

# Three essays on CEE economies : implications for their access to EMU

Cui, Yujie

2007

Cui, Y. J. (2007). Three essays on CEE economies : implications for their access to EMU.  
Doctoral thesis, Nanyang Technological University, Singapore.

<https://hdl.handle.net/10356/36162>

<https://doi.org/10.32657/10356/36162>

# **Three Essays on CEE Economies**

## **- Implications for Their Access to the EMU**

**Cui Yujie**

School of Humanities and Social Sciences

A thesis submitted to the Nanyang Technological University  
in fulfilment of the requirement for the degree of  
Doctor of Philosophy

**2007**





## Acknowledgements

My journey toward the completion of my Ph.D. degree has been long, challenging, uncertain at times, but rewarding. I am delighted that I now have the opportunity to express my gratitude for all the people who have helped me to make this thesis possible.

First and foremost, I am greatly indebted to my supervisor, Professor Park Donghyun, whose guidance, patience and encouragement helped me write this thesis. He opened a wonderful world for my academic career that I never imagined before. It was a great pleasure to me to conduct this study under his supervision.

I would also like to thank my Ph.D. committee members, Professor Cao Yong and Professor Christos Sakellariou, whose insightful comments have helped me to polish this thesis. Professor Chen Kang, Professor Tan Kim Heng and Professor Joseph Alba have been of great help whenever needed. Without their support, it would be extremely difficult for me to reach this point. I am deeply grateful to their generous help.

Needless to say, I am also grateful to all my colleagues, with whom I shared both happiness and sadness as a graduate student. Many thanks also go to the faculty, administrative and technical members in the Department of Economics at Nanyang Technological University, whose assistance was vital for my work. In particular, I would like to express my gratitude to Wendy Teo for her kind help all the time.

My father Cui Junyan, my mother Chen Yan and my brother Cui Yuli love, trust and support me all the time in my life, I could not have lived

through this Ph.D. period without them. Finally, I would like to thank my husband Xu Qiang, who has lightened my life in the past six years. Words are not powerful enough to express my love and gratitude to my family.

## **Abstract**

Eight Central and Eastern European (CEE) countries joined the European Union (EU) in May 2004. After joining the EU, they are obliged to join the European Monetary Union (EMU) in the future when they meet the Maastricht Criteria (MC). Initially almost all these countries showed interest in joining the EMU as soon as possible. More recently, however, some of them have begun to envisage a somewhat longer process because it is not clear whether joining the EMU as soon as possible will benefit them the most. Therefore, when is the best time for the monetary integration of the CEE countries into the EMU is an interesting and relevant research topic, which is the focus of this thesis.

This dissertation consists of three empirical studies that have implications for the accession of the CEE economies into the Eurozone.

The first essay uses Johansen's multivariate co-integration method and the constrained error correction model to investigate the impact of real exchange rate volatility on the exports of three key CEE economies – Czech Republic, Hungary and Poland – to the Eurozone in both the long run and the short run. Our results indicate a significant negative effect of exchange rate volatility on exports from the CEE to the Eurozone.

The second essay evaluates the impact of real exchange rate volatility on trade among CEE countries using the gravity model. We employ recently developed panel co-integration techniques for this problem. Our findings confirm a significant negative effect of exchange rate volatility on intra-CEE trade.

The third essay examines the impact of Eurozone shocks on the CEE economies and the role of real exchange rate as a shock absorber based on the structural vector auto-regression (VAR) model. Our analysis shows that the Eurozone shocks play a substantial role in driving the output fluctuations of the above three key CEE economies, and the adoption of the *euro* generally does not pose a substantial economic problem for them.

Based on the above three essays, the benefits of joining the EMU for the CEE countries (especially for the three key CEE economies) are shown to be significant; while the costs of joining it are not obvious. Therefore, we conclude that these countries should devote more efforts to meet the Maastricht convergence criteria so that they can become member states of the EMU at an earlier date.

## Table of Contents

Acknowledgements .....	i
Abstract .....	iii
1. Introduction.....	1
1.1 The EMU-accession Procedure .....	2
1.2 The Macroeconomic Situation of the CEE Economies .....	8
1.3 Potential Benefits and Costs of a Monetary Union .....	19
1.4 Objectives and Contributions of the Thesis .....	22
2. Essay I: Exchange Rate Volatility and Exports from CEE Economies to the Eurozone: Evidence from the Error Correction Model .....	27
2.1 Overview .....	27
2.2 Literature Review .....	28
2.2.1 The Theoretical Literature.....	28
2.2.2 The Empirical Literature .....	38
2.3 Model Specification and Empirical Methodology .....	44
2.3.1 Model Specification .....	45
2.3.2 Unit Root Test.....	46
2.3.3 Co-integration Test .....	49
2.3.4 Hansen Stability test.....	51
2.3.5 Error Correction Model .....	53
2.3.6 Measurement of Exchange Rate Volatility .....	53
2.4 Data Analysis and Empirical Results .....	59
2.4.1 Variables and Data Sources .....	59
2.4.2 Unit Root Test and Co-integration Test Results .....	59
2.4.3 Long-run Relationship and Hansen's Stability Test.....	62



