Lewis, 1995). Therefore we generalize this expression by adding a 'debt-elastic' risk premium term:

$$RP_t = -\psi_B\left(\frac{B_t - s_t B_t^*}{P_t Y_t}\right)$$

to the left hand side of (2.21). This specification of the risk premium term, which is increasing in a country's level of net foreign debt relative to output, and where the parameter $\psi_B > 0$ controls for the strength of the positive effect of the net foreign debt on the risk premium, ensures stationarity of the equilibrium dynamics, as demonstrated by Schmitt-Grohé and Uribe (2003). Given the incomplete asset markets, shocks can lead to permanent wealth reallocations which would induce nonstationarity and prevent computation of unconditional variances used in the estimation here. Moreover, this modification of the UIP condition is consistent with Lewis (1995) who finds empirical evidence for the existence of predicted interest rate differentials between home and foreign bonds which can be explained by differences in country risks. In steady state there is no net foreign debt and therefore no risk premium. The linearized form of the modified UIP condition is given by:[5]

$$\tilde{i}_t - \tilde{i}_t^* = \frac{1}{1-\beta}(E_t\tilde{s}_{t+1} - \tilde{s}_t) - \frac{\beta}{1-\beta}\psi_B(\tilde{B}_t - \bar{s}\tilde{B}_t^*) + \xi_t, \tag{2.22}$$

where ξ_t is a mean-zero disturbance, aimed at capturing time-varying deviations from UIP. This term is a common device in the literature (Kollmann, 2002), which was interpreted in different ways. In particular, McCallum and Nelson (1999) interpret this term as a representation of time-varying deviations from UIP omitted by linearization, while Mark and Wu (1999) and Jeanne and Rose (2002) derive it as a reflection of noise traders and a distribution of exchange rate expectations. More recently, Bacchetta and van Wincoop (2010) relate UIP deviations to infrequent portfolio decisions which can arise due to relatively small fees for active currency management. A similar UIP condition is implied by the foreign household's optimization. As a result, a bond allocation rule can be created to solve separately for $\tilde{B}_t$ and $\tilde{B}_t^*$. However, in the present chapter we look only at $\tilde{B}_t - \bar{s}\tilde{B}_t^*$, eliminating the need for the bond allocation rule.

2.2.4 Government and Monetary Authority

The government issues no debt. It finances consumption (G_t) and government transfers (T_t) through money creation (seignorage). The simple budget constraint of home government is given by:

$$T_t + G_t = \frac{1}{P_t}(M_t - M_{t-1}). \tag{2.23}$$

[5] Here we linearize around the symmetric steady state, where steady-state levels of home and foreign bonds are equal to zero. Therefore tildes over bonds indicate ratios to the nominal output in steady state.

The monetary policy will be specified in terms of an interest rate targeting rule which can be expressed in the linearized form as follows:

$$\tilde{i}_t = a_1(\tilde{P}_t - \tilde{P}_{t-1}) + a_2\tilde{Y}_t + a_3\tilde{s}_t + \phi_t, \tag{2.24}$$

where a_1, a_2, and a_3 are monetary policy parameters and denote monetary policy responses to inflation, output, and exchange rate fluctuations, respectively. The parameter a_1 is restricted to be above unity such that the Taylor principle is fulfilled. The parameter a_2 is restricted to be positive, and ϕ_t is a monetary policy shock.

2.2.5 Market Clearing Conditions

The market clearing condition for final goods equates production and absorption and is given by:

$$Y_t = C_t + I_t + G_t + AC_{It} + AC_{Ht} + AC^*_{Ht}. \tag{2.25}$$

The consolidated budget constraint of the economy results from combining the household's budget constraint with those of the firm and the government:

$$\begin{aligned}(B_t - B_{t-1}) - s_t(B^*_t - B^*_{t-1}) \quad = \quad & P_{Ht}Y_{Ht} + \left(\frac{1-n}{n}\right) s_t P^*_{Ht}Y^*_{Ht} + i_{t-1}B_{t-1} - s_t i^*_{t-1}B^*_{t-1} \\ & -P_t(C_t + I_t + G_t + AC_{It} + AC_{Ht} + AC^*_{Ht}). \end{aligned} \tag{2.26}$$

Using the market clearing condition for final goods and rewriting P_tY_t in terms of home and imported goods, the consolidated budget constraint reduces to:

$$\begin{aligned}(B_t - B_{t-1}) - s_t(B^*_t - B^*_{t-1}) \quad = \quad & P_{Ht}Y_{Ht} + \left(\frac{1-n}{n}\right) s_t P^*_{Ht}Y^*_{Ht} - (P_{Ht}Y_{Ht} + P_{Ft}Y_{Ft}) \\ & +i_{t-1}B_{t-1} - s_t i^*_{t-1}B^*_{t-1}. \end{aligned} \tag{2.27}$$

The economy's trade balance in real terms (X_t) is given by:

$$X_t = \underbrace{\left(\frac{1-n}{n}\right) \frac{s_t P^*_{Ht}}{P_t} Y^*_{Ht}}_{\text{Exports}} - \underbrace{\frac{P_{Ft}}{P_t} Y_{Ft}}_{\text{Imports}}. \tag{2.28}$$

Using the definition of the trade balance, the consolidated budget constraint can be expressed as:

$$\underbrace{(B_t - B_{t-1}) - s_t(B^*_t - B^*_{t-1})}_{-\text{Capital Account}} = \underbrace{P_tX_t + i_{t-1}B_{t-1} - s_t i^*_{t-1}B^*_{t-1}}_{\text{Current Account}}. \tag{2.29}$$

This condition represents the economy's balance-of-payments condition, which requires that the current account (sum of the trade balance and net foreign interest payments) is equal to the negative of the capital account (change in net foreign assets).

2.2.6 Stochastic Shocks

The economy faces five shocks. The assumptions on the stochastic shocks can be represented as follows:

- home bias shock:

$$(\log\theta_t - \log\bar{\theta}) = \rho_\theta(\log\theta_{t-1} - \log\bar{\theta}) + \varepsilon_{\theta t}, \tag{2.30}$$

- technology shock:

$$(\log A_t - \log\bar{A}) = \rho_A(\log A_{t-1} - \log\bar{A}) + \varepsilon_{At}, \tag{2.31}$$

- consumption preference (taste) shock:

$$\log\tau_t = \rho_\tau(\log\tau_{t-1}) + \varepsilon_{\tau t}, \tag{2.32}$$

- risk premium shock:

$$\xi_t = \rho_\xi(\xi_{t-1}) + \varepsilon_{\xi t}, \tag{2.33}$$

- monetary policy shock:

$$\phi_t = \rho_\phi(\phi_{t-1}) + \varepsilon_{\phi t}, \tag{2.34}$$

where $[\varepsilon_{\theta t}, \varepsilon_{At}, \varepsilon_{\tau t}, \varepsilon_{\xi t}, \varepsilon_{\phi t}]' \sim N(0, \Sigma)$. The stationarity assumptions imply that all autoregressive coefficients are smaller that 1 in modulus. Note that the risk premium shock is allowed to be correlated with other shocks.

We solve the model numerically by linearizing the equilibrium conditions (optimality and market clearing conditions) around the deterministic, fully symmetric steady state and by expressing these conditions as country differences, home minus the foreign counterpart.

2.3 Empirical Investigation

2.3.1 Data

Data from the USA will be used for the home country and an aggregate of its main trading partners for the foreign country. The main trading partners are not only the remaining G-7 countries (Canada, France, Germany, Italy, Japan, and the United Kingdom), but also China and Mexico, which were neglected in the previous literature. Table 2.1 in the appendix reports annual trade weights of the US with its main trading partners calculated as each country's share in total trade of the US with these countries. For example, in 2005 the shares of China and Mexico lie at 0.19 and 0.18, while those of France and Italy lie at 0.04 and 0.03, respectively. Due to numbers reported in Table 2.1, Mexico accounts for around 10-20% of the US trade with the mentioned countries in the selected time period, while China's share rises gradually over time, from 9% in 1999 to 20% in 2005. The five series used will be the exchange rate and the current account, which are of primary interest, as well as the interest rate, output, and the price level. The interest rate and output are included to help identifying monetary and technology shocks, respectively. The price level is important for investigating the role of price stickiness in the model. Moreover, these three variables have been widely used in tests regarding how well macroeconomic models can explain exchange rates (Meese and Rogoff, 1983).

All data are quarterly series at annual rates for the period 1980:1 to 2007:1, obtained from the International Financial Statistics and the Direction of Trade Statistics (both are provided by the International Monetary Fund), and are, except for interest rate, seasonally adjusted. Because the quarterly data for China is not available for earlier periods, China is included only from 1999:1 onwards. The exchange rate for each country is measured as the bilateral rate with the US Dollar (US Dollar per unit of foreign currency). The current account series for the US obtained from the International Financial Statistics is deflated using the GDP deflator. The output is measured as the national gross domestic product (GDP) deflated by the GDP deflator or consumer price index (CPI) for China, as GDP deflator is not available for China. The price level is the CPI, and the interest rate is a treasury bill rate or a call money rate.[6] Foreign aggregate variables are computed as a geometric weighted average, using time-varying trade weights based on each country's share of US trade (exports+imports) only with countries in the sample of the foreign aggregate. All series except for the current account are logged. Because the steady-state value of the current account in the theoretical model is necessarily zero and negative values of the current account are possible, the current account cannot be expressed in a form that represents percentage deviations from steady state in a log form. Instead the current account is scaled by taking it as a ratio to the mean of the US real output. Finally, all series are Hodrick-Prescott (HP) filtered with a smoothing parameter of 1600 to obtain deviations from trend, and the data other than the exchange rate and the current account

[6]The treasury bill rate is used for Canada, France, Italy, Mexico, the United Kingdom, and the USA. The call money rate is used for China, Germany, and Japan.

are transformed in country differences, home minus the foreign counterpart.

2.3.2 Econometric Methods

The econometric procedure fits the linear approximation of the structural model to the data, discussed above, adapting a maximum likelihood algorithm developed by Leeper and Sims (1994) and extended by Kim (2000).

The solution of the model can be expressed in the following autoregressive form:

$$\tilde{x}_t = \Theta_1 \tilde{x}_{t-1} + \Theta_0 \varepsilon_t,\ \varepsilon_t \sim N(0, \Sigma), \tag{2.35}$$

where $\tilde{x}_t$ is a vector containing all variables of the model transformed in the way discussed in Section 2.2 , Θ_1 and Θ_0 are matrices, where each cell is a potentially nonlinear function of the structural parameters, ε_t is a vector containing the five structural disturbances with the remaining elements equal to zero, and Σ is the variance-covariance matrix of these disturbances. To fit this model to the data of five observable variables, an algorithm is used to search for values of certain structural parameters and elements of the variance-covariance matrix (Σ), which will maximize the likelihood function, computed in a recursive way by the Kalman filtering method.

Some structural parameters are not estimated here, but are instead fixed at the values common in the real business cycle literature. This is because the data set used in the estimation omits relevant information or relevant series for these parameters, e.g., capital and labor. In particular, we set the capital share in the production of intermediate goods to be equal to $\alpha = 0.3$, the capital depreciation rate to $\delta = 0.026$ which implies an annual depreciation rate of 10%. The labor supply elasticity is set at unity ($\sigma_3 = 1$), and the steady state share of home intermediate goods in the home final goods aggregate is set to $\bar{\theta} = 0.8$. Following Rotemberg and Woodford (1992), the parameter ν which denotes the elasticity of substitution between individual intermediate goods in the aggregation function is set to 0.2, which implies a steady state price mark-up over marginal costs for intermediate goods of 1.2, consistent with the empirical findings of Martins et al. (1996). Finally, we set the time preference parameter β to be equal to 0.97 which results in $\bar{\imath} = 0.03$.

Moreover, for the model to be well defined, some parameters are restricted within the region specified in Table 2.2 in the appendix. In particular, the monetary policy reaction to inflation (a_1) is bounded below to fulfill the Taylor principle and rule out indeterminacy such that $a_1 > 1$. Autoregressive coefficients on shock processes are greater than zero and less than unity. The covariances between shocks are restricted such that the implied correlations lie between -1 and 1.

2.3.3 Estimation Results

The log-likelihood value of 1431.32 is achieved at the end of the estimation procedure. Bergin (2006) reports the associated value of 1797.55 by estimating the model on the data from the USA and the remaining G-7 countries. The lower log-likelihood value in our estimation does not indicate that the model using our parameter estimates performs worse than the model using the estimates of Bergin (2006), as several model solutions and the underlying data differ. In this sense, there is no direct standard of comparison for the log-likelihood value obtained here and in Bergin (2006). We rather evaluate the performance of the estimated model parameters in terms of fitting contemporaneous unconditional second moments of the data which is a standard fit measure in the DSGE literature. The maximum likelihood estimation used here is trying to fit a set of hundreds of moments and does not place the weight specifically on the set of second moments. Therefore, it is not obvious ex ante how well the estimates will match the small set of second moments. Thus by assessing the fit of the estimation, it is of high interest to look at the cyclical implications of the obtained parameter estimates. Table 2.3 reports standard deviations and contemporaneous correlations of the simulated model variables and the data. The results show, that for the transformed simulated model and data series (both types of series are HP filtered), the standard deviation of the exchange rate in the model (5.8309) matches very well that of the data (5.8509). Moreover, the standard deviations of the current account, price, and output from the data (0.1172, 2.6185, and 2.4958, respectively) are fitted well by the model (0.0999, 2.8069, and 2.4525, respectively). For the interest rate, the standard deviation of the model is less than that of the data. The correlation coefficient between the current account and output in the data given by -0.1501 is exactly matched by the model (-0.1500). Regarding other correlation coefficients, the model performs well in fitting the correlations between exchange rate and price, interest rate and output, and price and output. Overall, the model matches all the signs of the second moments, except for correlations between the current account and the exchange rate, and between the exchange rate and the interest rate. However, the correlations between these pairs of variables implied by the model are only slightly negative.

Table 2.4 shows obtained parameter estimates together with standard errors. Mostly all parameter estimates are reasonable, statistically significant, and lie within the specified intervals. The consumption elasticity term (σ_1) is statistically significantly estimated at 0.0604. The interest rate elasticity term of money demand (σ_2) is estimated at 0.0022 and implies together with the consumption elasticity term (σ_1) the income elasticity of money demand (σ_1/σ_2) of around 27. However, the estimate of σ_2 is not statistically significant and has a very large variance. The estimation procedure shows the likelihood is flat at this and any other point, indicating that the interest rate elasticity term of money demand is not identifiable. The parameter associated with investment adjustment costs (ψ_I) is estimated very close to zero, implying that there are almost no capital adjustment costs. The parameter associated with price adjustment costs (ψ_P) is estimated at 0.6259.

In the present estimation procedure we also estimate some parameters which are controversial in the theoretical literature. In particular, one such controversy regards the parameter which describes consumer preferences for home and foreign goods or, to be more precise, the degree of substitutability between home and foreign goods. As shown in Tille (2001), Van der Ploeg (1993), and Svensson and van Wijnbergen (1989), the degree of substitutability between home and foreign goods determines the strength of the expenditure switching effect of monetary policy and is therefore important for the international welfare implications of monetary shocks. Moreover, the level of the elasticity of substitution between home and foreign goods controls volatility of consumer prices (P), such as by given output volatilities of home and foreign final goods, a lower elasticity of substitution between home and foreign goods induces a higher volatility of consumer prices. There is a clear agreement that the elasticity of substitution between domestic goods and imports should be lower than the elasticity of substitution within a variety of the same good. However, there is a controversy about the exact magnitude of this elasticity. In particular, empirical studies based on micro-level evidence suggest high elasticities of around five (Harrigan, 1993), while the common assumption in the theoretical literature is the elasticity of substitution of one, which makes NOEM models extremely tractable allowing closed-form solutions. Bergin (2006) furthermore provides a statistical significant estimate for this elasticity which is somewhat higher than unity (1.130), estimating the described NOEM model on data from the US and the remaining G-7 countries, and he therefore advocates the unit elasticity of substitution between home and foreign goods. In the present estimation procedure, using in addition the data from China and Mexico, the elasticity of substitution between home and foreign goods (μ) is statistically significantly estimated at 0.7549, which is less then the value of unity. However, the reported statistical significance only indicate that this estimate is significantly different from zero and not from unity. Given the asymptotic normality of maximum likelihood estimates[7], we can use a lower one-sided t-test to verify the null hypothesis that $\mu \geq 1$. The obtained t-statistic (-14.5030) is sufficiently high in absolute terms and negative. We therefore reject the null hypothesis that the elasticity of substitution between home and foreign goods is higher or equal to one. The lower elasticity of substitution estimated here could result from using the additional data of emerging markets, China and Mexico, as goods imported from these countries to the US stem from different production sectors and do not compete directly with goods produced in the US.

The possibilities of modeling nominal rigidities open up another controversial issue in the theoretical literature. In the international setup, the debate occurs about the currency, in which prices are sticky. The traditional Keynesian approach assumes that prices are rigid only in exporters' currencies (producer-currency pricing) and not in importers' currency, so that nominal exchange rate depreciations lead to a proportional increase in the domestic-currency value of domestic imports and to a proportional decrease in the foreign-currency value of domestic exports. Therefore, domestic demand switches from imports toward domestic goods, and foreign demand shifts toward domestic products too. Thus, in the producer-currency framework, nominal exchange rate changes have significant short-run effects on international competitiveness and trade. Obstfeld and Rogoff (2000) provided empirical evidence supporting the assumption that nominal exchange rate changes play a key role in the short run in shifting world demand between countries. Under the alternative assumption of local-currency pricing, a nominal currency depreciation has no expenditure-switching effect in the short run. In dynamic general equilibrium settings, Kollmann (1997), Chari et al. (1997), and Betts and Devereux (2000) show the potential of local-currency pricing approach to replicate some controversial international business cycle regularities, such as the high variability of nominal and real exchange rates and the low comovements in international consumption levels. In the theoretical model presented here, both types of price rigidities are allowed to coexist, and we estimate the share of local-currency pricing firms, η. Table 2.4 shows that this parameter is estimated at 0.3936 at 0.05 significance level, implying that around 60% of home firms price their goods in do-

[7] The asymptotic normality and consistency of maximum likelihood estimates of the parameters of a state-space model are given under two regularity conditions which are fulfilled in our case. First, the state equation has to define a covariance stationary process. Second, the true parameters have not to lie on the boundary of the parameter space (Canova, 2007).

mestic currency, and indicating that there is no strong empirical support for local-currency pricing in NOEM models, at least as long as these models are up to explain the macroeconomic variables examined here. Contrariwise, Bergin (2006) provides an empirical evidence for local-currency pricing estimating η very close to its upper bound of unity. Our result indicates that China and Mexico as well as the change in the time sample (from 1980:1 to 2007:1) affect the result for the exchange rate pass-through, contradicting the common view that recent globalization and, especially, the emergence of China dampen the exchange rate pass-through and thus increase the local-currency pricing share. There are several studies which documented the decline in the exchange rate pass-through in industrial countries pointing to a 'China effect' as an explanatory factor, for example Marazzi et al. (2005) and Murray (2008). This 'China' or globalization effect can be summarized into two main aspects. First, the increased importance of emerging market economies in US trade and the pegging of their exchange rates to the US dollar might decrease the exchange rate pass-through of the US imports. Second, the competitive reaction of other exporting countries to the increased or potential supply from the emerging markets leads, in case of exporter's currency appreciations, to a constrained increase of US import prices denominated in US dollars. However, in our theoretical model, home and foreign countries are fully symmetric and, as the US dollar not only acts as a vehicle currency for US imports but also for US exports, and the emergence of China and Mexico not only drives the import side of the US trade but also its export side, there is a significant amount still assigned to the producer-currency pricing.

The parameter ψ_B which controls the strength of the positive effect of net foreign debt on the risk premium, is estimated at 0.0487. Although this estimate is not statistically significant, this result supports a portfolio balance approach linking inversely the nominal interest rate differential to the ratio of net foreign assets to GDP. The point estimate implies that when a country in our sample runs a ratio of net foreign debt to GDP of 20%, its domestic nominal interest rate would rise by 97.40 basis points. The corresponding significant estimates obtained by Lane and Milesi-Ferretti (2001) from cross-sectional and panel regressions on the data of industrial countries, in which they relate the real interest rate differential to the ratio of net foreign assets to exports, are fairly lower in absolute values and lie at -0.0107 from cross-sectional regressions and at -0.0254 from panel regressions. By looking at the result from panel regressions, their estimate implies that a 20 percentage points improvement in the ratio of net foreign assets to exports leads to a 50.80 basis points reduction in the real interest rate differential. Bergin (2006) estimates the parameter ψ_B at 0.00384 which implies that by the 20% ratio of net foreign debt to GDP the nominal interest rate would rise only by 7.68 basis points. The higher estimate obtained in our estimation procedure could result from including in our sample two emerging market economies, China and Mexico, which generally experience a higher country risk premium than industrial countries. In spite of its non-significance, we hope that this estimate would still provide a useful information for calibrations in future theoretical work.

Finally, Table 2.4 also lists estimates for parameters in the monetary policy reaction function which attempts to stabilize inflation, output, and exchange rate fluctuations. As it is well known, such a rule may lead to (local) indeterminacy. In our estimation strategy, we constrained the inflation parameter to be higher than unity and estimated monetary policy parameters only within the determinacy region. The response to inflation (a_1) is statistically significantly estimated at 1.3017, the response to output (a_2) is estimated very close to its lower bound of zero implying that there is no evidence for active output stabilization. Although the estimated positive response to the exchange rate is not statistically significant, this indicates that there is an active exchange rate stabilization as the depreciation in exchange rate (increase in $\tilde{s}$) will be counteracted by a higher nominal interest rate. However, one has to bear in mind that in the model which is transformed to country differences, the parameter a_3 is the sum of home and foreign monetary policy responses to bilateral exchange rates and, for this reason, we cannot identify an exchange rate response of a particular monetary authority. Regarding monetary policy parameters, Bergin (2006) gets similar results, finding evidence for active exchange rate stabilization and no evidence for active output stimulation. He estimated the response to inflation very close to its lower bound of the determinacy region.

Table 2.4 provides also some information about the nature of structural shocks, in particular about the nature of UIP shocks which have different interpretations in the literature. The estimated results show that monetary policy does not account for deviations from the UIP condition. Instead, the technology shock is highly responsible for deviations from the UIP since it exhibits a high positive and significant correlation with the UIP shock (the correlation coefficient is estimated at 0.8334). Furthermore, the UIP shock is positively correlated with the taste shock (the correlation coefficient is estimated at 0.5009). This result is interesting, as the taste shock directly affects marginal utility which is an important element in the risk premium term, dropped from the UIP condition due to linearization. Therefore, the positive correlation between UIP and taste shocks would confirm one possible interpretation of the UIP shocks as time-varying deviations from the UIP condition omitted by linearization. We also find a small negative correlation of the UIP shock with the home bias shock (the correlation coefficient is significantly estimated at -0.2280). This evidence can be interpreted through the link between the capital and the current account. In the case of an unexpected positive UIP shock, the higher interest rate for home bonds leads to a reallocation of home and foreign wealth towards home bonds, inducing a positive capital account in the home country. By the balance-of-payments condition, the positive capital account translates into a negative current account implying higher imports than exports. Therefore the negative correlation between UIP and home bias shocks proves true by the fact that the negative current account is reinforced by the negative home bias shock. The estimates of shock autocorrelations show that the taste shock is highly persistent, while all other shocks have a lower or medium-size degree of persistence.

By looking at impulse responses, one gets a better intuition about the estimated parameters and what these imply for the dynamics of the economy. Figure 2.1 shows impulse response functions to a one standard deviation technology shock for five series of interest: current account, exchange rate, interest rate, price, and output. The technology shock increases production of home intermediate goods relative to production of foreign intermediate goods. Higher output in the intermediate goods sector leads to lower home intermediate prices, which decreases partly production costs of final goods. Consequently, the production of final goods increases. Since the augmented supply of final goods is to some extent covered by a higher demand, the price of final goods decreases only slightly. As capital gets more productive and its rental price increases, home consumers invest and consume more, borrowing in addition from the foreign country and accumulating foreign debt. The increased net foreign debt raises the country risk premium which, due to the UIP condition, leads to an expected exchange rate appreciation. Therefore the exchange rate depreciates initially, followed by the appreciation. In the beginning, the depreciated exchange rate leads to a negligible deterioration in the current account, which is succeeded by a current account improvement of an insignificant amount. Due to the monetary policy reaction to the exchange rate depreciation, the nominal interest rate increases. Overall, the economy converges fast to its steady state as the technology shock is not highly persistent in our model.

Figure 2.2 shows impulse response functions of the five variables to a one standard deviation shock to the monetary policy rule. A rise in the domestic nominal interest rate relative to the foreign interest rate leads to an immediate fall in domestic output and the overall price level, indicating that demand of final goods deteriorates initially more than output. Due to the UIP condition, the increase in the interest rate induces an exchange rate appreciation which is followed by an expected depreciation. The monetary contraction also involves a small worsening in the current account.

In the following we look at impulse response functions of the five series of interest to the UIP shock, as illustrated in Figure 2.3. The UIP shock can be understood as a shock which leads to a portfolio shift away from home assets, such that a positive interest rate differential between home and foreign assets is required to restore the demand for home assets. In our economy, the UIP shock leads to an exchange rate depreciation which is followed by an expected appreciation. The nominal interest rate increases slightly in a reaction to the exchange rate depreciation and induces a fall in the consumption of final goods. Given initial prices, the production of final goods, however, decreases more, leading to a rise in the price level. The current account improves initially, deteriorating over time and even getting slightly negative during the convergence to its steady state. Overall, in our economy, the UIP shock, often included in the literature to create a high variation in the nominal exchange rate, implies not only a considerable response in the nominal exchange rate, but even in the production of final goods.

Figure 2.4 shows impulse responses to a one standard deviation of the taste shock. The positive taste shock induces an increase in the marginal utility of consumption leading to a rise in consumption of final goods, which even crowds out new investment. The production of final goods heightens not strong enough to cover the induced rise in consumption, implying an increase in the price level. As the demand for final goods increases, the demand for intermediate home and foreign goods increases too, as they are production factors in the final goods sector. However, due to the home bias, the increase in the demand for home intermediate goods is higher relative to this for foreign goods, which leads to a depreciation of the exchange rate. Because of a monetary policy reaction to the increase in the overall price level and to the depreciation of the exchange rate, the nominal interest rate goes up. The implied dynamics of the current account are negligibly small, the current account improves marginally at the beginning and worsens slightly later due to a tiny amount of newly accumulated foreign debt.

Finally, we look at the impulse responses of the five series of interest to a one standard deviation shock to the home bias (Figure 2.5). The positive home bias shock shifts the demand from foreign to home intermediate goods improving initially the current account through the trade balance. As the demand for home intermediate goods increases and their price rises, the demand for their production factors, namely capital and labor, rises too. Due to higher investment and consumption, the production of final goods increases. However, initial demand of final goods increases less than supply which induces overall prices to fall. The improvement in the current account induces the accumulation of net foreign wealth which diminishes the country risk premium. Due to the UIP condition, the lower risk premium involves an exchange rate appreciation followed by an expected depreciation. Because of monetary policy reaction to the initial changes in the price level and the exchange rate, the nominal interest rate falls in the beginning.

Once the model is estimated, the results can be used to evaluate the exogenous sources of fluctuations over the sample period. We use the matrix form of the solution presented in (2.35) and evaluated at values of the estimated parameters to calculate the fraction of the forecast error variance for each variable explained by each shock for different time horizons. The only difficulty in the calculation arises from the fact that the UIP shock is correlated with the other four structural shocks and one has to orthogonalize the shocks in order to disentangle the contributions of other shocks to the UIP shock. We orthogonalize shocks through a Cholesky decomposition of the covariance matrix of the exogenous variables, where the UIP shock is ordered last. The ordering of the remaining four shocks does not matter since they are not correlated with each other, i.e., they are already orthogonal to each other. Using this procedure we attribute any joint distribution between the UIP and four other shocks to these other shocks. Table 2.5 reports the variance of the observed variables decomposed into fractions that are explained by the shocks to technology, monetary policy, taste, home bias, and the UIP condition. The percentages of each variable's forecast error variance due to the five shocks are computed at different time horizons: from 1 to 5 quarters, 10 quarters, 20 quarters, and infinite time horizon, where the latter shows the fraction of the variance of each variable which each shock would explain in an infinitely long simulation of the estimated model. Note that the sum of five numbers in each row is 100%.

Table 2.5 shows that the independent part of the UIP shock explains about 95% of current account movements in the first period and remains very important for the variance explanation even in subsequential periods, e.g., the importance is around 60% in the medium run (10 and 20 quarters). An intuitive explanation for this is that UIP shocks can be understood as portfolio shifts on the international asset market which directly affect country's capital accounts. Therefore UIP shocks should affect the current account through the balance-of-payments condition. This finding is comparable to the results of Bergin (2006), who finds a fraction of the UIP shock in the forecast error variance of the current account to be around 60% in the short run, i.e., in the first 5 quarters. As Bergin (2006) already mentioned, the high importance of the UIP shocks may be linked to the fact that international capital flows are the main driving factor of the current account and not, as presumed before, the optimal intertemporal savings decision. The second most important shock depends on the forecast horizon. In the very short run (the 1st period) and in the infinite horizon the home bias shock advocates for around 5-6% of the current account movements. This arises from the fact that the positive home bias shock has initially a direct effect on the current account through the trade balance by shifting home demand towards home intermediate goods. In the short and medium run (from the 2nd to the 20th period) the technology shock explains around 20% of the current account fluctuations. The positive technology shock brings home residents in our economy to invest and consume more by borrowing from abroad, which drives the capital account and therefore the current account.

In contrast, Table 2.5 shows that around 65% of the exchange rate movements are explained by the technology shock. One link through which the technology shock affects exchange rate movements is partly explained above. The positive technology shock induces home residents to invest and consume more because of a positive wealth effect by borrowing from abroad. The higher net foreign debt increases the country risk premium which in turn drives, due to the UIP condition, the exchange rate to depreciate followed by an expected appreciation. Furthermore, the technology shock has an impact on the production level in the home intermediate goods sector, inducing changes in the price and output of final goods. The following nominal interest rate response creates exchange rate fluctuations via the UIP condition. Moreover, the major component of the UIP shock which drives the exchange rate is highly and positively correlated with the technology shock and is, due to our orthogonalization procedure, entirely attributed to the technology shock. The last explanation also applies to the second most important shock for exchange rate fluctuations, namely the taste shock, as its positive correlation with the UIP shock is completely ascribed to it. Otherwise, the taste shock, through its effect on the marginal utility of consumption, induces exchange rate fluctuations via price and quantity movements on the international intermediate goods market.

For the forecast error variance of the interest rate, we see from Table 2.5 that the monetary policy shock alone accounts for more than 90% of interest rate fluctuations over the whole forecast horizon. This is because the monetary policy shock directly affects the interest rate. The second most important shock is the taste shock which explains around 5% of the interest rate fluctuations. The taste shock, which influences the marginal utility of consumption, is positively correlated with the UIP shock. Since we orthogonalized the UIP shocks such that the joint distribution of the UIP and taste shock is completely attributed to the taste shock, we can conclude that the taste shock also contributes to the deviation of the UIP condition, and therefore drives partly the interest rate movements. The other explanation is that the taste shock also affects the money demand through its effect on the marginal utility of consumption, driving the interest rate as a variable equating money demand and supply.

The most important factor for price movements is the taste shock. It explains steadily over time around 80% of the price movements. The taste shock drives price fluctuations through its effect on the marginal utility of consumption and therefore on the demand for final goods as well as for home and foreign intermediate goods. The second most important shock for the price movements is the monetary policy shock, which explains around 15-20% of price fluctuations over time. There is a feedback of the monetary policy shock on the inflation and real activities which explains the importance of the monetary policy shock for the price fluctuations.

Table 2.5 shows that the most important factor for the forecast error variance of the output is the technology shock which steadily accounts for around 60% of output fluctuations. The second most important shock for understanding output fluctuations is the home bias shock which links home household's preferences towards home intermediate goods, inducing the increase in the demand and thus in the productions of final goods. The home bias shock accounts for around 30-40% of output fluctuations over the whole forecast horizon.

Summing up, the results from the variance decomposition for the current account show that primarily the independent part of the UIP shock drives the current account fluctuations. Given that this outcome also confirms the findings of Bergin (2006), we conclude that the fluctuations on the capital account side of the balance-of-payments, which then drive the adjustment in saving and investment on the current account side, deserve closer researchers' attention if they are interested in modeling and explaining current account movements. Regarding the exchange rate fluctuations, we find that, in contrast to Bergin (2006), the technology shock and its joint distribution with the UIP shock are the main driving forces. If we look again at the impulse responses of the UIP and the technology shock and keep in mind that these two shocks are strongly positively correlated, then we will better understand how the model succeeds in matching the high variance in the exchange rate and the very low variance in the current account. The combination of the positive UIP and the positive technology shock propagates the initial exchange rate depreciation, leaving the current account almost unchanged. For the future theoretical work, it would be interesting to find and investigate potential sources of the positive correlation between the UIP and the technology shock.

This chapter has made an attempt at reassessing the NOEM model, used by Bergin (2006), in its ability to fit to the data from the US and its main trading partners, including China and Mexico, which were neglected in the previous literature. For this purpose, we estimated a two-country dynamic stochastic general equilibrium model with nominal rigidities and monopolistic competition on the data from the US and the remaining G7-countries, China, and Mexico, using the maximum likelihood procedure. The model fits to the data reasonably well. The small set of contemporaneous second moments is matched surprisingly precisely, considering that the estimation procedure is designed to meet all moments of the data. We recognize that the model performs well in matching the standard deviations of the current account, exchange rate, price, and the output. The contemporaneous correlation between the current account and output is fitted exactly by the model. Regarding the estimates for the structural parameters which are controversial in the theoretical literature, we get answers that are different from those provided by Bergin (2006). For example, in contrast to Bergin (2006), we do not support the common assumption in the theoretical literature of a unit elasticity of substitution between home and foreign goods. We significantly estimate this elasticity at 0.7549 and reject the null hypothesis that this parameter is higher or equal to one. Furthermore, we do not provide an empirical support for complete local-currency pricing, as the share of pricing-to-market among all home intermediate producers is estimated only at 0.3936. Although this estimate is statistically significant at 0.05 significance level, it indicates that China and Mexico as well as the change in the time sample (from 1980:1 to 2007:1) affect the result for the exchange rate pass-through, contradicting the common view that the recent globalization and, especially, the emergence of China dampens the exchange rate pass-through and thus increase the share of local-currency pricing. However, in our theoretical model, home and foreign countries are fully symmetric and, as the US dollar not only acts as a vehicle currency for US imports but also for US exports, and the emergence of China and Mexico not only drives the import side of the US trade but also its export side, there is a significant amount still assigned to the producer-currency pricing. We also provide an estimate how the country risk premium reacts to changes in a country's net foreign debt position, reporting a higher value of 0.0487 than the corresponding estimate of Bergin (2006). This might point to the inclusion of China and Mexico in our data set which generally face a higher risk premium than industrial countries. Furthermore, the econometric analysis shows that the deviations from the UIP condition are not closely related to monetary shocks, they are rather positively correlated with technology shocks and shifts in the marginal utility of consumption. Moreover, we find that the independent part of the UIP shock is especially helpful in explaining fluctuations in the current account, while the technology shock and its common distribution with the UIP shock are helpful in explaining movements in the nominal exchange rate. As we support Bergin (2006) in identifying UIP shocks, and thus financial shocks on the capital account side, as driving forces for the current account, we strongly emphasize the importance of modeling international portfolio choices as factors moving the current account. Overall, we hope that the underlying study provides many avenues for critical future research, e.g., detecting potential sources for the positive correlation between the UIP and the technology shock as well as analyzing welfare implications of different monetary and fiscal policy instruments using estimates of structural parameters provided here.