2.4.4 Short-run Relationship..... 64

2.5 Summary..... 67

3. Essay II: Exchange Rate Volatility and Intra-CEE Trade: Evidence from the Gravity Approach..... 69

3.1 Overview ..... 69

3.2 Literature Review ..... 70

3.3 Model Specification and Empirical Methodology ..... 80

3.3.1 Model Specification ..... 80

3.3.2 Panel Unit Root Test..... 82

3.3.3 Panel Co-integration Test ..... 87

3.3.4 Panel Dynamic OLS Estimator ..... 89

3.4 Data Analysis and Empirical Results ..... 92

3.4.1 Variables and Data Sources ..... 92

3.4.2 Panel Unit Root Test Results ..... 93

3.4.3 Panel Co-integration Test Results ..... 94

3.4.4 Panel DOLS results ..... 95

3.5 Summary..... 96

4. Essay III: The OCA Theory and the Role of Exchange Rate in CEE Economies: Evidence from VAR Model..... 98

4.1 Overview ..... 98

4.2 Literature Review ..... 99

4.2.1 Optimum Currency Areas Theory ..... 99

4.2.2 Previous Work ..... 101

4.3 Model Specification and Empirical Methodology ..... 105

4.3.1 Model Specification ..... 105

4.3.2 Lag length Selection ..... 107

4.3.3 Identification of the VAR System ..... 108

4.3.4 Estimation of the VAR System..... 116

4.3.5 Forecast Error Variance Decompositions ..... 117

    4.4 Data Analysis and Empirical Results ..... 119

        4.4.1 Variables and Data Sources ..... 119

        4.4.2 Empirical Results..... 120

    4.5 Summary ..... 122

5. Conclusion..... 124

Reference..... 127

## List of Tables

Table 1-1 Entry of ERM II for Some CEE Countries .....	7
Table 1-2 Evolution of Exchange Rate Arrangements in CEECs.....	14
Table 1-3 Current Exchange Rate Regimes of the CEECs.....	15
Table 2-1 GARCH(1,1) Results .....	56
Table 2-2 Unit Root Test for Czech Republic .....	60
Table 2-3 Unit Root Test for Hungary.....	60
Table 2-4 Unit Root Test for Poland .....	60
Table 2-5 Johansen and Juselius Cointegration Test Results.....	61
Table 2-6 Estimates of Cointegrating Relationship .....	63
Table 2-7 Regression Results for Error Correction Models.....	66
Table 3-1 Free Trade Agreements among CEE Countries.....	69
Table 3-2 Free Trade Bilateral Agreements among CEE Countries.....	70
Table 3-3 Panel unit root test results – Level.....	94
Table 3-4 Panel unit root test results - 1 <sup>st</sup> Difference .....	94
Table 3-5 Panel Cointegration Tests .....	95
Table 3-6 DOLS Estimation Result .....	95
Table 3-7 Individual Effects on Distance, Adjacent and Area .....	96
Table 4-1 Proportion of the forecast error in domestic output growth (in percentage) .....	120
Table 4-2 Proportion of the forecast error in real exchange rates vis-à-vis Euro (in percentage).....	121



# List of Figures

Figure 1-1 CEEC Inflation Rates ..... 9

Figure 1-2 CEEC GDP Growth Rates..... 10

Figure 1-3 CEEC GDP Growth Rates Compared with the EMU..... 10

Figure 1-4 CEEC GDP per Capita Compared with the EMU ..... 11

Figure 1-5 CEEC Inflation Rates Compared with the EMU ..... 11

Figure 1-6 CEEC Long-Term Interest Rate..... 12

Figure 1-7 CEEC Government Budget Deficit ..... 16

Figure 1-8 CEEC Government Gross Debt ..... 16

Figure 1-9 The Degree of Openness for the CEE Countries ..... 17

Figure 1-10 Share of Trade Flows with the Eurozone as a Percentage of  
Total Trade Flows (Imports+Exports)..... 17

Figure 1-11 CEEC Unemployment Rates ..... 18

Figure 2-1 Czech Rep./Eurozone Exchange Rate Volatility..... 58

Figure 2-2 Hungary/Eurozone Exchange Rate Volatility..... 58

Figure 2-3 Poland/Eurozone Exchange Rate Volatility ..... 59

# 1. Introduction

Eight Central and Eastern European (CEE) countries, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia, and Slovenia, joined the European Union (EU) in May 2004, after fifteen years of transition from central planning to market economies. They are also expected to join the European Monetary Union (EMU) and adopt the *euro* when they fulfill the Maastricht Criteria (MC). That is, unlike Denmark and the United Kingdom, they do not have the right to opt out of the single currency and have to be Member States of the Eurozone<sup>1</sup> at some point in the future. However, as the Governing Council of the European Central Bank (ECB) noted in its "policy position of the Governing Council of the ECB on exchange rate issues relating to the acceding countries", there is no pre-set timetable for the adoption of the *euro* by these new EU Member States. Initially almost all these countries showed interest in joining the Eurozone as soon as possible. More recently, however, some of them have begun to envisage a somewhat longer process because it is not clear whether joining the Eurozone as soon as possible will benefit them the most. Therefore, when is the best time for the monetary integration of these Central and Eastern European countries (CEECs) into the Eurozone is an interesting and relevant topic. It is the focus of this dissertation.