Appendix to Chapter 2

Figure 2.1: Impulse responses to a one standard deviation technology shock

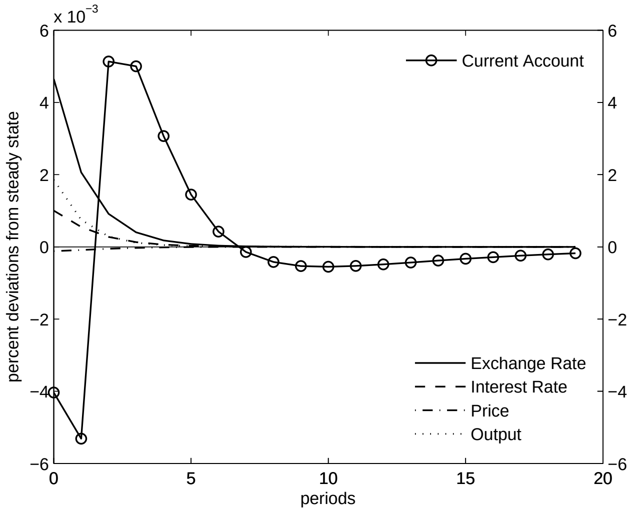


Figure 2.2: Impulse responses to a one standard deviation monetary policy shock

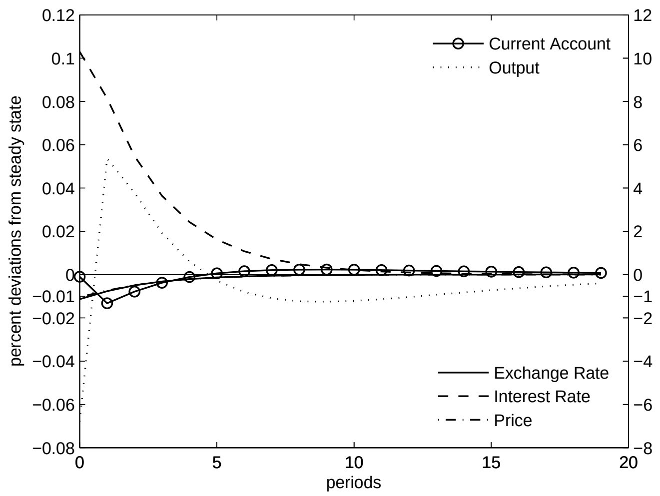


Figure 2.3: Impulse responses to a one standard deviation UIP shock

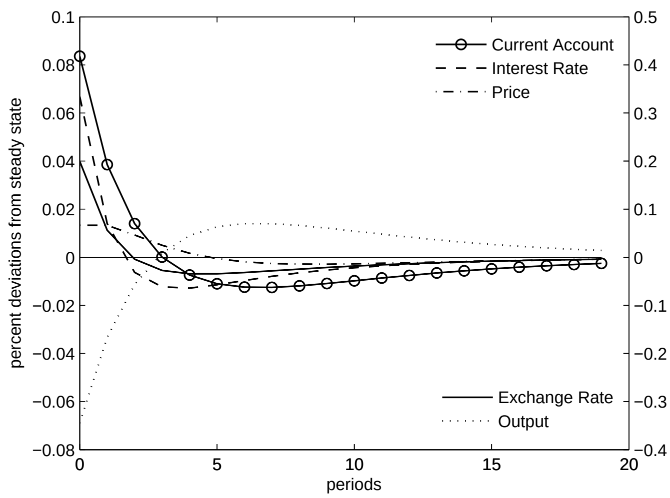


Figure 2.4: Impulse responses to a one standard deviation taste shock

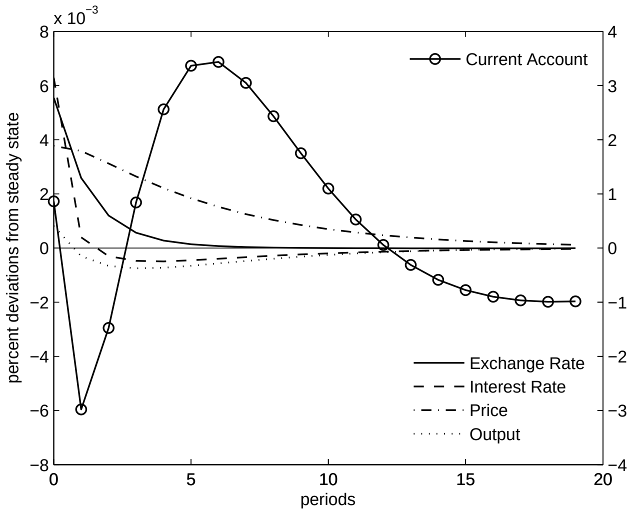


Figure 2.5: Impulse responses to a one standard deviation home bias shock

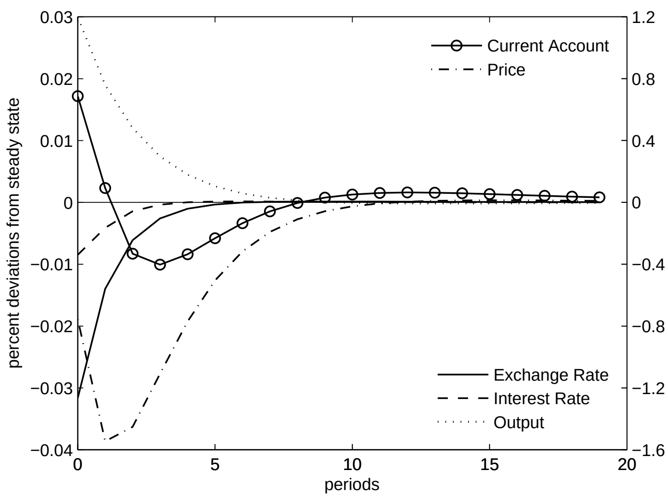


Table 2.1: Annual trade weights of the US with its main trading partners

Year	Canada	China	France	Germany	Italy	Japan	Mexico	United Kingdom
1980	0.34		0.06	0,10	0.04	0,24	0.12	0.10
1981	0.34		0.05	0.09	0.04	0.24	0.13	0.10
1982	0.34		0.05	0.09	0.04	0.26	0.12	0.10
1983	0.36		0.05	0.09	0.04	0.26	0.10	0.09
1984	0.37		0.05	0.09	0.04	0.27	0.10	0.09
1985	0.35		0.05	0.09	0.05	0.29	0.10	0.08
1986	0.32		0.05	0.10	0.05	0.32	0.08	0.08
1987	0.34		0.05	0.10	0.04	0.30	0.09	0.08
1988	0.34		0.05	0.09	0.04	0.29	0.10	0.08
1989	0.34		0.05	0.09	0.04	0.29	0.11	0.08
1990	0.34		0.05	0.09	0.04	0.27	0.11	0.09
1991	0.34		0.06	0.09	0.04	0.27	0.12	0.08
1992	0.34		0.05	0.09	0.04	0.26	0.14	0.08
1993	0.36		0.05	0.08	0.03	0.26	0.14	0.08
1994	0.36		0.05	0.08	0.03	0.26	0.15	0.08
1995	0.37		0.04	0.08	0.03	0.26	0.15	0.08
1996	0.37		0.04	0.08	0.04	0.23	0.16	0.08
1997	0.37		0.04	0.08	0.03	0.22	0.18	0.08
1998	0.36		0.05	0.08	0.03	0.20	0.19	0.08
1999	0.33	0.09	0.04	0.08	0.03	0.18	0.18	0.07
2000	0.32	0.10	0.04	0.07	0.03	0.17	0.20	0.07
2001	0.32	0.11	0.04	0.08	0.03	0.16	0.20	0.07
2002	0.32	0.13	0.04	0.08	0.03	0.15	0.20	0.06
2003	0.32	0.15	0.04	0.08	0.03	0.14	0.19	0.06
2004	0.31	0.17	0.04	0.08	0.03	0.13	0.19	0.06
2005	0.31	0.19	0.04	0.08	0.03	0.12	0.18	0.06
2006	0.30	0.20	0.03	0.07	0.03	0.12	0.19	0.06

Trade weights are calculated as each country's share in total US trade (exports+imports) with these countries.

Table 2.2: Parameter restrictions

Parameters		Values/Regions
Home bias	$\bar{\theta}$	0.8
EoS between individual intermediate goods	ν	0.2
Time preference	β	0.97
Labor supply elasticity	σ_3	1
Capital depreciation	δ	0.026
Capital share in z	α	0.3
Consumption elasticity	σ_1	$(0, \infty)$
Money demand elasticity	σ_2	$(0, \infty)$
Adjustment costs	ψ_P, ψ_I, ψ_B	$[0, \infty)$
Share of LCP	η	$[0, 1]$
EoS between Y_H and Y_F	μ	$(0, \infty)$
MP response to inflation	a_1	$(1, \infty)$
MP response to output	a_2	$[0, \infty)$
MP response to exchange rate	a_3	$(-\infty, \infty)$
Shocks autoregressive coefficients	ρ_θ, ρ_A, ρ_τ, ρ_ξ, ρ_ϕ	$(0, 1)$
Correlations with UIP shock		$[-1, 1]$

Table 2.3: Unconditional second moments

Model Forecast (Data)	Current account	Exchange rate	Interest rate	Price	Output
Current account	0.0999 (0.1172)	-0.0802 (0.0519)	-0.0917 (-0.2708)	0.0338 (0.1180)	-0.1500 (-0.1501)
Exchange rate	-	5.8309 (5.8509)	-0.0456 (0.1303)	0.3896 (0.3443)	0.5792 (0.4829)
Interest rate	-	-	12.8141 (18.8383)	-0.2333 (-0.0446)	0.0440 (0.0910)
Price	-	-	-	2.8069 (2.6185)	-0.0729 (-0.1061)
Output	-	-	-	-	2.4525 (2.4958)

Standard deviations are expressed in percent.

Table 2.4: Parameter estimates

Behavioral Parameters:		
Consumption elasticity	σ_1	0.0604 (0.0189)
Money demand elasticity	σ_2	0.0022 (210.6821)
Investment adjustment cost	ψ_I	0.0000 (0.0000)
Price adjustment cost	ψ_P	0.6259 (0.3386)
Bond cost	ψ_B	0.0487 (0.0381)
Share of LCP	η	0.3936 (0.1970)
EoS between Y_H and Y_F	μ	0.7549 (0.0169)
Monetary Policy Rule Parameters:		
Response to inflation	a_1	1.3017 (0.4651)
Response to output	a_2	0.0000 (0.0000)
Response to exchange rate	a_3	0.2485 (0.2065)
Shock autocorrelations:		
Technology	ρ_A	0.3858 (0.0457)
Monetary	ρ_ϕ	0.6650 (0.0381)
Taste	ρ_τ	0.8214 (0.0062)
Home bias	ρ_θ	0.5335 (0.0420)
UIP	ρ_ξ	0.4449 (0.0454)
Standard deviations of shocks:		
Technology	σ_A	0.0434 (0.0007)
Monetary	σ_ϕ	0.1193 (0.0092)
Taste	σ_τ	0.0220 (0.0008)
Home bias	σ_θ	0.0044 (0.0001)
UIP	σ_ξ	1.0470 (0.0929)
Correlations with UIP shock:		
Technology		0.8334 (0.0003)
Monetary		-0.0197 (0.0116)
Tastes		0.5009 (0.0000)
Home bias		-0.2280 (0.0016)

Values in parenthesis indicate standard errors.

Table 2.5: Variance decompositions (in percent)

Variable	Period	Shocks				
		Technology	Monetary	Taste	Home bias	UIP
Current Account	1	0.22	0.02	0.04	4.04	95.68
	2	18.44	0.09	2.06	3.64	75.77
	3	22.91	0.09	5.96	4.66	66.38
	4	23.42	0.09	8.98	5.45	62.06
	5	23.06	0.11	10.74	5.84	60.25
	10	21.31	0.37	12.67	5.68	59.97
	20	20.47	0.52	13.58	5.56	59.87
	∞	1.09	2.51	2.10	5.90	88.39
Exchange Rate	1	67.06	4.03	23.82	4.97	0.12
	2	66.22	4.84	23.93	4.90	0.11
	3	65.82	5.27	23.93	4.87	0.11
	4	65.65	5.48	23.91	4.85	0.11
	5	65.57	5.58	23.90	4.84	0.11
	10	65.51	5.64	23.89	4.84	0.12
	20	65.51	5.64	23.89	4.84	0.12
	∞	66.23	4.85	23.85	4.93	0.14
Interest Rate	1	0.86	90.59	8.45	0.10	0.00
	2	0.71	93.81	5.40	0.08	0.00
	3	0.65	94.63	4.65	0.07	0.00
	4	0.62	94.91	4.40	0.07	0.00
	5	0.61	95.01	4.32	0.06	0.00
	10	0.59	95.05	4.30	0.06	0.00
	20	0.59	95.04	4.31	0.06	0.00
	∞	0.69	93.20	6.03	0.08	0.00
Price	1	0.30	23.30	76.39	0.01	0.00
	2	0.25	19.34	80.38	0.02	0.01
	3	0.22	16.86	82.89	0.03	0.00
	4	0.19	15.27	84.50	0.03	0.01
	5	0.18	14.24	85.55	0.03	0.00
	10	0.15	12.49	87.33	0.03	0.00
	20	0.15	12.22	87.60	0.03	0.00
	∞	0.23	17.54	82.18	0.03	0.01
Output	1	66.62	0.09	3.19	27.79	2.31
	2	60.02	0.08	2.87	34.58	2.45
	3	57.25	0.07	3.50	36.81	2.37
	4	55.89	0.07	4.37	37.35	2.32
	5	55.08	0.07	5.22	37.31	2.32
	10	53.59	0.09	7.21	36.52	2.59
	20	53.36	0.10	7.42	36.37	2.75
	∞	58.31	0.17	9.28	29.53	2.71

Market Structure

Formally, the price indexes for home intermediate goods sold in the home country (P_{Ht}) and for imported foreign intermediate goods solve the following problems
for P_{Ht}:

$$\min_{y_{Ht}(i)} \int_0^1 p_{Ht}(i) y_{Ht}(i) di$$
$$\text{s.t. } Y_{Ht} = \left(\int_0^1 y_{Ht}(i)^{\frac{1}{1+\nu}} di \right)^{1+\nu} = 1,$$

and for P_{Ft}:

$$\min_{y_{Ft}(i)} \int_0^\eta p_{Ft}(j) y_{Ft}(j) dj + \int_\eta^1 s_t p_{Ft}(j) y_{Ft}(j) dj$$
$$\text{s.t. } Y_{Ft} = \left(\int_0^1 y_{Ft}(j)^{\frac{1}{1+\nu}} dj \right)^{1+\nu} = 1.$$

The price index for final goods solves the problem:

$$\min_{Y_{Ht}, Y_{Ft}} P_{Ht} Y_{Ht} + P_{Ft} Y_{Ft}$$
$$\text{s.t. } Y_t = \left[\theta_t^{\frac{1}{\mu}} Y_{Ht}^{\frac{\mu-1}{\mu}} + (1-\theta_t)^{\frac{1}{\mu}} Y_{Ft}^{\frac{\mu-1}{\mu}} \right]^{\frac{\mu}{\mu-1}} = 1.$$

The following optimization problem leads to the solution for the demand function for individual home goods:

$$\max_{y_{Ht}(i)} Y_{Ht} = \left(\int_0^1 y_{Ht}(i)^{\frac{1}{1+\nu}} di \right)^{1+\nu}$$
$$\text{s.t. } \int_0^1 p_{Ht}(i) y_{Ht}(i) di = I,$$

where I is any fixed total nominal expenditure on goods.

Transformed equilibrium conditions

The equilibrium conditions (optimality and market clearing conditions) are used in the linearized form and are expressed as country differences. The system may be written in the following 19 variables: $\tilde{C}_t - \tilde{C}_t^*$, $\tilde{M}_t - \tilde{M}_t^*$, $\tilde{i}_t - \tilde{i}_t^*$, $\tilde{L}_t - \tilde{L}_t^*$, $\tilde{K}_t - \tilde{K}_t^*$, $\tilde{I}_t - \tilde{I}_t^*$, $\tilde{Y}_t - \tilde{Y}_t^*$, $\tilde{Y}_{Ht} - \tilde{Y}_{Ft}^*$, $\tilde{Y}_{Ft} - \tilde{Y}_{Ht}^*$, $\tilde{z}_t - \tilde{z}_t^*$, $\tilde{B}_t - \bar{s}\tilde{B}_t^*$, $\tilde{r}_t - \tilde{r}_t^*$, $\tilde{P}_t - \tilde{P}_t^*$, $\tilde{W}_t - \tilde{W}_t^*$, $\tilde{P}_{Ht} - \tilde{P}_{Ft}^*$, $\tilde{P}_{Ft} - \tilde{P}_{Ht}^*$, $\tilde{s}_t$, $\tilde{X}_t$, $\widetilde{CA}_t$. Numbered below are the 19 linearized conditions that determine these sequences. Considering the intertemporal Euler equation (2.17), the steady-state nominal interest rate is:

$$\bar{i} = \frac{1-\beta}{\beta}.$$

The linearized home intertemporal Euler equation (2.17):

$$\sigma_1 \tilde{C}_t - \tilde{\tau}_t = \sigma_1 E_t \tilde{C}_{t+1} - E_t \tilde{\tau}_{t+1} + E_t \tilde{P}_{t+1} - \tilde{P}_t - (1-\beta)\tilde{i}_t$$

together with the foreign counterpart is transformed to:

$$\begin{aligned} \sigma_1(\tilde{C}_t - \tilde{C}_t^*) - (\tilde{\tau}_t - \tilde{\tau}_t^*) \quad = \quad & \sigma_1 E_t(\tilde{C}_{t+1} - \tilde{C}_{t+1}^*) - E_t(\tilde{\tau}_{t+1} - \tilde{\tau}_{t+1}^*) \\ & + E_t(\tilde{P}_{t+1} - \tilde{P}_{t+1}^*) - (\tilde{P}_t - \tilde{P}_t^*) - (1-\beta)(\tilde{i}_t - \tilde{i}_t^*). \end{aligned} \tag{2.36}$$

The linearized money demand function (2.18):

$$\sigma_1 \tilde{C}_t + \sigma_2 \tilde{P}_t - \sigma_2 \tilde{M}_t - \tilde{\tau}_t - \beta \tilde{i}_t = 0$$

combined with the foreign counterpart is expressed as a country difference:

$$\sigma_1(\tilde{C}_t - \tilde{C}_t^*) + \sigma_2(\tilde{P}_t - \tilde{P}_t^*) - \sigma_2(\tilde{M}_t - \tilde{M}_t^*) - (\tilde{\tau}_t - \tilde{\tau}_t^*) - \beta(\tilde{i}_t - \tilde{i}_t^*) = 0. \tag{2.37}$$

The linearized labor supply function (2.19):

$$\frac{1}{\sigma_3}\tilde{L}_t = \tilde{\tau}_t - \sigma_1 \tilde{C}_t + \tilde{W}_t - \tilde{P}_t$$

results in the following country difference:

$$\frac{1}{\sigma_3}(\tilde{L}_t - \tilde{L}_t^*) = (\tilde{\tau}_t - \tilde{\tau}_t^*) - \sigma_1(\tilde{C}_t - \tilde{C}_t^*) + (\tilde{W}_t - \tilde{W}_t^*) - (\tilde{P}_t - \tilde{P}_t^*). \tag{2.38}$$

Considering the intertemporal optimality condition with respect to capital (2.20) and using the steady-state level of the nominal interest rate ($\bar{i}$), the steady-state level of the real rental rate is:

$$\bar{r} = 1/\beta - (1-\delta) = \bar{i} + \delta.$$

The linearized form for the optimal capital accumulation condition (2.20):

$$\begin{aligned} (1+\beta)\psi_I \tilde{K}_t - \beta\psi_I E_t \tilde{K}_{t+1} - \psi_I \tilde{K}_{t-1} - (1-\beta(1-\delta))E_t \tilde{r}_{t+1} \\ -\sigma_1 \tilde{C}_t + \sigma_1 E_t \tilde{C}_{t+1} + \tilde{\tau}_t - E_t \tilde{\tau}_{t+1} = 0. \end{aligned}$$

together with the foreign counterpart results in the following country difference:

$$\begin{aligned} (1+\beta)\psi_I(\tilde{K}_t - \tilde{K}_t^*) - \beta\psi_I E_t(\tilde{K}_{t+1} - \tilde{K}_{t+1}^*) - \psi_I(\tilde{K}_{t-1} - \tilde{K}_{t-1}^*) \\ -(1-\beta(1-\delta))E_t(\tilde{r}_{t+1} - \tilde{r}_{t+1}^*) - \sigma_1(\tilde{C}_t - \tilde{C}_t^*) \\ +\sigma_1 E_t(\tilde{C}_{t+1} - \tilde{C}_{t+1}^*) + (\tilde{\tau}_t - \tilde{\tau}_t^*) - E_t(\tilde{\tau}_{t+1} - \tilde{\tau}_{t+1}^*) = 0. \end{aligned} \tag{2.39}$$

Considering the capital stock transition function (2.13), the steady-state level of investment is:

$$\bar{I} = \delta \bar{K}.$$

The linearized form of the capital stock transition function (2.13) expressed as a country difference is given by:

$$\delta(\tilde{I}_t - \tilde{I}_t^*) = (\tilde{K}_t - \tilde{K}_t^*) - (1-\delta)(\tilde{K}_{t-1} - \tilde{K}_{t-1}^*). \tag{2.40}$$

The production function for intermediate goods (2.5) in the linearized form and expressed as a country difference is given by:

$$(\tilde{z}_t - \tilde{z}_t^*) = (\tilde{A}_t - \tilde{A}_t^*) + \alpha(\tilde{K}_{t-1} - \tilde{K}_{t-1}^*) + (1-\alpha)(\tilde{L}_t - \tilde{L}_t^*). \tag{2.41}$$

The linearized form of the optimal trade-off between capital and labor expressed a a country difference is:

$$(\tilde{P}_t - \tilde{P}_t^*) + (\tilde{r}_t - \tilde{r}_t^*) + (\tilde{K}_{t-1} - \tilde{K}_{t-1}^*) = (\tilde{W}_t - \tilde{W}_t^*) + (\tilde{L}_t - \tilde{L}_t^*). \tag{2.42}$$

Using the steady-state condition of the optimal price setting rule for domestic sales of all home firms (2.8), which implies that a steady-state price-marginal cost markup factor of intermediate goods is $1 + \nu$:

$$\bar{P}_H = (1+\nu) \underbrace{\frac{\bar{P}\bar{r}}{\alpha \bar{A}(\bar{L}(i)/\bar{K}(i))^{(1-\alpha)}}}_{\overline{MC}},$$

and the fact that all home firms produce the same and set the same price for their domestic sales:

$$\bar{y}_H(i) = \bar{Y}_H, \bar{p}_H(i) = \bar{P}_H,$$

the linearized form of the optimal price setting rule for domestic sales of local- and producer-currency pricing firms will be derived as:

$$\nu(\tilde{y}_{Ht}(i) - \tilde{Y}_{Ht}) + \widetilde{mc}_t - (1+\nu)\tilde{P}_{Ht} + [\nu - (1+\beta)\nu\psi_P]\tilde{p}_{Ht}(i)$$
$$+\nu\psi_P\tilde{p}_{Ht-1}(i) + \beta\nu\psi E_t\tilde{p}_{Ht+1}(i) = 0,$$

where

$$\widetilde{mc}_t = \tilde{P}_t + \tilde{r}_t - \tilde{A}_t + (1-\alpha)\tilde{K}_{t-1} - (1-\alpha)\tilde{L}_t.$$

The linearized form of the price index for domestic sales of home goods is:

$$\tilde{P}_{Ht} = \eta\tilde{p}_{Ht}(lcp) + (1-\eta)\tilde{p}_{Ht}(pcp),$$

where *lcp* and *pcp* indicate local- and producer-currency pricing, respectively. Substituting price setting rules into the price index above leads to:

$$\widetilde{mc}_t - [1 + (1+\beta)\nu\psi_P]\tilde{P}_{Ht} + \nu\psi_P\tilde{P}_{Ht-1} + \beta\nu\psi_P E_t\tilde{P}_{Ht+1} = 0.$$

The foreign counterpart is:

$$\widetilde{mc}^*_t - [1 + (1+\beta)\nu\psi_P]\tilde{P}^*_{Ft} + \nu\psi_P\tilde{P}^*_{Ft-1} + \beta\nu\psi_P E_t\tilde{P}^*_{Ft+1} = 0,$$

where

$$\widetilde{mc}^*_t = \tilde{P}^*_t + \tilde{r}^*_t - \tilde{A}^*_t + (1-\alpha)\tilde{K}^*_{t-1} - (1-\alpha)\tilde{L}^*_t.$$

Then the country difference results in:

$$\begin{aligned}(\widetilde{mc}_t - \widetilde{mc}^*_t) - [1 + (1+\beta)\nu\psi_P](\tilde{P}_{Ht} - \tilde{P}^*_{Ft})\\ +\nu\psi_P(\tilde{P}_{Ht-1} - \tilde{P}^*_{Ft-1}) + \beta\nu\psi_P E_t(\tilde{P}_{Ht+1} - \tilde{P}^*_{Ft+1}) = 0.\end{aligned} \tag{2.43}$$

The linearized form of the optimal price setting rule for exports of home local-currency pricing firms (2.9) is:

$$\begin{aligned}\nu(\tilde{y}^*_{Ht}(lcp) - \tilde{Y}^*_{Ht}) + \widetilde{mc}_t - (1+\nu)\tilde{P}^*_{Ht} + [\nu - (1+\beta)\nu\psi_P]\tilde{p}^*_{Ht}(lcp)\\ +\nu\psi_P\tilde{p}^*_{Ht-1}(lcp) + \beta\nu\psi_P E_t\tilde{p}^*_{Ht+1}(lcp) - \tilde{s}_t = 0,\end{aligned}$$

and for producer-currency pricing firms (2.10), this is:

$$\begin{aligned}\nu(\tilde{y}^*_{Ht}(pcp) - \tilde{Y}^*_{Ht}) + \widetilde{mc}_t - (1+\nu)\tilde{P}^*_{Ht} + [\nu - (1+\beta)\nu\psi_P]\tilde{p}^*_{Ht}(pcp)\\ +\nu\psi_P\tilde{p}^*_{Ht-1}(pcp) + \beta\nu\psi_P E_t\tilde{p}^*_{Ht+1}(pcp) - (1+\nu)\tilde{s}_t = 0.\end{aligned}$$

The linearized form of the export price index for home goods is:

$$\tilde{P}^*_{Ht} = \eta\tilde{p}^*_{Ht}(lcp) + (1-\eta)\tilde{p}^*_{Ht}(pcp) - (1-\eta)\tilde{s}_t.$$

Substituting price setting rules of local- and producer-currency pricing firms into the export price index leads to:

$$\begin{aligned}\widetilde{mc}_t - [1 + (1+\beta)\nu\psi_P]\tilde{P}^*_{Ht} + \nu\psi_P\tilde{P}^*_{Ht-1} + [\beta\nu\psi_P]E_t\tilde{P}^*_{Ht+1}\\ -[(1-\eta)(1+\beta)\nu\psi_P + 1]\tilde{s}_t + (1-\eta)\nu\psi_P\tilde{s}_{t-1} + (1-\eta)\beta\nu\psi_P E_t\tilde{s}_{t+1} = 0.\end{aligned}$$

The counterpart for foreign country exports is given by:

$$\widetilde{mc}_t^* - [1+(1+\beta)\nu\psi_P]\tilde{P}_{Ft} + \nu\psi_P\tilde{P}_{Ft-1} + [\beta\nu\psi_P]E_t\tilde{P}_{Ft+1}$$
$$+[(1-\eta)(1+\beta)\nu\psi_P + 1]\tilde{s}_t - (1-\eta)\nu\psi_P\tilde{s}_{t-1} - (1-\eta)\beta\nu\psi_P E_t\tilde{s}_{t+1} = 0.$$

We combine these two expressions to get the following country difference:

$$\begin{aligned}-(\widetilde{mc}_t - \widetilde{mc}_t^*) - [1+(1+\beta)\nu\psi_P](\tilde{P}_{Ft} - \tilde{P}_{Ht}^*) + \nu\psi_P(\tilde{P}_{Ft-1} - \tilde{P}_{Ht-1}^*)\\ +[\beta\nu\psi_P]E_t(\tilde{P}_{Ft+1} - \tilde{P}_{Ht+1}^*) - 2[(1-\eta)(1+\beta)\nu\psi_P + 1]\tilde{s}_t\\ +2(1-\eta)\nu\psi_P\tilde{s}_{t-1} + 2(1-\eta)\beta\nu\psi_P E_t\tilde{s}_{t+1} = 0.\end{aligned} \tag{2.44}$$

The price indexes linearized around the fully symmetric steady state are:

$$\tilde{P}_t = \bar{\theta}\tilde{P}_{Ht} + (1-\bar{\theta})\bar{P}_{Ft},$$
$$\tilde{P}_t^* = \bar{\theta}\tilde{P}_{Ft}^* + (1-\bar{\theta})\bar{P}_{Ht}^*.$$

Then the country difference is:

$$(\tilde{P}_t - \tilde{P}_t^*) = \bar{\theta}(\tilde{P}_{Ht} - \tilde{P}_{Ft}^*) + (1-\bar{\theta})(\tilde{P}_{Ft} - \tilde{P}_{Ht}^*). \tag{2.45}$$

The linearized aggregate home demands for home and foreign goods (2.2), (2.3) are:

$$\tilde{Y}_{Ht} = \tilde{Y}_t + \mu\tilde{P}_t - \mu\tilde{P}_{Ht} + \tilde{\theta}_t,$$
$$\tilde{Y}_{Ft} = \tilde{Y}_t + \mu\tilde{P}_t - \mu\tilde{P}_{Ft} - \left(\frac{\bar{\theta}}{1-\bar{\theta}}\right)\tilde{\theta}_t.$$

The foreign counterparts are:

$$\tilde{Y}_{Ft}^* = \tilde{Y}_t^* + \mu\tilde{P}_t^* - \mu\tilde{P}_{Ft}^* + \tilde{\theta}_t^*,$$
$$\tilde{Y}_{Ht}^* = \tilde{Y}_t^* + \mu\tilde{P}_t^* - \mu\tilde{P}_{Ht}^* - \left(\frac{\bar{\theta}}{1-\bar{\theta}}\right)\tilde{\theta}_t^*,$$

Then the country differences are:

$$(\tilde{Y}_{Ht} - \tilde{Y}_{Ft}^*) = (\tilde{Y}_t - \tilde{Y}_t^*) + \mu(\tilde{P}_t - \tilde{P}_t^*) - \mu(\tilde{P}_{Ht} - \tilde{P}_{Ft}^*) + (\tilde{\theta}_t - \tilde{\theta}_t^*), \tag{2.46}$$
$$(\tilde{Y}_{Ft} - \tilde{Y}_{Ht}^*) = (\tilde{Y}_t - \tilde{Y}_t^*) + \mu(\tilde{P}_t - \tilde{P}_t^*) - \mu(\tilde{P}_{Ft} - \tilde{P}_{Ht}^*) - \left(\frac{\bar{\theta}}{1-\bar{\theta}}\right)(\tilde{\theta}_t - \tilde{\theta}_t^*). \tag{2.47}$$

Using the linearized final goods demand (2.25):

$$\tilde{Y}_t = \frac{\bar{C}}{\bar{Y}}\tilde{C}_t + \frac{\bar{I}}{\bar{Y}}\tilde{I}_t + \frac{\bar{G}}{\bar{Y}}\tilde{G}_t$$

together with the foreign counterpart:

$$\tilde{Y}_t^* = \frac{\bar{C}}{\bar{Y}}\tilde{C}_t^* + \frac{\bar{I}}{\bar{Y}}\tilde{I}_t^* + \frac{\bar{G}}{\bar{Y}}\tilde{G}_t^*,$$

results in the following country difference:[8]

$$(\tilde{Y}_t - \tilde{Y}_t^*) = \frac{\bar{C}}{\bar{Y}}(\tilde{C}_t - \tilde{C}_t^*) + \frac{\bar{I}}{\bar{Y}}(\tilde{I}_t - \tilde{I}_t^*) + \frac{\bar{G}}{\bar{Y}}(\tilde{G}_t - \tilde{G}_t^*). \tag{2.48}$$

The linearized home goods market clearing condition (aggregated over individual firms (2.6)) is:

$$\bar{\theta}\tilde{Y}_{Ht} + (1-\bar{\theta})\tilde{Y}_{Ht}^* = \tilde{z}_t,$$

Combined with the foreign counterpart, this results in the country difference:

$$\bar{\theta}(\tilde{Y}_{Ht} - \tilde{Y}_{Ft}^*) - (1-\bar{\theta})(\tilde{Y}_{Ft} - \tilde{Y}_{Ht}^*) = (\tilde{Z}_t - \tilde{Z}_t^*). \tag{2.49}$$

The linearized form of the trade balance (deviations are taken as a ratio to GDP (Y_t)) is:

$$\frac{1}{1-\bar{\theta}}\tilde{X}_t = \tilde{s}_t - (\tilde{P}_{Ft} - \tilde{P}_{Ht}^*) - (\tilde{Y}_{Ft} - \tilde{Y}_{Ht}^*). \tag{2.50}$$

The linearized form of the current account (deviations are taken as a ratio to GDP) is:

$$\widetilde{CA}_t = (\tilde{B}_t - \bar{s}\tilde{B}_t^*) - (\tilde{B}_{t-1} - \bar{s}\tilde{B}_{t-1}^*). \tag{2.51}$$

Then the linearized form of the balance-of-payments condition (2.29) is:

$$\tilde{X}_t + \frac{1}{\beta}(\tilde{B}_{t-1} - \bar{s}\tilde{B}_{t-1}^*) - (\tilde{B}_t - \bar{s}\tilde{B}_t^*) = 0. \tag{2.52}$$

The linearized form of the modified interest rate parity condition as discussed in Section 2.2 is:

$$\tilde{i}_t - \tilde{i}_t^* = \frac{1}{1-\beta}(E_t\tilde{s}_{t+1} - \tilde{s}_t) - \frac{\beta}{1-\beta}\psi_B(\tilde{B}_t - \bar{s}\tilde{B}_t^*) + \xi_t. \tag{2.53}$$

In addition, the linearized version of the interest rate targeting rule (2.24) completes the set of equilibrium conditions:

$$\tilde{i}_t = a_1(\tilde{P}_t - \tilde{P}_{t-1}) + a_2\tilde{Y}_t + a_3\tilde{s}_t + \phi_t. \tag{2.54}$$

[8] Given parameter values α, β, δ, ν, and abstracting from government expenditures in a steady state, we can define the steady-state ratio of investment to output as $\alpha\delta/[(1+\nu)(1/\beta-(1-\delta))]$. The steady-state ratio of consumption to output is then $1-\bar{I}/\bar{Y}$.

Chapter 3

Trade Elasticities in Transition Countries

3.1 Introduction

The role of trade elasticities is central in translating economic analysis into macroeconomic policy. The most prominent example is the Consultative Group on Exchange Rate Issues (CGER) at the International Monetary Fund (IMF), which measures exchange rate misalignments using three complimentary approaches within the course of exchange rate surveillance (International Monetary Fund, 2006b), the IMF's core mandate. Within one of those methodologies, the so called 'macroeconomic balance approach', the CGER measures the exchange rate adjustment needed to eliminate a gap between the current account projected over the medium term at the prevailing exchange rates and the estimated equilibrium current account balance ('current account norm'). By doing so, the CGER crucially relies on country-specific estimates of elasticities of the current account or the trade balance with respect to real exchange rates, which in turn are computed using elasticities of import and export volumes with respect to the real exchange rate. Certainly, trade elasticities are equally important for predicting current account or trade balance shifts implied by a given real exchange rate change.

A special attention in this context should be paid to transition economies from Central and Eastern Europe (CEE) whose real effective exchange rates (REERs) substantially appreciated in a consistent manner since the initial output collapse in the earlier 90's until the occurrence of the recent global financial crisis. REERs in countries from the Commonwealth of Independent States (CIS) - the late bloomers - followed a similar pattern initially, but leveled off after the Russian ruble crisis in 1998 and restarted their initial appreciation phase from 2004 onwards. At the same time, the CIS countries have experienced considerable terms of trade improvements due to higher prices for commodities which they mainly export. However, a simultaneous real exchange rate appreciation, by typically boosting imports and reducing exports, can worsen an external balance, independently of valuation effects on trade flows implied by the terms of trade.

The present chapter investigates import and export volume elasticities with respect to a relative price variable, the REER, and to an income variable for the CEE[1] and CIS[2] countries by estimating trade demand equations, in order to measure trade balance implications of real exchange rate movements. In doing so, we apply different dynamic panel estimation techniques where we allow for discrepancies in trade elasticities between CEE and CIS transition countries that could arise from different trade structures potentially implied by the distinct 'catching-up' processes. Furthermore, the chapter verifies the out-of-sample prediction power of obtained trade elasticities for trade balance ratios to asses the validity of those estimates for translating economic analysis into macroeconomic policy considerations.

Estimating trade demand equations is a long-standing, and relatively successful, part of empirical international economics. The literature examining price and income responses of trade flows is extensive. The seminal contribution by Houthakker and Magee (1969) was followed by a comprehensive survey by Goldstein and Khan (1981). Four broad conclusions arose from this survey on empirical trade studies for industrial countries: (1) the sum of long-run import and export demand elasticities with respect to their relative price exceeds one, i.e., the traditional 'Marshall-Lerner' condition applies; (2) short-run price elasticities of demand for imports and exports are considerably smaller than long-run elasticities; (3) income elasticities of demand range between 1 and 2 on both import and export sides; and (4) there are significant differences in both price and income elasticities of demand across commodity groups. Extensions to the standard trade equation model using more sophisticated econometric methods have resulted in a large body of work on income and price elasticities for a wide range of countries, now including developing countries as well. Numerous empirical trade studies used extensively econometric methodologies in time-

[1]The CEE country group consists of Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovak Republic, and Slovenia.

[2]CIS is comprised of Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyz Republic, Moldova, Russia, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan.

series analysis, such as cointegration approaches and error correction models (e.g., Hooper et al., 1998); autoregressive distributed lag (ARDL) models using ordinary least squares and taking into account nonstationarity of data series (e.g., Senhadji, 1997; Senhadji and Montenegro, 1998); and new cointegration techniques based on the ARDL approach to cointegration that do not require unit root testing (e.g., Bahmani-Oskooee and Kara, 2005). This research broadly supports the original findings in the Goldstein and Khan survey that long-run coefficients are generally more elastic than in the short-run, and that the 'Marshall-Lerner' condition holds. A study by the International Monetary Fund (2006a), which explores the impact of exchange rate movements on the trade balance in a large set of emerging market countries (excluding transition countries) by estimating conventional trade demand equations with dynamic panel estimation techniques, finds that the response of exports to movements in exchange rates crucially depends on the composition and nature of exports, e.g., manufactures or primary commodities. It also constitutes a larger (in absolute values) price elasticity of imports compared to exports, which suggests that the trade balance response to changes in the exchange rate comes more from the import side.

However, most of the existing research is based on the experience of advanced countries, or large samples of developing and emerging market countries. These studies have excluded transition countries, in part because of the structural changes these economies have undergone since their independence, and also because of insufficient time series available for individual country estimates. The empirical research on trade demand elasticities for transition economies is therefore comparatively limited and uses exclusively time-series estimation techniques (e.g., Stučka, 2003; Hacker and Hatemi-J, 2004). The present chapter endeavors to bring the transition countries, namely those from the CEE and the CIS, into the universe of estimated price and activity elasticities of trade volumes in order to investigate current account or trade balance implications of real exchange rate movements. To circumvent small sample handicaps that are associated with individual time-series analysis for transition countries, this study examines price and income elasticities of export and import volumes for transition countries applying different dynamic panel estimation techniques.

The significant results for trade elasticities indicate that increases in domestic and foreign income produce proportional or larger increases in imports and exports in the selected transition countries, with export elasticities being almost twice as high as those of import demand. REERs have a very small impact on trade volumes, which supports the baseline assumption for the estimation approach that goods produced by different countries are imperfect substitutes and is in line with price elasticities previously found for other countries in the literature. Taking into consideration the highest price elasticities of export and import volumes which we obtained from our estimates, we find that the 'Marshall-Lerner' condition is not satisfied for transition countries as a whole, under the assumption of initially balanced external trade positions. Furthermore we observe that the long-run external trade flows in transition countries are largely driven by income changes; changes in REERs or in relative prices do not have any significant impacts on exports and imports in the long run. The estimated price and income elasticities of export and import demands perform quite well in predicting out-of-sample changes in trade balance ratios for Armenia, Georgia, and Russia. Following the 'macroeconomic balance approach' and taking into account only relative price effects on trade volumes, actual changes in trade balances can be matched for a bigger set of countries, including in addition Estonia, Kazakhstan, the Slovak Republic, Slovenia, and Uzbekistan.