In this chapter, we first present some background information on

---

<sup>1</sup> The **Eurozone** (also known as **Euro Area**, **Eurosystem** or **Euroland**) is the subset of EU Member States which have adopted the *euro*, creating a currency union.

the EMU-accession procedure, including the European Exchange Rate Mechanism (ERM) and the Maastricht Criteria. Next we describe some of the most important macroeconomic indicators of the CEE economies, followed by a general discussion of the potential benefits and costs of entering a monetary union. Finally we introduce the three empirical studies that we conduct in this dissertation.

## **1.1 The EMU-accession Procedure**

The Eurozone came into existence with the official launch of the *euro* on 1 January 1999. It included eleven EU Member States: Austria, Belgium, Finland, France (except Pacific territories), Germany, Ireland, Italy, Luxembourg, Netherlands, Portugal, and Spain. Later, Greece met the convergence criteria in 2000 and was admitted on 1 January 2001, bringing total Eurozone membership to its current level of twelve Member States, known as EU-12.

Among the other thirteen countries of the European Union that have not yet adopted the *euro* (Denmark, Sweden, the United Kingdom, Cyprus, Malta and the eight CEE economies), Denmark and the United Kingdom got special derogations in the original Maastricht Treaty of the European Union. They are not legally required to join the Eurozone unless their governments decide otherwise, either by parliamentary vote or referendum. The other countries, including the eight CEE countries, are obliged to enter the EMU eventually. However, according to the general commitments in the pre-accession agreements signed by the new entrants with the European Commission, the CEE will not transfer

their monetary authority from the start but rather enter the Union as "Member States with derogation" to full EMU-membership.

According to the ECB, monetary integration of CEE economies in the Eurozone should be a multilateral, successive and phased process, leading finally to their adoption of the *euro*. The Commission envisages a three-phased process:

- The pre-accession phase, during which the accession nations shall fulfill the general EU membership criteria. In this phase, they keep their monetary sovereignty, but have to adopt the monetary and exchange rate policy-related provisions of the *Acquis Communautaire* as follows:
  - To treat their economic policies as a matter of common concern
  - To exclude all central bank credits to the government and guarantee an acceptable degree of central bank independence
  - To avoid excessive deficits
  - To regard the exchange rate policy as a matter of common interest
  - To submit regular convergence programmes
- The accession phase, in which the accession countries are already in the EU but still outside of the Eurozone. In this phase, CEE countries lose to a considerable degree (but not yet fully) their monetary sovereignty. Exchange rates of the CEE countries are the major concern in this phase. In particular,



excessive exchange rate fluctuations or misalignments of their exchange rates would be regarded as inconsistent with the proper functioning of the single market and potentially harmful to other EU members. In addition, the economic policies of the CEE also become a matter of common concern and are subject to coordination and common surveillance procedures. In order to meet the Maastricht convergence criterion of exchange rate stability, as one of the preconditions for joining the Eurozone, the CEE also need to participate for at least two years in the ERM II, a specific system of a fixed, yet adjustable exchange rates that is designed for the so called pre-ins, EU member countries which are not yet ready for joining the Eurozone. The duration of the accession countries' stay in this phase could last for more than two years if it is considered appropriate for their economies or for the stability of the Euro area.

- The actual *euro* phase, which starts when the CEE countries meet the required criteria for the joining in the Eurozone: to adopt the *euro* and to give up their own national currencies. From then on, the CEE countries will have equal rights and obligations in the conduct of the single European monetary policy as the other EU members of the Eurozone. It is important to note here that no additional transition-type requirements are to be applied for full EMU membership. Once a Member State adopts the *euro*, its National Central Bank (NCB) automatically becomes a part of the Eurozone.

Currently all the eight CEE countries have passed the first phase and stepped in the second phase.

## **European Exchange Rate Mechanism**

The European Exchange Rate Mechanism (ERM) was introduced in March 1979 as part of the European Monetary System (EMS), to reduce exchange rate variability and achieve monetary stability in Europe, in preparation for the introduction of the *euro*. It is based on the concept of fixed currency exchange rate margins, but with exchange rates variable within those margins. Before the introduction of the *euro*, exchange rates were based on the European Currency Unit (ECU), whose value was determined as a weighted average of the participating currencies.

In 1999, the ERM II replaced the original ERM, which is defined as the "Resolution of the European Council on the establishment of an exchange rate mechanism in the third stage of the EMU" (hereafter, the Resolution<sup>2</sup>). The main objective of the ERM II is to support a stable economic environment needed for the single market, in which real exchange rate misalignments and excessive nominal exchange rate fluctuations between the *euro* and other EU currencies must be avoided. In addition, the ERM II is also expected to provide Member States outside the Eurozone with a reference for their monetary policies, to facilitate real convergence so that they can adopt the *euro* eventually,

---

<sup>2</sup> Resolution of the European Council on the establishment of an exchange rate mechanism in the third stage of EMU, Amsterdam 16 June 1997

and to help protect participants from unwarranted pressures in foreign exchange markets.

The main features of the ERM II include: (i) a central rate against the *euro*; (ii) a standard fluctuation band of  $\pm 15\%$  around the central rate; (iii) obligatory interventions at the margins, which are in principle automatic and unlimited; and (iv) availability for very short-term financing. The Resolution emphasizes, however, that the ECB and the participating National Central Banks (NCBs) “could suspend intervention, if this were to conflict with their primary objective.” Such a decision to suspend intervention would “take due account of all relevant factors and in particular of the need to maintain price stability and the credible functioning of the exchange rate mechanism.”

In addition to help the participating Member States orient their policies to stability and to foster convergence, as stated above, participation in ERM II also plays a role in the convergence criteria for joining the Eurozone, because participation in it for a period of at least two years without severe tensions and without devaluing (relative to the *euro*) at the country's own initiative is one of the pre-conditions to join the Euro area. These dual roles of the ERM II hence have implications for the exchange rate policies of acceding countries upon ERM II entry.

As stated by European Commission, “in certain cases, staying outside the ERMII for some time (after accession) may be useful in light of large and volatile capital flows, large fiscal imbalances, and/or risks of large economic shocks” (“Acceding countries and ERMII “, a document prepared by the European Commission for the High Level Meeting in



Athens on 28 May 2003). Participation in the ERM II system is therefore voluntary, although the member countries are expected to join the Mechanism eventually. Whether it is preferable to enter into the ERM II system as soon as possible depends on a number of factors and is related to the specific situation of each individual country.

Among the eight new CEECs, five of them have already become a full participant in the ERM II mechanism. The following table shows the dates when they enter:

Date of entry	Country	Notes
28 June 2004	Estonia	Estonia had pegged its currency to the <i>German Mark</i> , and then the <i>euro</i> .
	Lithuania	The Lithuanian <i>litas</i> was pegged to the <i>US dollar</i> until 2 February 2002, when it switched to a <i>euro</i> peg.
	Slovenia	The Slovenian <i>tolar</i> floats in a $\pm 15\%$ range against the <i>euro</i> . (Since entering into ERM II it has floated in the range of $\pm 1\%$ )
2 May 2005	Latvia	Latvia has a currency board arrangement whose anchor switched from the <i>SDR</i> to the <i>euro</i> on 1 Jan. 2005. The current <i>lats</i> fluctuation margin is $\pm 1\%$ against the <i>euro</i> .
28 Nov. 2005	Slovakia	The <i>koruna</i> now floats in a $\pm 15\%$ against the <i>euro</i> .

Table 1-1 Entry of ERM II for Some CEE Countries

The three largest countries, the Czech Republic, Hungary and Poland are still outside of the ERM II. Although they are expected to follow eventually, the exact times are still unclear.

### Maastricht Criteria (MC)

To join in the Euro area currency union, the CEE countries have to fulfill the convergence criteria outlined in the Treaty of Maastricht. The four main criteria are shown in the following.



- The *Inflation Convergence Criterion* - annual inflation (of CPI) rate not higher than the average inflation rate in 3 EU Member States with the lowest inflation + 1.5% points;
- The *Interest Rate Convergence Criterion* - long-term interest rate (10 year government bond rate) not higher than the average interest rates in 3 EU member states with the lowest inflation +2% points;
- The *ERM Criterion* - (against *euro*) for two years to remain within +/-15% of the pre-established central rate;
- The *Excessive Debt Criterion* - fiscal deficit of general government not higher than 3% of GDP and public debt not higher than 60% of GDP;

The rationale behind the Maastricht Criteria is that deficits have to be sustainable in order to avoid negative externalities to other Eurozone members and that inflation and exchange rate instability have negative effects on long-run growth. It seems that the CEE economies' chances of fulfilling the Maastricht Criteria depend less on capability than determination. If the candidates set their minds to it, these nominal barriers usually do not pose a significant problem to entry. The more frequently asked question is whether it is beneficial to enter EMU as quickly as possible.

## **1.2 The Macroeconomic Situation of the CEE Economies**

After introducing the EMU accession procedure, in this section, we shall look at some of the most important macroeconomic indicators of the

CEE economies, which give us the implications on how soon they are able to meet the convergence criteria.