The remainder of the chapter is organized as follows. Section 3.2 highlights stylized facts about the external economic performance in selected transition countries and describes patterns of relative prices, trade volumes and external balances. Section 3.3 presents the underlying econometric strategies and discusses estimated results. In this section we first review specifications of standard trade demand equations. We then establish time-series properties of variables used in the empirical analysis and apply accordingly suitable econometric approaches to estimate short- and long-run price and income elasticities of import and export volumes. Section 3.4 summarizes the results for trade elasticities and discusses their trade balance implications by verifying the out-of-sample prediction power of obtained trade elasticities in individual transition countries. The final section concludes.

3.2 External Economic Performance in Countries from CEE and the CIS

Transition countries usually experienced substantial real exchange rate appreciations, due to an adjustment toward a new equilibrium from the initially undervalued real exchange rates and due to productivity gains caused by market-based reforms. These strong real exchange rate revaluations can then lead to marked fluctuations in trade or current account balances in these countries, depending on price elasticities of demands for their exports and imports. In this section we examine recent developments in REERs and other external indicators for two groups of transition countries: countries from CEE, which undertook fast market-based reforms and started the transition process earlier, and countries from the CIS, which have engaged later and more slowly in structural economic reforms.

During the 1995-2008 period - the time period of our empirical study - the CEE countries observed a clear and strong appreciation trend in REERs, with the largest appreciation, of around 100%, taken place in the Slovak Republic, and the lowest appreciation, of around 5%, in Slovenia. In other CEE countries REER levels in 2008 were between 150 and 190% of their 1995 levels (Figure 3.1, where an increase in REERs indicates REER appreciation). The appreciation process evolved continuously, except for longer lasting depreciation phases in Poland (from 2001 to 2004) and Latvia (from 2000 to 2005). The CIS countries, except for Armenia, Belarus, Turkmenistan, and the Kyrgyz Republic, experienced a slight appreciation in the first years of their transition process. This development, however, was interrupted by the Russian crisis of 1998-99, during and after which the currencies of the CIS countries depreciated in real effective terms, restarting their steady appreciation process in 2004 and onwards (with exception of Belarus, Tajikistan, Turkmenistan, and Uzbekistan). The REER appreciation process in Russia begun even earlier, namely in 2000. Compared to 1998, the REERs in 2008 have increased mostly in Armenia (+42%) and in Russia (+40%), while the Kazakh and Ukranian currencies reached only 94 and 95%, respectively, of their levels in 1998.

At the same time, despite the strong loss of price competitiveness, measured by the appreciation of REERs, countries from CEE could increase their export volumes steadily by substantial amounts (Figure 3.2). In countries which have closer trade links to Russia (Bulgaria, the Baltic countries, and Poland), export volumes decreased during and in the aftermath of the Russian financial crisis. However, they returned to the previous upward trends after almost two years. Hungary and Lithuania became the best export performers in this group of transition countries as they nearly quadrupled their export volumes from 1995 to 2008, even though from the lowest levels. The Slovak Republic, whose currency appreciated most in real effective terms among the CEE countries during the time period of our study, and Slovenia, whose REER changed only slightly, showed both a similar evolution of their export volumes, which almost doubled in 2008 in comparison to 1995.

The strong real export performance and concurrent REER appreciation, generally observed for the CEE countries, suggest that either other, non-price, factors were more important in determining the export demand, or that the REER appreciation was beneficial for an export activity growth (certainly not via the 'expenditure switching effect' induced by a rise in relative prices). For example, Kaminski et al. (1996) argue that the export performance in transition countries in Europe and Central Asia can be explained by these countries's ability to implement market-based reforms including price liberalization, macroeconomic stability, and openness to international trade. Furthermore Kaminski et al. (1996) bring forward the argument that the real appreciation in transition countries with initially heavily devalued currencies is a source of pressure for restructuring and enhancement of efficiency in the production sector, and therefore tends to increase export growth, as long as currencies do not overvalue. Most of the CIS countries demonstrated a similar strong export performance between 1995 and 2008 (Figure 3.2), where Azerbaijan and Kazakshstan as oil-exporting countries could even multiply their initial, even though very low, export volumes in 1995 by a factor of six and nine, respectively, up to 2008. The export activity of countries which have tight trade relations with Russia such as Moldova, Ukraine, and Belarus, was evidently hurt by the Russian crisis of 1998-99, and then restarted its steady expansion already in 2000. The REER depreciation in most CIS countries until 2003 can surely partly explain the export expansion in the CIS countries at that time. Export volumes, however, continued to increase even during the REER appreciation episodes at the end of our time sample.

During the 1995-2008 period, import volumes in the CEE countries show a steady upward trend (Figure 3.3), similar to those of export volumes which can mainly be related to the trade integration process with Western Europe as well as to solid concurrent currency appreciations, which made foreign products relatively cheaper in comparison to domestically produced goods and therefore increased the expenditure for imports. Interestingly, being at the same time the best export performers, Lithuania and Hungary take positions of the best import performers within the CEE countries as they could raise their import volumes by a factor of five and four, respectively, between 1995 and 2008. Even though their currencies did not appreciate the most during this period. The Slovak Republic and Slovenia showed a very similar evolution of their import volumes, which quadrupled and tripled, respectively, between 1995 and 2008. In Latvia, import volumes decreased year-on-year by 14% in 2008, after a long period of a positive import growth, showing an early impact of the recent global financial crisis on the Latvian economy. Among the

CIS countries there is only Kazakhstan whose import volumes decreased year-on-year by around 9% in 2008. In most other CIS countries import volumes expanded steadily since 2000 until the end of our time sample, and this in comparable or higher terms than export volumes. The import volumes in Azerbaijan and Kazakhstan, both the best export performers among the CIS countries, expanded the strongest between 1995 and 2008, confirming the evidence already observed in the CEE country group also for the CIS group. Furthermore, as in the corresponding CEE countries, the import extension in Azerbaijan and Kazakhstan can not be mainly explained by REER appreciations, as the currencies of Azerbaijan and Kazakhstan started their steady appreciation period only later, in 2005 and 2004, respectively. There might be other supporting factors; one might think of an income effect from raised export revenues (probably more evident for the CIS countries) and of a high import content of exports (probably more evident for the CEE countries). As the REERs in the most CIS countries started to appreciate in 2004, they can account only partly for the sizeable import volume extensions in these countries which have started earlier, namely in 2000.

Reflecting the strong export and import performance in the CEE countries between 1995 and 2008, the trade balance to GDP ratios in most CEE countries remained steadily negative in the range of 3-15% of GDP (Figure 3.4). Hungary, one of the best export and import performers in the CEE group, had the smallest mean trade deficit of 3 percent of GDP over our time sample. A steady deterioration in trade balance ratios is observed for Bulgaria, Latvia, and Romania. Contrarily, the Czech Republic improved its initial trade balance deficit of about 9% in 1996 to a trade balance surplus of around 3%. Trade balance ratios in the CIS countries fluctuate more over time and vary more between individual countries. The trade balance performance of Azerbaijan is thereby most remarkable among the CIS countries, as Azerbaijan improved its initial trade balance deficit of around 25% of GDP in 1998 by 75 percentage points to almost 50% of GDP in only ten years. Perceptible trade balance improvements can be observed in almost all CIS countries in 1999 and 2000 with some stabilization thereafter. Since 2005 trade balances have deteriorated in most CIS countries mainly due to higher import expansions and concurrent REER appreciations. Kazakhstan and Russia experienced only a slight and short-lived worsening of their trade balance surpluses in 2005 and thereafter. Their trade balance ratio positions have started to improve or have stabilized in 2008. Uzbekistan has shown steady trade balance ratios since 2005, which coincides with a flat REER evolution.

Summing up, the transition process, which took place earlier in the CEE countries and was characterized by a gradual steady REER appreciation, a sizeable export as well as import volume extension, and a negative trade balance, started only late in the CIS countries due to a later conduction of market-based reforms and was interrupted by the Russian crisis of 1998-99. However, since the early 2000s a similar pattern in the selected external indicators, such as a gradual REER appreciation, a steady export as well as import volume expansion, and a deterioration in the trade balance, can be observed in mostly all CIS countries, except for emerged oil exporters.

3.3 Trade Demand Equations

3.3.1 Econometric Model

This study examines price and income elasticities of export and import volumes by applying different panel estimation techniques on a sample of 22 transition countries from CEE and the CIS. The standard approach for specifying and estimating trade equations is the 'imperfect substitutes model' illustrated by Goldstein and Khan (1981). The central assumption of this model is that goods produced in foreign countries are not perfect substitutes to domestically produced goods in domestic consumption. This basic framework provides a trade demand model which relates an export (import) volume to foreign (domestic) income, e.g., real foreign output (real domestic demand), and relative prices, e.g., the real exchange rate. Therefore export (import) demand equation can be specified in the form of the ARDL (1, 1, 1) model as follows:

- import demand

$$m_{it} = \alpha_0 + \alpha_1 m_{it-1} + \beta_0 y_{it} + \beta_1 y_{it-1} + \chi_0 p_{it} + \chi_1 p_{it-1} + \mu_i + \nu_{it}, \quad (3.1)$$

- export demand

$$x_{it} = \delta_0 + \delta_1 x_{it-1} + \phi_0 y^*_{it} + \phi_1 y^*_{it-1} + \theta_0 p_{it} + \theta_1 p_{it-1} + \mu_i + \nu_{it}, \quad (3.2)$$

where m_{it} is the import volume of country i in year t, y_{it} is real domestic demand, p_{it} is the real effective exchange rate, x_{it} is the export volume (total or non-oil), and y^*_{it} is real world GDP or export-weighted real GDP of trading partners. All variables are expressed in natural logarithms. Of the error components, μ_i is the unobserved time-invariant country-specific effect with $E(\mu_i) = 0, E(\nu_{it}) = 0$, and $E(\mu_i \nu_{it}) = 0$ for $i = 1, 2, \ldots, N$ and

$t = 2, 3, \ldots, T$. It is assumed that all independent variables are potentially correlated with country-specific effects and idiosyncratic shocks (ν_{it}).

3.3.2 Empirical Analysis

Data Description

The study applies various dynamic panel data approaches to estimate trade elasticities for a group of 22 countries comprised of 12 CIS countries and 10 countries from CEE (footnotes 1 and 2). Available data covers 14 annual observations from 1995-2008, thus providing 286 observations for panel regressions. The appendix provides a detailed description of the variables and data sources.

Panel Unit Root Tests

As a preliminary step, the panel data set is tested for the existence of unit roots by applying several panel unit root tests: tests which assume a common unit root process such as Levin et al. (2002) (LLC), Harris and Tzavalis (1999) (HT), and a test which assumes individual unit root processes such as Maddala and Wu (1999) (MW).[3] Table 3.9 shows that the results for variables entering the import demand equation are not unambiguous. Two tests, the LLC and MW, show that the REER is nonstationary in levels and stationary in first differences. The HT test finds, however, all variables entering the import demand equation to be stationary in levels. Additionally, by the MW test, real domestic demand is found to be integrated of order one, whereas it is shown to be stationary by the two other panel unit root tests. Ambiguous results are shown in Table 3.10 for variables entering the export demand equation. All variables appear to be stationarity in levels under HT, whereas the MW test indicates that non-oil export volume and world real GDP are nonstationary in levels but stationary in first differences.

In view of the ambiguous results regarding the time properties of the data series and due to the caveats about the low power of panel unit root tests coming from the small time dimension, the chosen econometric methodology follows two paths. First, assuming that all data series are persistent but stationary, we apply the Generalized Method of

[3] The choice of the implemented tests was based on the results from a large scale simulation study conducted by Hlouskova and Wagner (2006), in which various panel unit root tests designed for cross-sectionally independent panels were examined with regards to their performance as a function of the time and cross-section dimensions.

Moments (GMM) System estimator, or the so-called Blundell and Bond (1998) estimator that is a further modification of the Arellano and Bond (1991) estimator. The GMM System estimator is designed for panel data sets with the number of cross-section units being large relative to the number of time observations and is valid under the assumption that independent variables are not strictly exogenous. Second, as a robustness check of the GMM results and under the assumption that the data is nonstationary and integrated of order one, we apply various panel cointegration techniques to estimate short- and long-run trade elasticities.

Import Demand Equation

GMM System Estimator First, assuming that the variables are stationary, the import demand equation is estimated with the GMM System estimator. Due to endogeneity problems which can arise from including real exchange rates and trade volumes simultaneously in one estimated relationship, we treat both variables as endogenous in both import and export demand equations and instrument them by lags of these variables dated $t-2$ and earlier for the equation in first differences and by lagged first differences of these variables for the equation in levels. Furthermore the real domestic demand variable in the import equation is treated as predetermined and is instrumented by its lags dated $t-1$ and earlier in the equation in differences and by the contemporaneous first difference in the equation in levels.

The short- and long-run elasticities of import volumes with respect to real domestic demand and the REER are reported in Table 3.1 with the short-run elasticity of import volume with respect to income being equal to $\hat{\beta}_0$ (with respect to the REER: $\hat{\chi}_0$) and the long-run elasticity being $(\hat{\beta}_0+\hat{\beta}_1)/(1-\hat{\alpha}_1)$ (with respect to the REER: $(\hat{\chi}_0+\hat{\chi}_1)/(1-\hat{\alpha}_1)$). The estimation results indicate that the income elasticity of imports in transition countries is relatively high and lies well above unity - that is, 1.1 in the short-run and 1.5 in the long-run. These statistically significant income elasticities are economically meaningful, pointing at a overproportional demand for foreign goods in case of increasing real domestic demand, especially in the longer run. The significant estimate of the price elasticity of imports lies at 0.7 in the short-run, showing that a REER appreciation increases import demand in transition countries. There are direct and indirect channels through which a REER appreciation can raise the absorption of foreign goods. As a result of the REER appreciation, other things equal, foreign goods become relatively cheaper in comparison to domestic goods and therefore domestic households are induced to switch their expenditure from domestic to foreign goods. This direct price effect is usually called substitution or 'expenditure switching' effect. Furthermore, the REER appreciation can indirectly affect demand for imported goods through a valuation effect on net wealth. For example, in case of a net foreign debt country whose debt is denominated in foreign currency, a REER appreciation driven by a nominal appreciation lowers the domestic currency value of foreign debt and raises the domestic net wealth which stimulates demand for home as well as for imported goods. The price elasticity of imports therefore reflects the direct substitution and the mentioned wealth effect. The price impact on import demand is however smaller than the income effect in transition countries. In the long run there are no significant import demand effects of relative price movements.

By dividing the sample into two groups of countries, CEE and CIS, we check whether there are any significant differences in price and income responses of import volumes in these two country groups. The results, shown in Table 3.1, indicate that the income effect on import demand in both groups of transition countries is high and statistically significant in the short run, 1.2 for CEE and 1.0 for CIS countries. In the long run, evidence of a high positive elasticity of imports with respect to real domestic absorption can be observed only in case of CEE countries. However, the significant impact of the REER in the short run on import volumes is evident only for CIS countries. The results of a standard t-test with the null hypothesis of identical elasticities in two groups of transition countries indicate that short- and long-run elasticities with respect to real domestic demand and the REER obtained in two separate estimations are not statistically significantly different from each other.[4]

Panel Cointegration Techniques Assuming that the underlying series are nonstationary and integrated of order one, we use alternative estimation methods based on panel cointegration techniques and rewrite the ARDL (1, 1, 1) model in (3.1) and (3.2) into an error correction representation form, e.g., for (3.1):

$$\begin{aligned}\Delta m_{it} &= -(1-\alpha_1)\left[m_{it-1} - \left(\frac{\beta_0+\beta_1}{1-\alpha_1}\right) y_{it-1} - \left(\frac{\chi_0+\chi_1}{1-\alpha_1}\right) p_{it-1}\right] \\ &\quad +\beta_0 \Delta y_{it} + \chi_0 \Delta p_{it} + \alpha_0 + \mu_i + \nu_{it}. \qquad (3.3)\end{aligned}$$

[4]To obtain such a statistical comparison we interact the estimated model for the whole sample with a group dummy variable for CIS countries and test whether estimates of the corresponding dummy variables (deviations of import elasticities between CIS and CEE countries) are significantly different from zero. The t-statistics and probability values are reported in the appendix in Table 3.11.

Table 3.1: Import Demand: Coefficient Estimates and Implied Elasticities

System GMM	Whole Sample		Partitioning			
			CEE		CIS	
	Coefficient Estimates	Long-run Elasticities	Coefficient Estimates	Long-run Elasticities	Coefficient Estimates	Long-run Elasticities
Import Volume						
First Lag	0.915***		0.884***		1.005***	
	(0.096)		(0.109)		(0.113)	
Real Domestic Demand						
Contemporaneous	1.071***	1.438***	1.208***	1.190***	0.994***	-0.856
	(0.113)	(0.129)	(0.113)	(0.154)	(0.114)	(45.837)
First Lag	-0.950***		-1.069***		-0.990***	
	(0.121)		(0.132)		(0.091)	
REER						
Contemporaneous	0.654***	-0.566	0.225	-0.735	0.465*	17.709
	(0.210)	(0.650)	(0.272)	(1.719)	(0.238)	(405.104)
First Lag	-0.702**		-0.311		-0.550	
	(0.291)		(0.230)		(0.353)	
Diagnostic Statistics						
N of observations	286		130		156	
N of countries	22		10		12	
Tests						
Hansen test	16.13		7.10		1.53	
AB test for AR(1)	-2.19**		-0.96		-2.17**	
AB test for AR(2)	-0.35		-1.48		-0.60	

Note: Robust standard errors in brackets. Estimations with intercept.

* indicates significance at 10% level, ** at 5%, and *** at 1% level.

Within this representation we distinguish between a long-run (equilibrium) relationship among trade demand variables (expression in square brackets in (3.3)) and short-run dynamics (β_0 and χ_0) which in turn are influenced by deviations from the long-run equilibrium. The coefficient $-(1-\alpha_1)$ is the error correcting speed of adjustment term, which is expected to be significantly negative under the assumption that variables are cointegrated and, therefore, show a return to the long-run equilibrium. If this coefficient was equal to zero, there would be no evidence for a long-run relationship. The error correction representation is thus only reasonable if the underlying variables are cointegrated, i.e., if they significantly respond to any deviations from the long-run equilibrium. To confirm the validity of the baseline specification estimates obtained from the GMM System estimator, three different panel cointegration estimators are used here. The first estimator is the mean-group (MG) estimator proposed by Pesaran and Smith (1995), which consists of estimating ARDL models in the error correction representation form separately for each country. The MG estimator then derives panel estimates as simple averages of individual country estimates. The second estimator proposed by Pesaran et al. (1999) assumes that the long-run responses of the dependent trade demand variable to changes in relative prices and income are equal across countries. This estimator, called the pooled mean-group (PMG) estimator pools individual long-run coefficients, while allowing other coefficients (e.g., intercepts, short-run coefficients) to differ across countries. The validity of the cross-sectional long-run homogeneity restriction of the PMG estimator can be tested by the Hausman test (Hausman, 1978). The third estimator, the dynamic fixed effects (DFE) estimator, like the PMG estimator, restricts coefficients of the cointegrating relationship to be equal across panels. Further the DFE estimator assumes that short-run coefficients and the speed of adjustment coefficient are equal across individual countries, while allowing for country-specific intercepts. As for the PMG, the validity of the homogeneity assumption made by the DFE estimator can be tested using the Hausman test.