## GDP Growth and Inflation Rate

Even though the economies of the CEE countries have a painful transition period with a decline in output and employment in the beginning, they can be regarded as quite successful in the past seventeen years striving for market economies. That is, the current macroeconomic situation in most CEE economies is characterized by massive decelerations in inflation rates to single-digit values (see Figure 1-1) and relatively robust GDP growth rate (see Figure 1-2), due to the fact that strong Foreign Direct Investments (FDI) and capital inflows are attracted with the low wages, the well-educated workforce, the good institutions, and the political stability. Figure 1-3 compares the GDP growth rate of the CEECs with the one of the EMU in the past three years, in which we can see clearly that the GDP growth rates of the CEE economies are growing much faster than the average of the EMU member countries.

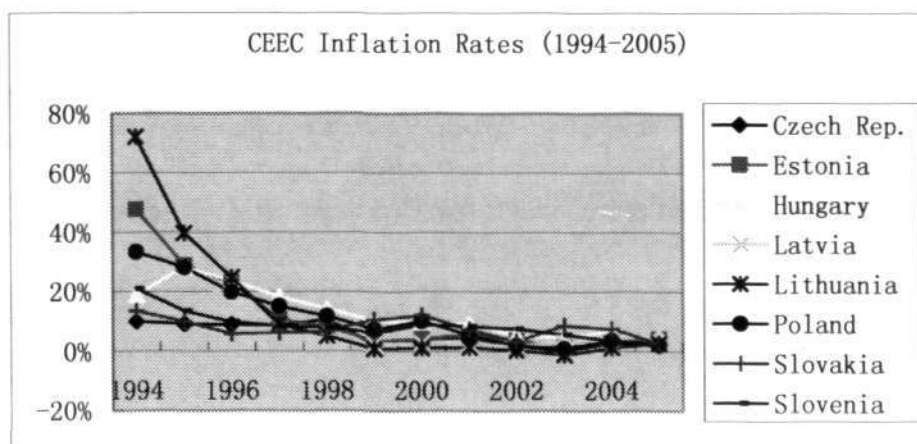


Figure 1-1 CEEC Inflation Rates  
Source: International Financial Statistics

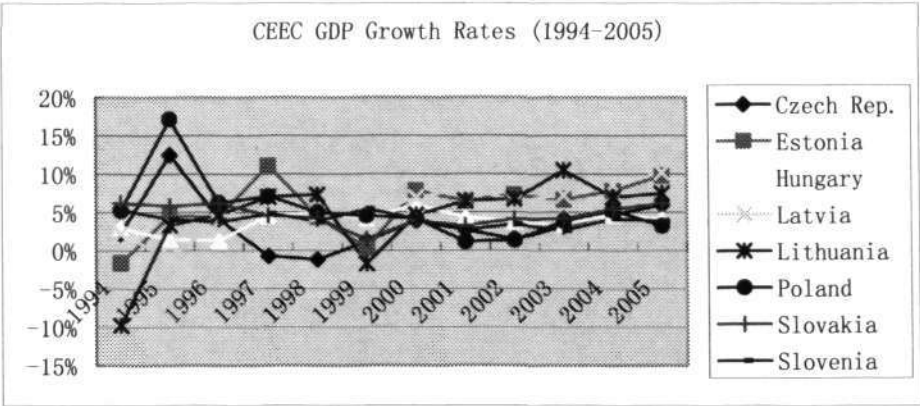


Figure 1-2 CEEC GDP Growth Rates  
Source: International Financial Statistics

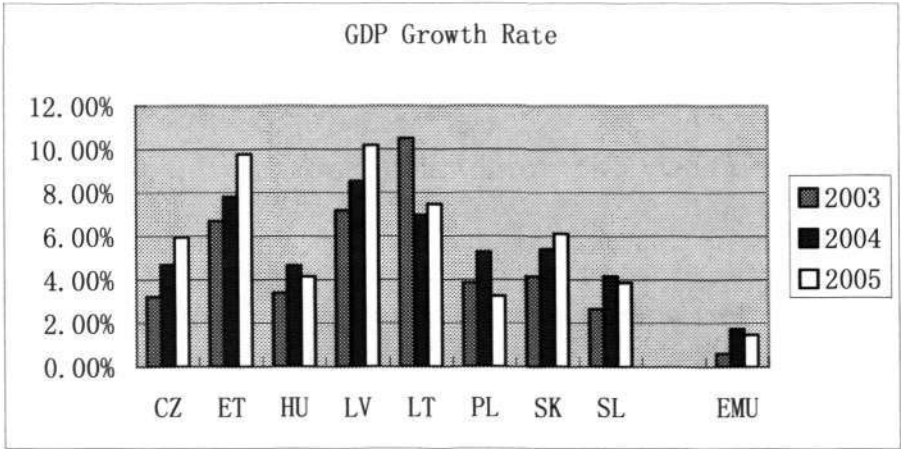


Figure 1-3 CEEC GDP Growth Rates Compared with the EMU  
Source: International Financial Statistics

At the same time, despite the above good aspects, the GDP per Capita for most of the CEE countries are still way below those of the western EU Member States, ranging from 22.5% in Latvia to 57.6% in Slovenia in Year 2005, as can be derived from Figure 1-4. This was taken by the ECB Commission as a symptom of unfinished transition, which, in its view, warrants a considerable delay in EMU accession of these countries. In addition, although the inflation rates of the CEE countries are in the single-digit range, they are not very stable over the past three years (see Figure 1-5). This is partly attributable to the instable prices in fuel and other raw materials. The resource-limited CEE countries are heavily dependent upon them.