The results obtained from the above mentioned panel cointegration techniques are presented in Table 3.2. The Hausman test which was used to verify the validity of a stronger homogeneity assumption in pairwise comparisons of the applied panel cointegration methods indicates that the homogeneity assumption of long-run as well as short-run elasticity coefficients is valid for the given import demand data set, and therefore the DFE estimator is proven to be a more efficient estimator. In particular, the Hausman statistic for a comparison of the MG and PMG estimators is calculated at 0.13 and is $\chi^2(2)$ distributed. Therefore we conclude that the PMG estimator, which is an efficient estimator under the null hypothesis of no systematic differences of individual long-run coefficients, is preferred here. Testing the MG and PMG estimators pairwisely with the DFE estimator, the Hausman statistics (0.00 for MG vs. DFE and 0.12 for PMG vs. DFE) indicate that there are no systematic differences of short-run coefficients across the countries as well, and therefore the DFE estimator is preferred over the MG and PMG models.

The results from the DFE model in Table 3.2 show that the real domestic demand has a significant positive impact on import volumes in the short and in the long run. However, the short-run income elasticity (1.1) is slightly higher than in the long-run (1.0). In comparison to the import elasticities obtained from the GMM System estimator, the

Table 3.2: Import Demand Elasticities from Error Correction Models

	MG	PMG	DFE
Real Domestic Demand			
short-run	1.155***	1.171***	1.134***
	(0.168)	(0.116)	(0.074)
long-run	1.073***	1.183***	0.994***
	(0.310)	(0.022)	(0.142)
REER			
short-run	-0.167	0.001	0.076
	(0.120)	(0.072)	(0.047)
long-run	0.054	-0.137	-0.188
	(0.346)	(0.090)	(0.195)
Error Correction Term			
	-0.541***	-0.279***	-0.155***
	(0.085)	(0.065)	(0.031)
Diagnostic Statistics			
N of observations		286	
N of countries		22	

Note: Standard errors in brackets. Estimations with intercept.

* indicates significance at 10% level, ** at 5%, and *** at 1% level.

short-run income elasticity from the DFE matches very closely the corresponding GMM coefficient, while the long-run income elasticity from the DFE is markedly lower than the one from the GMM estimator. The DFE estimation results suggest that the REER does not significantly affect the import volume neither in the short nor in the long run. The error correction speed of adjustment is significantly negative (-0.2) which indicates the presence of the cointegration relationship between import demand variables to which they return in the long run.

Further we estimate import demand elasticities, using the DFE estimator, separately for the two groups of transition countries, CEE and CIS. The results reported in Table 3.3 show that import demand elasticities with respect to real domestic demand for CEE and CIS countries do not change substantially from those obtained for the whole sample. The income elasticities are positive and highly significant both in the short and in the long run. In the case of CEE countries, the long-run income elasticity is markedly higher than in the short run, while a lower income elasticity in the long run is evident for CIS countries as in the case of the whole sample estimates. The REER has a positive significant effect on import volumes only in the short run in the CEE sample. The DFE model estimates show that there is no evidence for a significant real exchange rate impact on import demand in CIS countries and in CEE countries in the long run. Interested in identifying whether the import demand elasticities from the DFE model, estimated separately for CEE and CIS countries, are significantly different, we perform a t-test and find that the long-run income elasticities differ significantly between the two groups of transition countries, while other elasticities do not differ significantly.[5]

Table 3.3: Import Demand Elasticities from DFE Model

	Whole Sample	Partitioning	
		CEE	CIS
Real Domestic Demand			
short-run	1.134***	1.137***	1.164***
	(0.074)	(0.119)	(0.099)
long-run	0.994***	1.340***	0.826***
	(0.142)	(0.202)	(0.165)
REER			
short-run	0.076	0.234**	0.057
	(0.120)	(0.113)	(0.057)
long-run	-0.188	0.202	-0.289
	(0.195)	(0.387)	(0.199)
Error Correction Term			
	-0.155***	-0.204***	-0.192***
	(0.031)	(0.058)	(0.045)
Diagnostic Statistics			
N of observations	286	130	156
N of countries	22	10	12

Note: Standard errors in brackets. Estimations with intercept.

* indicates significance at 10% level, ** at 5%, and *** at 1% level.

[5]To obtain such a statistical comparison we interact the estimated model for the whole sample with a group dummy variable for CIS countries, as in the case of the GMM System estimator, and test whether estimates of the corresponding dummy variables (difference of import demand elasticities between CIS and CEE countries) are significantly different from zero. The t-statistics and probability values are reported in the appendix in Table 3.11.

Export Demand Equation

We now follow the same econometric procedures to estimate the export demand equation (3.2). By doing so we regress export (total or non-oil) volumes on foreign income and relative prices, while the export-weighted real GDP of the main export partners or the real world GDP are used as the foreign income variable and the REER as the relative price variable.

GMM System Estimator When applying the GMM System estimator, the export-weighted real GDP or the real world GDP are assumed to be exogenous and are instrumented with their contemporaneous first differences in the transformed equation and with their levels in the equation in levels. The export volumes and the REER are assumed to be endogenous and are instrumented in the same way as their equivalents in the import demand equation.

The results for the total export demand equation where the export-weighted real GDP acts as the foreign income variable are reported in Table 3.4. The estimation results indicate that in the short run total export volumes in the selected transition countries are driven by fluctuations in the REER, which has a strong positive and significant impact (0.4) on total export volumes. The short-run price elasticity is positive, contrary to economic theory according to which a negative export elasticity with respect to the REER is expected, as an increase in the REER (real appreciation) reduces export demand through the substitution effect, and therefore export volume. But the economic reasoning for a strong positive short-run export elasticity with respect to the REER can be drawn from the supply (or production) side: a real exchange rate appreciation (an increase in relative prices of domestically produced - or exported - goods) attracts more resources into the export sector and, as long as export demand is not constrained, raises export volumes. This is likely for primary commodities for which demand is almost perfectly price inelastic. On average, from 1995 to 2008 and across all CIS countries in the sample, exports of primary commodities (including fuels) amount to around 67% of total exports, while in the CEE country group this proportion lies at 24%.[6] The estimation results from partitioning the whole sample into the two groups of transition countries, the CEE and CIS, underpin this argument as the short-run export elasticity with respect to the REER in CIS countries

[6]Source: UNCTAD's (United Nations Conference on Trade and Development) statistical database on http://uncstadstat.unctad.org and authors' own calculations.

is estimated at almost the same size (0.5), while the CEE exports' sensitivity to REER movements is negligibly small. With regard to the whole sample, the price elasticity estimate reverses to a negative sign in the long run, predicting that a REER depreciation raises total export volumes through a higher foreign demand for relatively cheaper exports from the transition countries. However, this estimate is not statistically significant. The foreign income variable has a slight positive impact on total export volumes in the selected transition countries in the short run which is not statistically significant, but a high positive and significant effect in the long run (1.3), indicating that exports from transition countries increase more than proportionally with a higher foreign income. By partitioning the whole sample into the CEE and CIS groups, the export-weighted real GDP of most important export partners has only minor statistically significant impacts on total exports in the short run in both groups of countries, but of different signs (-0.1 for CEE and 0.1 for CIS). The negligibly small negative impact of foreign income on the CEE export volumes is difficult to interpret as an income effect. Countries with less income might substitute high quality manufactured products from the Western European countries with lower quality manufactured products from the CEE countries, which would increase the CEE export volumes. A significant positive income effect which is magnified in the long run is evident for the CIS countries; the elasticity of total export volumes with respect to the export-weighted real GDP of main export partners ranges from 0.1 in the short run to 1.6 in the long run. As in the case of the import demand estimation we are also interested in detecting whether differences in estimated elasticities of total exports between CEE and CIS countries are statistically significant. The results indicate that the significant estimates for total export elasticities with respect to the export-weighted real GDP of different signs in the short run are significantly different between the CEE and CIS groups of countries, such that this evidence can be attributed to structural differences of foreign demand for export goods from these countries.[7] CEE countries are likely to export more manufactured goods which represent quality substitutes to manufactured goods from the Western European countries, while CIS countries are mostly exporters of primary commodities, demand for which is procyclical. Furthermore, the long-run elasticities with respect to the REER are significantly different between the two groups of transition countries. The long-run elasticity of total exports with respect to the relative price is quite high for CEE countries and lies at 7.5, while for CIS countries this is of different sign and equates to -1.9. Although the

[7] The t-statistic and probability values for estimated export demand elasticities are reported in the appendix in Table 3.12.

separate estimates for the long-run export demand elasticity with respect to the REER are not statistically significant in the partitioning exercise, they point to an increase of total export volumes for CIS countries if their currencies depreciate, as one would expect from economic theory.

Table 3.4: Total Export Demand: Coefficient Estimates and Implied Elasticities

System GMM	Whole Sample		Partitioning			
			CEE		CIS	
	Coefficient Estimates	Long-run Elasticities	Coefficient Estimates	Long-run Elasticities	Coefficient Estimates	Long-run Elasticities
Total Export Volume						
First Lag	0.959***		1.024***		0.869***	
	(0.030)		(0.017)		(0.042)	
Export-weighted Real GDP of Export Partners						
Contemporaneous	0.041	1.331*	-0.055*	1.421	0.136*	1.629**
	(0.039)	(0.772)	(0.026)	(0.884)	(0.069)	(0.683)
First Lag	0.014		0.022		0.078*	
	(0.032)		(0.018)		(0.042)	
REER						
Contemporaneous	0.444*	-2.826	0.018	7.534	0.510	-1.909
	(0.220)	(2.416)	(0.336)	(4.258)	(0.291)	(1.154)
First Lag	-0.561*		-0.195		-0.761*	
	(0.297)		(0.259)		(0.357)	
Diagnostic Statistics						
N of observations	286		130		156	
N of countries	22		10		12	
Tests						
Hansen test	21.49		7.58		6.50	
AB test for AR(1)	-2.46**		-1.71		-2.47**	
AB test for AR(2)	-1.50		-1.36		-1.11	

Note: Robust standard errors in brackets. Estimations with intercept.

* indicates significance at 10% level, ** at 5%, and *** at 1% level.

In addition, we estimate the total export demand equation using the real world GDP as the foreign income variable. The results are not reported here as they do not provide any statistically significant impacts of the REER on total export demand.[8] The world real GDP seems to be the most important driving source for total exports considering the whole sample of transition countries and the factor with the most positive significant impact in

[8] All estimation results and codes can be provided by the authors on request.

the short run in the separate groups of transition countries.

Finding that the REER appreciation has a positive, though insignificant, impact on total exports in the CIS countries, which results in a significant impact of the same direction for the whole sample, and detecting that the short-run total export elasticities with respect to the export-weighted real GDP are significantly different between the two groups of transition countries, we further explore whether this evidence comes from substantial oil exports in the CIS group of countries (from Azerbaijan, Kazakhstan, and Russia) and estimate the same export demand equation using non-oil export volumes as an independent variable.[9] If a REER appreciation will still appear to raise total exports of the CIS transition countries and the statistically significant difference in the short-run export demand elasticities with respect to income between CEE and CIS groups will still persist, we will then conclude that exports from CEE and CIS countries are fundamentally differently affected by the chosen independent factors. The non-oil export demand estimation using the export-weighted real GDP as the income variable and the REER as the relative price variable provides non-significant short- and long-run coefficients for the whole sample.[10] The estimated short- and long-run coefficients of the non-oil export demand determinants appear to be insignificant also in case of partitioning the sample in the CEE and CIS country groups. Therefore we can conclude that the positive impact of a REER appreciation on total exports for the whole sample and the short-run total export elasticities with respect to export-weighted real GDP of opposite signs for the CEE (negative) and CIS (positive) come mainly from substantial oil exports contained in total exports for the CIS countries and are not based on any fundamental group differences.

Panel Cointegration Techniques Because we now assume that the underlying data series in the export demand equation are non-stationary and integrated of order one, we apply various alternative estimation methods based on panel cointegration techniques that we have already used for the estimation of the import demand equation, and rewrite the ARDL (1,1,1) model specification (3.2) into an error correction representation form given

[9] Ideally, the export demand equation would be estimated on the data for non-commodity exports. This data is, however, not available in the World Economic Outlook Database of the IMF for both groups of countries.

[10] The estimation results are not shown here but can be provided by the authors on request.

by:

$$\begin{aligned}\Delta x_{it} &= -(1-\delta_1)\left[x_{it-1} - \left(\frac{\phi_0+\phi_1}{1-\delta_1}\right) y^*_{it-1} - \left(\frac{\theta_0+\theta_1}{1-\delta_1}\right) p_{it-1}\right] \\ &\quad +\phi_0 \Delta y^*_{it} + \theta_0 \Delta p_{it} + \delta_0 + \mu_i + \nu_{it}, \end{aligned} \tag{3.4}$$

The export demand equation using total exports as a dependent and the export-weighted real GDP of export partners as the foreign income variable is estimated first and the corresponding results are represented in Table 3.5. As mentioned in Section 3.3.2, the applied panel cointegration estimators differ in their assumptions about the homogeneity of coefficients, while the validity of a specific homogeneity assumption is tested by performing the Hausman (1978) test. For the estimations represented in Table 3.5 the Hausman test, performed pairwise, indicates that the homogeneity assumption for short- as well as for long-run coefficients is valid, and therefore the DFE estimator is proven to be more efficient.[11] The results from the DFE model in Table 3.5 show a significant positive impact of the REER on total exports in the short run (0.1) which confirms the corresponding estimation result obtained from the GMM System estimator. As mentioned in the discussion of the GMM System estimates, the economic reasoning for this evidence might come from the production side, as increasing prices (revenues) in the export sector of transition countries raises the production output of this sector, as long as the foreign demand is almost fully price inelastic. The error correction speed of adjustment is significantly negative (-0.1), which indicates the presence of a cointegration relationship between total export volumes, the REER and the export-weighted foreign GDP, to which variables return in the long run, even though at a slow pace. The export-weighted real GDP of export partners does not show any significant impacts neither in the short nor in the long run.

Furthermore, we reestimate the total export demand equation using the world real GDP as the foreign income variable by applying the same panel cointegration estimators. As usual, the Hausman (1978) test is performed pairwise in order to prove the validity of the homogeneity assumption on cross-country coefficients under the PMG and DFE estimators and to identify the most efficient estimator. The calculated Hausman statistics indicate that the more efficient DFE estimator under the valid homogeneity assumption of short- and long-run cross-country coefficients is preferred here.[12] The results from the DFE model

[11] The calculated Hausman statistic ($\chi^2(2)$ distributed) for MG-PMG is 0.66, for MG-DFE 0.00, and for PMG-DFE 0.18.

[12] The calculated Hausman statistic ($\chi^2(2)$ distributed) for MG-PMG is 0.05, for MG-DFE 0.00, and for

Table 3.5: Total Export Demand Elasticities from Error Correction Models I

	MG	PMG	DFE
Export-weighted Real GDP of Export Partners			
short-run	0.002	0.000	0.009
	(0.031)	(0.023)	(0.020)
long-run	1.266	0.348***	0.323
	(1.626)	(0.072)	(0.364)
REER			
short-run	-0.118	-0.049	0.105*
	(0.213)	(0.156)	(0.063)
long-run	1.091	-1.315***	-0.396
	(2.311)	(0.121)	(0.734)
Error Correction Term			
	-0.202***	-0.122***	-0.053***
	(0.072)	(0.045)	(0.020)
Diagnostic Statistics			
N of observations		286	
N of countries		22	

Note: Standard errors in brackets. Estimations with intercept.

* indicates significance at 10% level, ** at 5%, and *** at 1% level.

in Table 3.6 show a positive significant impact of the REER on total export volumes in the selected transition countries (0.1), which matches perfectly the corresponding estimate from the previous DFE model of the total export demand equation using the export-weighted real foreign GDP as the income variable. The world real GDP is found to have a strong positive impact on total exports in the short as well as in the long run. Surprisingly, the short-run income coefficient is slightly higher than in the long-run. The error correction speed of adjustment is significantly negative (-0.2), which indicates that there is a panel cointegration relationship between total exports of the selected transition countries, the world real GDP, and the REER.

As in the case of the GMM System estimation, we now verify our 'production-side'-hypothesis about the economic reasoning of the positive short-run coefficient of the REER on total export volumes by partitioning the whole sample into the CEE and CIS country

PMG-DFE 0.01.

Table 3.6: Total Export Demand Elasticities from Error Correction Models II

	MG	PMG	DFE
World Real GDP			
short-run	1.205	2.242***	2.490***
	(0.989)	(0.639)	(0.760)
long-run	2.037***	2.123***	2.282***
	(0.472)	(0.036)	(0.216)
REER			
short-run	-0.069	0.059	0.103*
	(0.191)	(0.129)	(0.058)
long-run	-0.015	-0.240***	0.029
	(0.651)	(0.080)	(0.141)
Error Correction Term			
	-0.692***	-0.332***	-0.232***
	(0.078)	(0.066)	(0.036)
Diagnostic Statistics			
N of observations		286	
N of countries		22	

Note: Standard errors in brackets. Estimations with intercept.

* indicates significance at 10% level, ** at 5%, and *** at 1% level.

groups, as the CIS transition countries are mainly exporters of primary commodities. The results obtained from the DFE model using the world real GDP as the income variable show, however, that the REER does not have any significant impact in the separated groups of transition countries (Table 3.7). The world GDP is found to be the most important driving source for total exports in each group of transition countries. The values of the coefficients for the short- and long-run elasticities of total exports with respect to the REER in the whole sample, although insignificant, are shown to be dominated by the evidence of the CIS transition countries, which supports our explanation hypothesis that the positive relationship between the REER appreciation and the increase in total exports is driven by supply (production) factors. For the CEE countries the REER appreciation has a negligibly small positive impact on total exports in the short run, while in the long-run the REER appreciation reduces total export volumes, in line with economic theory and in contrast to the evidence of the CIS countries. However, a further test shows that the separate short- and long-run total export elasticities with respect to the REER for the

CEE and the CIS countries are not significantly different from each other.[13]

Table 3.7: Export Demand Elasticities from DFE Model

	Whole Sample	Partitioning	
		CEE	CIS
World Real GDP			
short-run	2.490***	2.610***	2.287*
	(0.760)	(0.698)	(1.271)
long-run	2.282***	2.521***	2.270***
	(0.216)	(0.206)	(0.415)
REER			
short-run	0.103*	0.045	0.108
	(0.058)	(0.113)	(0.076)
long-run	0.029	-0.137	0.027
	(0.141)	(0.194)	(0.232)
Error Correction Term			
	-0.232***	-0.445***	-0.204***
	(0.036)	(0.066)	(0.047)
Diagnostic Statistics			
N of observations	286	130	156
N of countries	22	10	12

Note: Standard errors in brackets. Estimations with intercept.

* indicates significance at 10% level, ** at 5%, and *** at 1% level.

In addition, the demand equation for non-oil exports is estimated using the world real GDP as the foreign income variable and the REER as the relative price variable. The obtained coefficients suggest that the world real GDP is the only significant driving factor of demand for non-oil exports, while the REER does not have any impact in case of the whole sample and for the separate groups of countries.[14] No significant differences in the short- and long-run elasticities of non-oil exports with respect to the world real GDP and the REER between the CEE and CIS countries are detected by partitioning the whole sample. Also in this estimation procedure, the significant positive impact of the REER

[13]The t-statistics and probability values for (differences in) estimated elasticities are reported in the appendix in Table 3.13.

[14]Due to insignificant REER elasticities of non-oil exports, estimation result are not reported here but can be provided by the authors on request.

appreciation on total exports in the short run seems to disappear by excluding oil exports from the data, such that one still can conclude that the positive significant impact of the REER on total exports might be driven by supply factors in the oil sector.

3.4 Summary of Results and Implications for the Trade Balance

According to our statistically significant results, increases in domestic income produce more than proportional or proportional increases in imports in transition countries, except for the long-run response of the CIS imports to a rise in domestic income, which turned out to be below unity. Similarly, increases in foreign income produce more than proportional increases in total exports in transition countries, except for the surprisingly negative, though negligible small, response of the CEE total exports and the small reaction of the CIS total exports in the short run obtained from the GMM estimator. Taking into consideration the highest (in absolute terms) obtained income elasticities for imports and exports, we find large gaps between import and export elasticities with respect to income, with export elasticities being almost twice as high as those of import demand. This detected large gap in income elasticities in transition countries can be explained by the systematic relationship between income elasticities and growth rates which was documented by Krugman (1989) as the empirical regularity and named as the '45-degree rule'. The '45-degree rule' points out that fast-growing countries appear to have high income elasticities of demand for their exports and low income elasticities of import demand, which preserves their real exchange rates from long-term trends or substantial changes in the long run. The mean annual growth rate of the real domestic demand across time and country in our sample lies at 5 percent, such that the selected transition countries can be characterized as fast-growing countries with the favorable combination of a high income elasticity of their exports and a low income elasticity of their import demand, which supports the '45-degree rule'.

The obtained statistically significant price elasticities for exports and imports in transition countries are fairly low, which supports the baseline assumption for the estimation approach that goods produced by different countries are imperfect substitutes and are in line with price elasticities previously found in the literature. Moreover, trade volumes used in our estimations include primary commodities and services. Demand for primary commodities is generally price inelastic, and services face a very low price elasticity of demand due to a lack of substitutes. Furthermore we observed that in the long run international trade flows in transition countries are largely driven by income changes, changes in REERs do not have any significant impact on exports and imports in the long run.

Trade elasticities with respect to real exchange rates play a very important role in macroeconomic policy considerations, especially in macroeconomic policy issues regarding external adjustment, e.g., global imbalances. One of the approaches to assess the equilibrium exchange rate and the exchange rate adjustment required to restore external imbalances is crucially based upon price elasticities of trade volumes. The 'macroeconomic balance approach' of the CGER of the IMF calculates the real exchange rate change which is needed to close a gap between the actual current account balance and the estimated equilibrium current account ('current account norm'), according to a current account elasticity with respect to the real exchange rate. The current account or trade balance elasticity with respect to the real exchange rate is in turn obtained by combining price elasticities of trade volumes and the corresponding trade ratios. To illustrate we briefly present here the CGER methodology to compute the trade balance elasticity, see also Hakura and Billmeier (2008). The nominal trade balance B denominated in local currency is given by $PX - \frac{EP^*}{P}M$, where P, P^* are, respectively, local-currency prices of domestic and foreign output, while X, M are export and import volumes. In terms of ratios to domestic nominal output and the real exchange rate, the trade balance definition can be rewritten as: $\frac{B}{PY} = \frac{X}{Y} - \frac{1}{\epsilon}\frac{M}{Y}$, where Y is domestic real output and ϵ the real exchange rate, with an increase indicating a real exchange rate appreciation. Taking derivatives of the definition of trade balance as a ratio to GDP with respect to the real exchange rate, we obtain the following condition:

$$\frac{\partial(\frac{B}{PY})}{\partial\epsilon/\epsilon} = \varepsilon_X \frac{PX}{PY} - (\varepsilon_M - 1)\frac{EP^*M}{PY}. \tag{3.5}$$

Assuming that external trade is initially balanced, the real exchange rate depreciation will lead to an improvement in the trade balance if $\varepsilon_X - \varepsilon_M + 1 < 0$, or $-\varepsilon_X + \varepsilon_M > 1$, where ε_X and ε_M represent elasticities of export and import volumes with respect to changes in ϵ. From the view of economic theory, ε_X is expected to be negative, as export volumes tend to decrease in case of a real exchange rate appreciation, and ε_M is expected to be positive. The condition for an improvement in the trade balance can then be written as $|\varepsilon_X| + \varepsilon_M > 1$, which represents the traditional 'Marshall-Lerner' condition. But in our study ε_X is estimated to be positive, such that there is no need to apply the modulus to ε_X. Taking into consideration the highest price elasticities of export (0.4) and import volumes (0.7) in the short run which we obtained from our estimates, we find that the

'Marshall-Lerner' condition is not satisfied for transition countries as a whole, such that a real exchange rate depreciation (appreciation) will lead to an deterioration (improvement) in the trade balance, starting from initially balanced external trade positions. However, in case of a non-zero initial trade balance, the transmission of a real exchange rate change to the trade balance will crucially depend on the initial export and import ratios to GDP.

Therefore, in the next step, we make predictions on the evolvement of trade or current account balances taking into account initial external trade positions and considering trade balance effects of income changes via income elasticities in addition to real exchange rate impacts. Using the total differential of the definition of the trade balance, as shown in Krugman (1989), we can write the change in trade balance as:

$$\Delta\left(\frac{B}{PY}\right) = \frac{X}{Y}\left(\varepsilon_X\hat{\epsilon} + \zeta_X\hat{Y}^*\right) - \frac{1}{\epsilon}\frac{M}{Y}\left((\varepsilon_M - 1)\hat{\epsilon} + \zeta_M\hat{Y}\right), \tag{3.6}$$

where ζ_X, ζ_M are income elasticities of demand for exports and imports, respectively, and $\hat{\epsilon}, \hat{Y}^*, \hat{Y}$ are annual percentage growth rates of the REER, the real world GDP, and the real domestic demand. $\Delta\left(\frac{B}{PY}\right)$ represents changes in the trade balance to GDP ratio in percentage points. Using the upper expression and the obtained significant estimates for price and income elasticities of trade volumes in the short run for the whole sample and applying actual data on annual growth rates of the individual REER, real domestic demand, the world real GDP and the individual export and import to GDP ratios, we can straightforward calculate changes in the trade balance ratios for 2009 and 2010 for all countries in our sample.[15] As a measure for the predicted power for estimated price and income elasticities of export and import demands we then assess mean squared deviations of predicted trade balance ratios from the actual ones for single countries, for the CEE and CIS countries as individual groups, and for the whole sample.[16] Considering mean squared deviations calculated for the two groups of transition countries, the CEE and CIS countries, we find that the mean squared errors are substantial in both groups of countries, which is surely related to the uniqueness of the recent global financial crisis and its peculiar impact on GDPs worldwide. The mean squared errors of the CIS countries as a group are thereby almost three times higher than those of the CEE countries, due to exceptional adjustments

[15]We take into consideration only statistically significant whole-sample estimates in the short-run, as separate estimates for the two groups of transition countries are either not statistically significant or do not significantly differ from each other. The estimates from the GMM model are used for elasticities of imports, and those from the DFE model for elasticities of exports. Note that the data for our estimation ends in 2008.

[16]Single figures for obtained mean squared deviations can be provided by the authors on request.

in REERs in some CIS countries in 2009, such as Azerbaijan, Belarus, and Uzbekistan, and due to substantial reactions of real domestic demands in 2009 as well as in 2010 in several CIS countries, among others in Kazakhstan. However, the estimated price and income elasticities of export and import demands perform quite well in predicting changes in trade balance ratios for Armenia, Georgia, and Russia (Table 3.8). Especially in a case of Georgia, the predictions on the basis of our estimates and the total differential of the trade balance match extraordinarily well actually occurred changes in the trade balance to GDP ratio. In both years, the model in (3.6) and the estimates predict correctly not only the sign of the trade balance adjustment, but, most importantly, also its amount.

Table 3.8: Trade Balance Adjustment

	$\hat{\epsilon}$	$\hat{Y}^*$	$\hat{Y}$	$\Delta\left(\frac{B}{PY}\right)$	
				Predicted	Actual
Armenia					
2009	-9.31	-0.58	-11.70	2.89	-1.60
2010	1.48	4.77	2.75	0.90	0.55
Georgia					
2009	-2.81	-0.58	-10.63	5.95	7.31
2010	-4.53	4.77	5.09	-0.96	-1.24
Russia					
2009	-37.41	-0.58	-18.39	1.68	-1.81
2010	9.33	4.77	7.00	3.65	1.47

Note: $\hat{\epsilon}, \hat{Y}^*$, and $\hat{Y}$ are annual percentage growth rates of, respectively, REER, real world GDP, and real domestic demand. $\Delta\left(\frac{B}{PY}\right)$ represents changes in trade balance ratio to GDP in percentage points.

In addition, we calculate out-of-sample predictions and the corresponding mean squared errors for changes in trade balance to GDP ratios using only data for actual changes in REERs and our estimates of import and export demand elasticities with respect to the REER on the basis of the formula in (3.5), which is also used in the 'macroeconomic balance approach' by the CGER. The obtained results show that mean squared errors decrease by two thirds for the CEE countries as a group and by half for the CIS countries, compared to the mean squared deviations from the previous exercise. Even if the model and obtained price elasticities suit better for the CEE group as a whole, the most exact (in comparison to the previous model using the total differential) predictions are made for trade balance changes in Armenia. However, in Georgia and Russia, the model with only REER changes has less predictive power. Nevertheless the forecasts of the smaller model for trade balance changes in 2010, where the consequences of the global financial crises in most countries were limited, match the actual changes pretty well for a number of countries, among others for Armenia, Estonia, Georgia, Kazakhstan, Russia, the Slovak Republic, Slovenia, and Uzbekistan. Therefore, our estimates for price elasticities of export and import demands are suitable for deriving trade balance elasticities with respect to the REER which are used in the 'macroeconomic balance approach' by the CGER in order to draw policy recommendations on the exchange rate adjustment required for eliminating a gap between the actual current account and its macroeconomic equilibrium norm.

3.5 Conclusions

Trade elasticities play a crucial role in translating economic analysis into macroeconomic policy. The most prominent example is the CGER at the IMF which, by means of trade elasticities with respect to the real exchange rate, derives the exchange rate misalignment or, in other words, the exchange rate adjustment needed to eliminate present current account deviations from the equilibrium current account ('current account norm'). Certainly, trade elasticities are equally important for predicting current account or trade balance shifts implied by a given real exchange rate change.

The dynamic panel estimation results for 22 transition countries comprised of 12 CIS countries and 10 countries from the CEE for the period 1995-2008 indicate that increases in domestic and foreign income produce more than proportional increases in imports and exports in the selected transition countries, with export elasticities being almost twice as high as those of import demand. The high discrepancy between export and import elasticities with respect to income coincides with a relatively high mean annual growth rate of the real domestic demand in our sample and can therefore be well explained by the '45-degree rule' documented by Krugman (1989). Furthermore, the selected transition countries are estimated to have fairly low import and export elasticities with respect to the REER in the short run of 0.7 and 0.4, respectively, which are broadly in line with price elasticities previously found in the literature. The low price elasticities support the baseline assumption for the estimation approach that goods produced by different countries are imperfect substitutes. Moreover, these price elasticities indicate that the traditional

'Marshall-Lerner' condition does not hold for the selected transition countries, such that, assuming initially balanced external positions, a REER depreciation will lead to a trade balance deterioration in these countries. However, in the long run international trade flows in transition countries are mainly driven by income changes; changes in REERs do not have any significant impacts on exports and imports in the long run.

As trade elasticities are primarily used to derive macroeconomic policy conclusions on exchange rate misalignments or external adjustments, which are often a source of heated international policy debates, it is very important to verify the ability of the estimated trade elasticities to correctly predict actual trade balance changes in transition countries. Using the definition of the trade balance as the difference between exports and imports and employing real data on export and import to GDP ratios for 2009 and 2010, we found that the estimated price and income elasticities of trade demands perform quite well in predicting out-of-sample trade balance changes for Armenia, Georgia, and Russia. Taking into consideration the 'macroeconomic balance approach' and thus only price elasticities of trade demands, actual out-of-sample changes in trade balances can be matched for a bigger set of countries, including in addition Estonia, Kazakhstan, the Slovak Republic, Slovenia, and Uzbekistan. We therefore conclude that our estimates for price elasticities of export and import demands are suitable for deriving trade balance elasticities with respect to the REER for transition countries, on which the 'macroeconomic balance approach' of the CGER extensively relies. However, more extensive empirical research on trade demand elasticities for transition countries by differentiating export and import sectors due to their nature (e.g., primary commodities, manufactures) and by using the corresponding relative prices will be worthwhile and will become feasible with the provision of more comprehensive data sets for transition countries, especially for the CIS countries. Alternatively, export supply equations can be estimated for the CIS countries, as they mainly export primary commodities for which the world demand is fully price inelastic and other factors than relative price changes seem to drive export volumes in these countries.

Appendix to Chapter 3

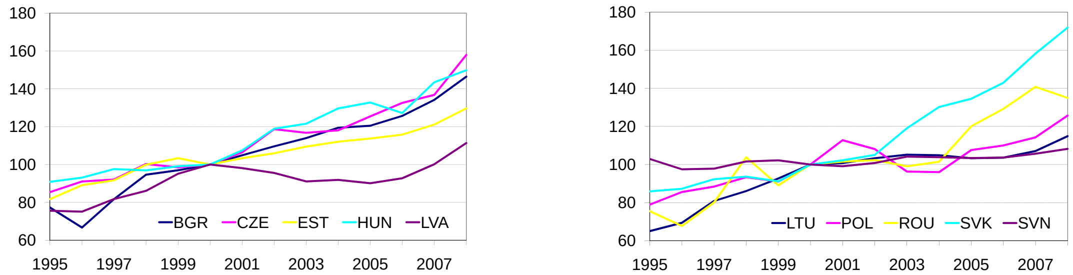
Data Description

Import volume: value of imports of goods and services (denominated in US Dollar) deflated by price deflator for imports of goods and services (2000=100) and converted into national currency at the average market bilateral exchange rate to US Dollar in 2000.
Real domestic demand: GDP at constant prices (2000) expressed in national currency or GDP at current prices expressed in national currency deflated by GDP delfator (2000=100) less net exports (exports-imports, see data description for import and export volumes) expressed in national currency at 2000 prices.
Real effective exchange rate: trade-weighted real exchange rate (deflated by consumer price index (CPI)), 2000=100, average total trade weights for 1999-2001, source: IMF Information Notice System.
Export volume: value of exports of goods and services (denominated in US Dollar) deflated by price deflator for exports of goods and services (2000=100) and converted into national currency at the average market bilateral exchange rate to US Dollar in 2000.
Non-oil export volume: in oil exporting countries value of non-oil exports (denominated in US Dollar) with values of exports of services (both denominated in US Dollar) deflated by price deflator for non-oil exports (2000=100) and converted into national currency at the average market bilateral exchange rate to US Dollar in 2000; in other countries total export volume (see data description for export volume).
World real gross domestic product: world real GDP expressed in US Dollar at 2000 prices.
Export-weighted real gross domestic product of main trading partners: real GDPs (GDP at current prices in national currency deflated by GDP deflator (2000=100) and converted into US Dollar at average market bilateral exchange rate) of the 10 most important export partner countries expressed in US Dollar at 2000 prices and weighted by their time-varying shares in exports of the exporting country (see data description for time varying export shares).
Time-varying export shares: value of merchandise exports to one of 10 most important export partners expressed in US Dollar relative to total value of merchandise exports to 10 most important export partners, source: IMF Direction of Trade Statistics.
Unless otherwise indicated, all variables are obtained from the IMF World Economic Outlook database.

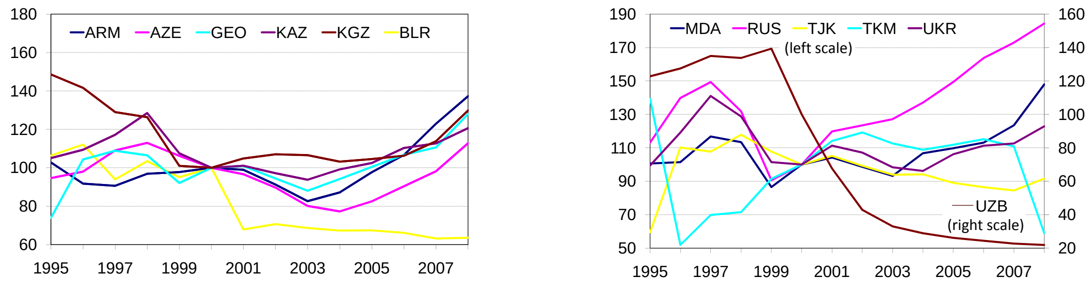
Figure 3.1: Real Effective Exchange Rates

(Index, 2000=100)

CEE Countries



CIS Countries



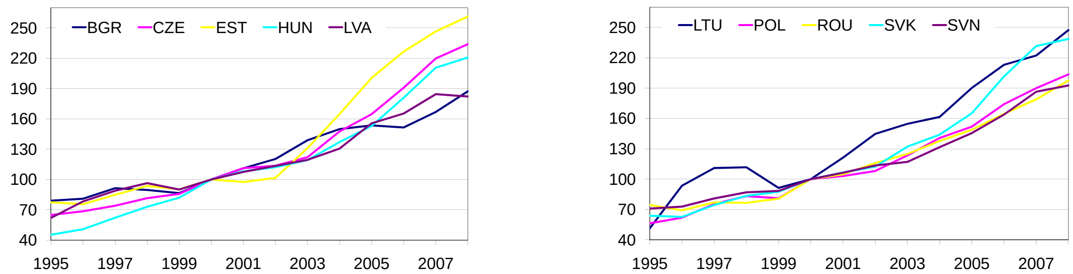
Note: An increase in the index indicates a real effective exchange rate appreciation.

Source: IMF Information Notice System.