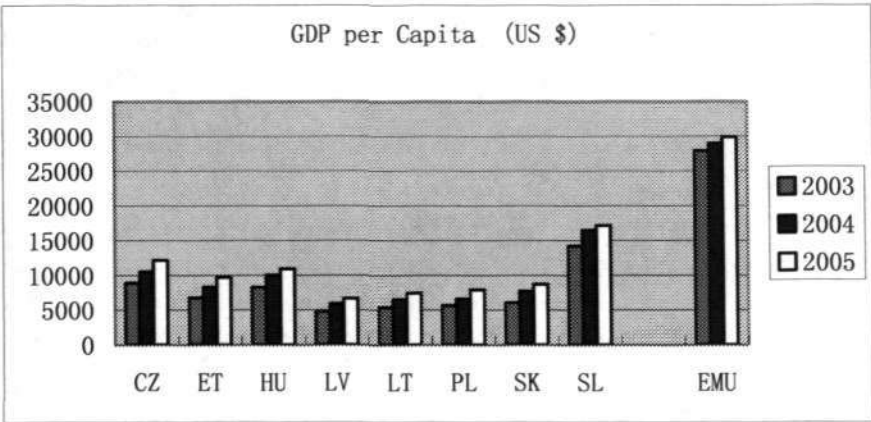


Figure 1-4 CEEC GDP per Capita Compared with the EMU  
Source: International Financial Statistics

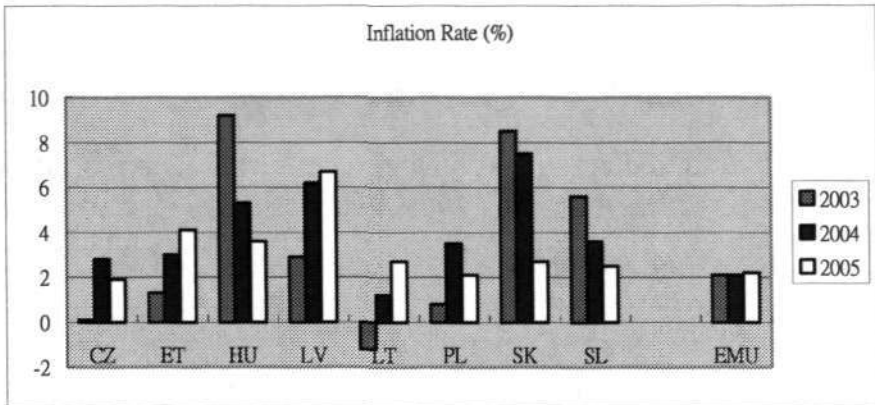


Figure 1-5 CEEC Inflation Rates Compared with the EMU  
Source: International Financial Statistics and National Statistical Office

## Long-Term Interest Rate

Concerning long-term interest rates, most CEE countries stand in the range of 3~4% at the end of Year 2005, which is quite similar to the value of the EMU Member States (on average about 3.4%), as can be seen from Figure 1-6. However, Hungary and Poland still have relatively high long-term interest rate, with Hungary above the second Maastricht criterion (i.e., not exceeding by more than 2 percentage points that of the three best performing EMU Member States) and Poland slightly lower than it.

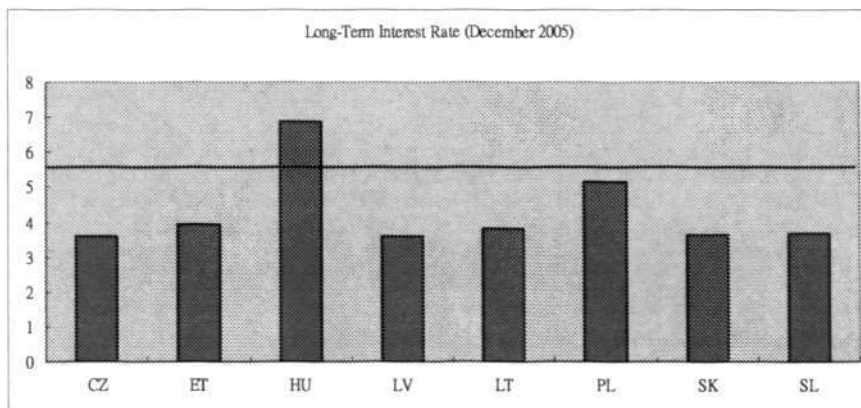


Figure 1-6 CEEC Long-Term Interest Rate<sup>3</sup>  
Source: ECB and EU-Commission

## Exchange Rate Mechanism

The exchange rate systems and the corresponding monetary policy regimes adopted are quite diverse across these countries. The monetary authority of every country has been always trying to evaluate and find out the best policy regime for its economy.