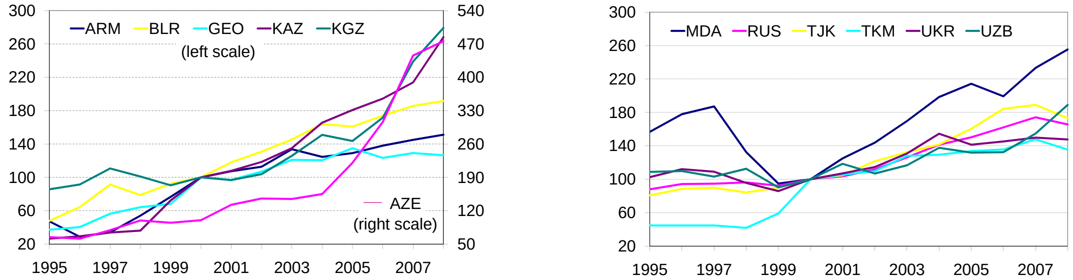
Figure 3.2: Real Exports of Goods and Services

(2000=100, US Dollar)

CEE Countries



CIS Countries

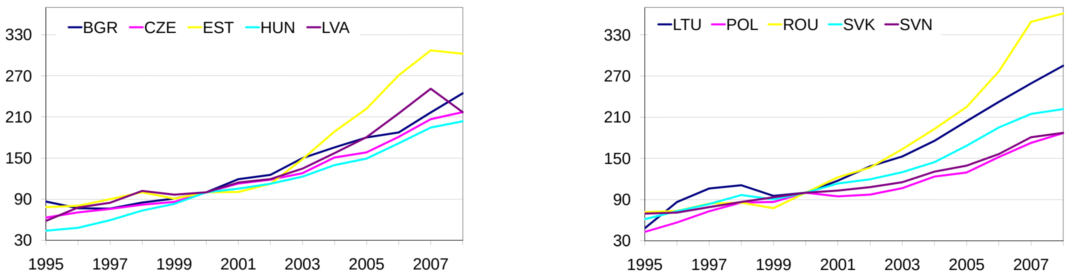


Source: IMF World Economic Outlook database.

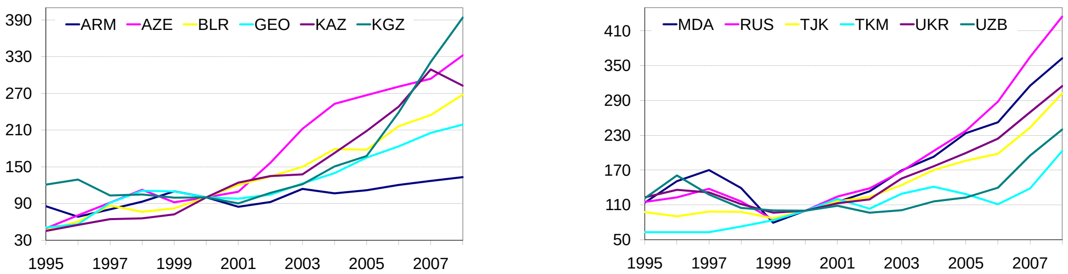
Figure 3.3: Real Imports of Goods and Services

(2000=100, US Dollar)

CEE Countries



CIS Countries

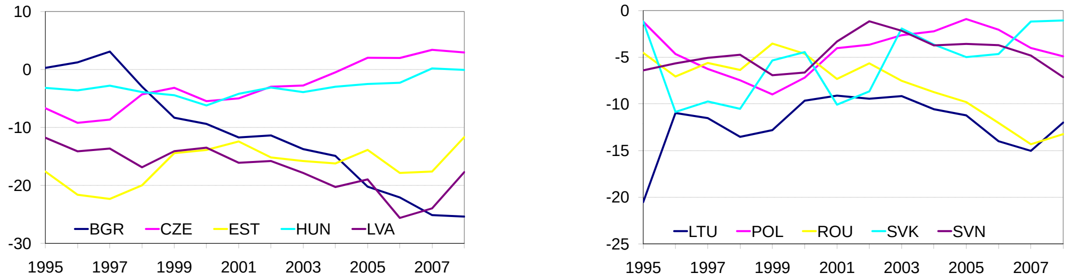


Source: IMF World Economic Outlook database.

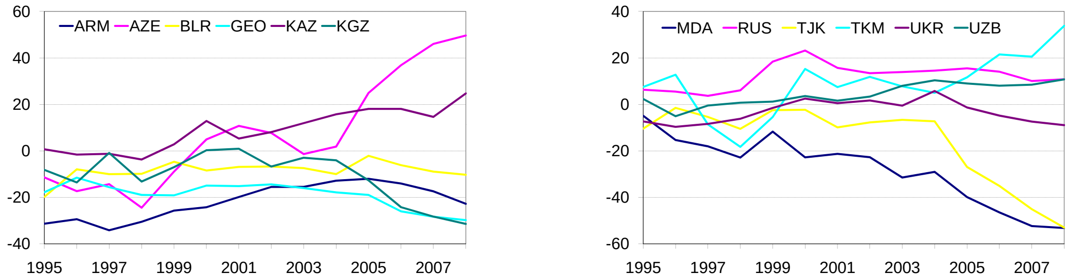
Figure 3.4: Trade Balance

(in percent of GDP)

CEE Countries



CIS Countries



Source: IMF World Economic Outlook database and authors' own calculations.

Table 3.9: Panel Unit Root Test Statistics for Variables Entering the Import Demand Equation

Variables:	LLC	MW	HT
Import Volume (i+t)	-5.5312***	78.1079***	3.2584***
in first differences (i)	-9.7155***	134.7020***	-11.9632***
Real GDP (i+t)	-8.8738***	99.2790***	-4.3190***
in first differences (i)	-14.4765***	125.5630***	-3.2233***
Real Domestic Demand (i+t)	-4.4697***	41.5396	5.6420***
in first differences (i)	-6.9612***	92.3769***	-10.0193***
REER (i)	-0.0336	40.8734	4.5604***
in first differences (i)	-15.2758***	181.0780***	-16.3108***

Note: * indicates unit root rejection at 10% significance level, ** at 5%, and *** at 1% level. i indicates individual effects and t individual linear trends included as exogenous variables.

Table 3.10: Panel Unit Root Test Statistics for Variables Entering the Export Demand Equation

Variables:	LLC	MW	HT
Total Export Volume (i+t)	-5.2726***	58.7993*	4.0354***
in first differences (i)	-10.8648***	140.1550***	-13.3168***
Non-oil Export Volume (i+t)	-5.3960***	53.1600	1.8277*
in first differences (i)	-10.8330***	140.9750***	-17.6568***
Export-weighted Real GDP	-4.5962***	75.9426***	4.1059***
of Export Partners			
in first differences (i)	-14.8070***	177.1040***	-25.5066***
World Real GDP (i+t)	-1.5325*	5.6060	7.6436***
in first differences (i+t)	-9.5588***	94.1669***	-8.6190***
REER (i)	-0.0336	40.8730	4.5604***
in first differences (i)	-15.2758***	181.0780***	-16.3108***

Note: * indicates unit root rejection at 10% significance level, ** at 5%, and *** at 1% level. i indicates individual effects and t individual linear trends included as exogenous variables.

Table 3.11: Import Demand: Differences in Estimated Elasticities

	System GMM		DFE	
	t-Statistic	p-Value	t-Statistic	p-Value
Real Domestic Demand				
short-run	-1.36	0.188	0.04	0.965
long-run	-0.05	0.964	-2.54**	0.012
REER				
short-run	0.68	0.505	-0.89	0.377
long-run	0.05	0.964	0.39	0.698

The null hypothesis: elasticities are identical in two groups, CEE and CIS.

Table 3.12: Export Demand: Differences in Estimated Elasticities (System GMM)

	t-Statistic	p-Value
Export-weighted Real GDP of Export Partners		
short-run	2.64**	0.015
long-run	0.19	0.850
REER		
short-run	1.14	0.269
long-run	-2.20**	0.039

The null hypothesis: elasticities are identical in two groups, CEE and CIS.

Table 3.13: Export Demand: Differences in Estimated Elasticities (DFE)

	t-Statistic	p-Value
World Real GDP		
short-run	-0.21	0.834
long-run	-0.53	0.599
REER		
short-run	0.33	0.743
long-run	0.45	0.655

The null hypothesis: elasticities are identical in two groups, CEE and CIS.

Bibliography

Arellano, C. and Mendoza, E. (2003). Credit Frictions and 'Sudden Stops' in Small Open Economies: An Equilibrium Business Cycle Framework for Emerging Market Crises. In Altug, S., Chadha, J., and Nolan, C., editors, *Dynamic Macroeconomic Analysis: Theory and Policy in General Equilibrium*. Cambridge University Press.

Arellano, M. and Bond, S. (1991). Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations. *Review of Economic Studies*, 58(2):277–297.

Arellano, M. and Bover, O. (1995). Another look at the instrumental variable estimation of error-components models. *Journal of Econometrics*, 68:29–51.

Bacchetta, P. and van Wincoop, E. (2010). Infrequent Portfolio Decisions: A Solution to the Forward Discount Puzzle. *American Economic Review*, 100(3).

Bahmani-Oskooee, M. and Kara, O. (2005). Income and Price Elasticities of Trade: Some New Estimates. *International Trade Journal*, 19(2):165–178.

Berganza, J. C., Chang, R., and Herrero, A. G. (2004). Balance Sheet Effects and the Country Risk Premium: An Empirical Investigation. *Review of World Economics*, 140(4):592–612.

Bergin, P. R. (2003). Putting the 'New Open Economy Macroeconomics' to a test. *Journal of International Economics*, 60:3–34.

Bergin, P. R. (2006). How well can the New Open Economy Macroeconomics explain the exchange rate and current account? *Journal of International Money and Finance*, 25:675–701.

Betts, C. and Devereux, M. B. (2000). Exchange rate dynamics in a model of pricing-to-market. *Journal of International Economics*, 50:215–244.

Blundell, R. and Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics*, 87:115–143.

Calvo, G. A., Izquierdo, A., and Talvi, E. (2006). Phoenix Mirales in Emerging Markets: Recovering without Credit from Systemic Financial Crises. *NBER Working Paper No. 12101.*

Canova, F. (2007). *Methods for Applied Macroeconomic Research.* Princeton University Press.

Céspedes, L. F., Chang, R., and Velasco, A. (2004). Balance Sheets and Exchange Rate Policy. *American Economic Review*, 94(4):1183–1193.

Chari, V. V., Kehoe, P. J., and McGrattan, E. R. (1997). Monetary Shocks and Real Exchange Rates in Sticky Price Models of International Business Cycles. NBER Working Paper No. 5876.

Christiano, L. J. (1991). Modeling the Liquidity Effect of a Money Shock. *Federal Reserve Bank of Minneapolis, Quarterly Review*, 1511:3–34.

Christiano, L. J. and Eichenbaum, M. (1992). Liquidity Effects and the Monetary Transmission Mechanism. *American Economic Review, Papers and Proceedings*, 82(2):346–353.

Christiano, L. J., Eichenbaum, M., and Evans, C. L. (1997). Sticky price and limited participation models of money: A comparison. *European Economic Review*, 41:1201–1249.

Christiano, L. J., Gust, C., and Roldos, J. (2004). Monetary policy in a financial crisis. *Journal of Economic Theory*, 119:64–103.

Cook, D. and Devereux, M. B. (2005). Accounting for the East Asian Crisis: A Quantitative Model of Capital Outflows in Small Open Economies. *Journal of Money, Credit and Banking*, 38(3):721–749.

Corsetti, G. (2007). New Open Economy Macroeconomics. *CEPR Working Paper No. DP6578.*

Corsetti, G., Dedola, L., and Leduc, S. (2008). International Risk Sharing and the Transmission of Productivity Shocks. *Review of Economic Studies*, 75:443–473.

Eichengreen, B., Hausmann, R., and Panizza, U. (2002). Original Sin: The Pain, the Mystery, and the Road to Redemption. University of California, Berkeley, mimeo.

Enders, Z. and Müller, G. J. (2009). On the international transmission of technology shocks. *Journal of International Economics*, 78:45–59.

Gertler, M., Gilchrist, S., and Natalucci, F. M. (2007). External Constraints on Monetary Policy and the Financial Accelerator. *Journal of Money, Credit and Banking*, 39:295–330.

Goldstein, M. and Khan, M. S. (1981). Income and Price Effects in Foreign Trade. In Jones, R. W. and Kenen, P. B., editors, *Handbook of International Economics*, volume II, pages 1041–1105. Elsevier Science Publishers B. V.

Greenwood, J., Hercowitz, Z., and Huffman, G. W. (1988). Investment, Capacity Utilization, and the Real Business Cycle. *American Economic Review*, 78(3):402–417.

Hacker, R. S. and Hatemi-J, A. (2004). The effect of exchange rate changes on trade balances in the short and long run: Evidence from German trade with transitional Central European economies. *Economics of Transition*, 12(4):777–799.

Hakura, D. S. and Billmeier, A. (2008). Trade Elasticities in the Middle East and Central Asia: What is the Role of Oil? IMF Working Paper No. 08/216.

Harrigan, J. (1993). OECD imports and trade barriers in 1983. *Journal of International Economics*, 35:91–111.

Harris, R. D. F. and Tzavalis, E. (1999). Inference for unit roots in dynamic panels where the time dimension is fixed. *Journal of Econometrics*, 91:201–226.

Hausman, J. A. (1978). Specification Tests in Econometrics. *Econometrica*, 46(6):1251–1271.

Hlouskova, J. and Wagner, M. (2006). The Performance of Panel Unit Root and Stationarity Tests: Results from a Large Scale Simulation Study. *Econometric Reviews*, 25(1):85–116.

Hooper, P., Johnson, K., and Marquez, J. (1998). Trade Elasticities for G-7 Countries. International Finance Discussion Paper No. 609, Board of Governors of the Federal Reserve System.

Houthakker, H. S. and Magee, S. P. (1969). Income and Price Elasticities in World Trade. *Review of Economics and Statistics*, 51(2):111–125.

International Monetary Fund (2006a). Exchange Rates and Trade Balance Adjustment in Emerging Market Economies.

International Monetary Fund (2006b). Methodology for CGER Exchange Rate Assessments.

Jeanne, O. and Rose, A. K. (2002). Noise Trading and Exchange Rate Regimes. *Quarterly Journal of Economics*, 117:537–569.

Kaminski, B., Wang, Z. K., Winters, L. A., Sapir, A., and Székely, I. P. (1996). Export Performance in Transition Economies. *Economic Policy*, 11(23):421–442.

Kehoe, T. J. and Ruhl, K. J. (2007). Sudden Stop, Sectoral Reallocation, and the Real Exchange Rate. University of Minnesota, mimeo.

Kim, J. (2000). Constructing and estimating a realisitic optimizing model of monetary policy. *Journal of Monetary Economics*, 45:329–359.

Kollmann, R. (1997). The Exchange Rate in a Dynamic-Optimizing Current Account Model with Nominal Rigidities: A Quantitative Investigation. IMF Working Paper No. 97/7.

Kollmann, R. (2002). Monetary polic rules in the open economy: effects on welfare and business cycles. *Journal of Monetary Economics*, 49:989–1015.

Krugman, P. (1989). Differences in Income Elasticities and Trends in Real Exchange Rates. *European Economic Review*, 33:1031–1054.

Lane, P. R. (2001). The New Open Economy Macroeconomics: A Survey. *Journal of International Economics*, 54:235–266.

Lane, P. R. and Milesi-Ferretti, G. M. (2001). Long-Term Capital Movements. NBER Working Paper No. 8366.

Leeper, E. M. and Sims, C. A. (1994). Toward a Modern Macroeconomic Model Usable for Policy Analysis. NBER Working Paper No. 4761.

Levin, A., Lin, C., and Chu, C. J. (2002). Unit root tests in panel data: asymptotic and finite-sample properties. *Journal of Econometrics*, 108:1–24.

Lewis, K. K. (1995). Puzzles in International Financial Markets. In Grossman, G. M. and Rogoff, K., editors, *Handbook of International Economics*, volume III, pages 1913–1971. Elsevier Science Publishers B. V.

Lubik, T. and Schorfheide, F. (2006). A Bayesian Look at New Open Economy Macroeconomics. *NBER Macroeconomics Annual 2005*, 20:313–366.

Lucas, R. E. (1976). Econometric Policy Evaluation: A Critique. *Carnegie-Rochester Conference Series on Public Policy*, I:19–46.

Maddala, G. S. and Wu, S. (1999). A Comparative Study of Unit Root Tests with Panel Data and a New Simple Test. *Oxford Bulletin of Economics and Statistics*, 61(S1):631–652.

Marazzi, M., Sheets, N., Vigfusson, R., Faust, J., Gagnon, J., Marquez, J., Martin, R., Reeve, T., and Rogers, J. (2005). Exchange Rate Pass-trough to U.S. Import Prices: Some New Evidence. International Finance Discussion Papers No. 833, Board of Governors of the Federal Reserve System.

Mark, N. and Wu, Y. (1999). Rethinking Deviations from Uncovered Interest Parity: The Role of Covariance Risk and Noise. *Economic Journal*, 108:1686–1706.

Martins, J., Scarpetta, S., and Pilat, D. (1996). Mark-up pricing, market structure and the business cycle. *OECD Economic Studies*, 27:71–105.

McCallum, B. T. and Nelson, E. (1999). Nominal income targeting in a open-economy optimizing model. *Journal of Monetary Economics*, 43:553–578.

Meese, R. A. and Rogoff, K. (1983). Empirical exchange rate models of the seventies: Do they fit out of sample? *Journal of International Economics*, 14:3–24.

Mendoza, E. G. (1991). Real Business Cycles in a Small Open Economy. *American Economic Review*, 81(4):797–818.

Mendoza, E. G. (2006). Lessons from the Debt-Deflation Theory of Sudden Stops. *American Economic Review, Papers and Proceedings*, 96(2):411–416.

Murray, J. (2008). Some Puzzles Related to Exchange Rate Pass-Through. mimeo, Bank of Canada.

Obstfeld, M. and Rogoff, K. (1995). Exchange Rate Dynamics Redux. *Journal of Political Economy*, 103(3):624–660.

Obstfeld, M. and Rogoff, K. (2000). New directions for stochastic open economy models. *Journal of International Economics*, 50(1):117–153.

Pesaran, M. H., Shin, Y., and Smith, R. P. (1999). Pooled Mean Group Estimation of Dynamic Heterogenous Panels. *Journal of the American Statistical Association*, 94(446):621–634.

Pesaran, M. H. and Smith, R. (1995). Estimating long-run relationships from dynamic heterogenous panels. *Journal of Econometrics*, 68:79–113.

Rotemberg, J. and Woodford, M. (1992). Oligopolistic Pricing and the Effects of Aggregate Demand on Economic Activity. *Journal of Political Economy*, 100(6):1153–1207.

Schmitt-Grohé, S. and Uribe, M. (2003). Closing small open economy models. *Journal of International Economics*, 61:163–185.

Senhadji, A. (1997). Time-Series Estimation of Structural Import Demand Equations: A Cross-Country Analysis. IMF Working Paper No. 97/132.

Senhadji, A. and Montenegro, C. (1998). Time Series Analysis of Export Demand Equations: A Cross-Country Analysis. IMF Working Paper No. 98/149.

Stučka, T. (2003). The Impact of Exchange Rate Changes on the Trade Balance in Croatia. Croatian National Bank Working Paper No. 11.

Svensson, L. E. O. and van Wijnbergen, S. (1989). Excess Capacity, Monopolistic Competition, and International Transmission of Monetary Disturbances. *Economic Journal*, 99(397):785–805.

Tille, C. (2001). The role of consumption substitutability in the international transmission of monetary shocks. *Journal of International Economics*, 53:421–444.

Tornell, A. and Westermann, F. (2002). The Credit Channel in Middle Income Countries. *NBER Working Paper No. 9355.*

Uribe, M. and Yue, V. Z. (2006). Country spreads and emerging countries: Who drives whom? *Journal of International Economics*, 69:6–36.

Van der Ploeg, F. (1993). Channels of international policy transmission. *Journal of International Transmission*, 34:245–267.