In practice, exchange rate arrangements can seldom be subdivided into fully pegged or fully flexible regimes, but they cover a broad variety of “intermediate” regimes. The International Monetary Fund (IMF) classifications of the exchange rate arrangements, as issued by the IMF Annual Reports on Exchange Rate Arrangements and Exchange Restrictions, have provided a measure for the commitment by the monetary authorities in favor of specified exchange rate targets. In particular, the IMF classifies exchange rate arrangements into eight groups with a rising degree of exchange rate flexibility, as follows:

1. Exchange rate arrangements with no separate legal tender
2. Currency board arrangements

<sup>3</sup> Estonia does not have suitable government bonds on the financial market and the current indicator represents the interest rates on new Estonian Kroon-denominated loans to non-financial corporations and households with maturities over five years.

3. Other conventional fixed peg arrangements (within a band of most  $\pm 1\%$ )
4. Pegged exchange rate arrangements within horizontal bands (at least  $\pm 1\%$ )
5. Crawling pegs (with small, pre-announced adjustment)
6. Exchange rates with crawling bands
7. Managed floating with no pre-announced path for the exchange rate
8. Independent floating (market-determined exchange rate and independent monetary policy)

These eight classifications are generally sub-divided into fixed exchange rate arrangements (1 and 2), intermediate exchange rate arrangements (3 to 6) and flexible exchange rate arrangements (7 and 8) (Fischer 2001).

Even though their economic tasks and problems were similar to a substantial degree at the beginning of transition in the late 1980s and early 1990s, the CEE countries have chosen different exchange rate regimes to deal with them. Following the liberalization of wages, prices and external trade, a sharp depreciation (overshooting) of the exchange rate has taken place subsequently in many countries. In order to control inflation when facing the insufficiently developed indirect macroeconomic policy instruments (i.e., the indirect monetary policy tools such as open market operations, refinancing, and reserve requirements for commercial banks), a number of CEE countries prefer to anchor their currencies with a fixed exchange rate regime. Only few of them, setting out from a



position closer to perceived macroeconomic equilibrium, opted for more flexible arrangements. Such exchange rate-based stabilization has played a positive role in restoring the domestic equilibrium to some extent, though in some cases at the cost of widening current account imbalances. Further down the line, a number of countries chose or were forced to abandon their fixed regimes. Table 1-2 shows the evolution of the exchange rate arrangements from Year 1990 to Year 2004.

	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04
Czech Rep.	3	3	3	3	3	3	6	7	7	7	7	7	7	7	7
Estonia	N.A.	N.A.	2	2	2	2	2	2	2	2	2	2	2	2	2
Hungary	3	3	3	3	3	6	6	6	6	6	6	4	4	4	4
Latvia	N.A.	N.A.	8	8	3	3	3	3	3	3	3	3	3	3	3
Lithuania	N.A.	N.A.	8	8	2	2	2	2	2	2	2	2	2	2	2
Poland	3	5	5	5	5	6	6	6	6	6	8	8	8	8	8
Slovakia	3	3	3	3	3	3	6	6	7	7	7	7	7	7	7
Slovenia	N.A.	N.A.	7	7	7	7	7	7	7	7	7	7	7	7	4

Table 1-2 Evolution of Exchange Rate Arrangements in CEECs  
Source: IMF (various issues)

The current exchange rate arrangements of the CEECs are summarized in the Table below.

Country	Currency	Monetary policy strategy	Features
Czech Republic	Koruna	Inflation targeting	Target: 3%, with $\pm 1$ tolerance band
Estonia	Kroon	Exchange targeting	Managed float exchange rate Participates in ERM II since 28 June 2004 with $\pm 15\%$ fluctuation band. Continues with its currency board arrangement as a unilateral commitment
Hungary	Forint	Combined rate and exchange targeting	Exchange rate target: peg to the <i>euro</i> with $\pm 15\%$ fluctuation band. Inflation target: 4% ( $\pm 1$ p.pt.) by end-2005, 3.5% ( $\pm 1$ p.pt.) by end-2006, and 3% ( $\pm 1$ p.pt.) medium term target from 2007
Latvia	Lats	Exchange targeting	Participates in ERM II since 2 May 2005 with a $\pm 15\%$ fluctuation band. Continues with a fluctuation band of $\pm 1\%$ as a unilateral commitment.
Lithuania	Litas	Exchange targeting	Participates in ERM II since 28 June 2004 with $\pm 15\%$ fluctuation band. Continues with its currency board arrangement as a unilateral commitment
Poland	Zloty	Inflation targeting	Inflation target: 2.5% $\pm 1$ percentage point (12-month increase in the CPI) as from 2004. Free float exchange rate.

Slovakia	Koruna	Inflation targeting in the conditions of ERM II	Inflation objective: short-term inflation target set at 3.5%±0.5 p.p. at end-2005. The inflation target for the period 2006-2008 is set below 2.5% for end-2006 and below 2% at end-2007 and at end-2008. Participates in ERM II since 25 November 2005 with ±15% fluctuation band.
Slovenia	Tola	Two-pillar strategy monitoring monetary, real, external and financial indicators of macroeconomic conditions	Participates in ERM II since 28 June 2004 with ±15% fluctuation band.

Table 1-3 Current Exchange Rate Regimes of the CEECs

Looking at the evolution of the exchange rate arrangements in the eight CEE countries, we can see a clear trend towards the corners of fixed and flexible options emerges. At the same time, as is shown in Table 1-3, this change has been asymmetric. The range of exchange rate regimes in the history covered the whole spectrum of possibilities from free floating to currency board arrangements. In most countries, exchange rate policy has been determined by the double objectives of exchange rate stability and external competitiveness and, more generally, by the need to strengthen the credibility of macroeconomic policies. Currently, the exchange rate regimes still vary for the three CEECs that are outside of ERM II. Different monetary policies are employed to suit their own needs.

**Government Budget Deficit and Gross Debt**

Regarding the fiscal criteria, as can be observed from Figure 1-7, the budget deficit varies significantly across countries, with the CEE ERM-insiders having fiscal deficits of below 3% of GDP (Estonia even a surplus), while the Czech Republic, Hungary and Poland have fiscal deficits above the threshold. In principle, a modest budget deficit or surplus can be achieved with a model featuring a high ratio of state



spending or with a liberal model. Which model should be used, however, depends partially on the GDP per capita for the country. If Czech Republic, Hungary and Poland wish to avoid structural deficits of over 3% of GDP, they may need to move forward with further fiscal reforms. These countries, however, do not seem to move as quickly as possible, which shows that they are probably still in the hesitant mood to join the EMU. As for the government debt to GDP ratio, all the CEE countries are below 60% of GDP in the past three years (see Figure 1-8), which conforms to the fourth convergence criterion.

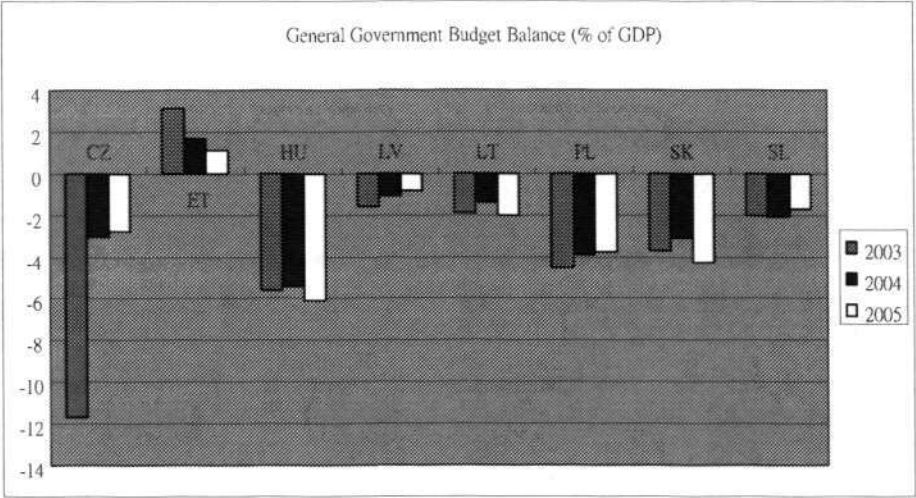


Figure 1-7 CEEC Government Budget Deficit  
Source: National Statistical Offices and EU-Commission

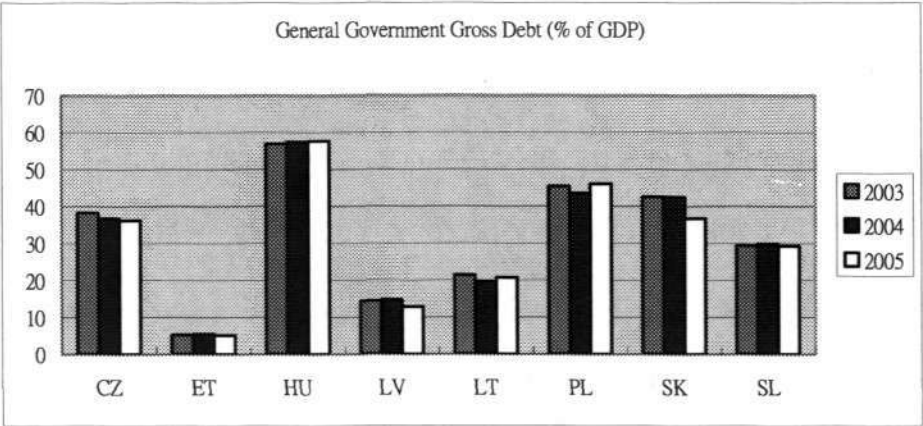


Figure 1-8 CEEC Government Gross Debt  
Source: National Statistical Offices and EU-Commission

In addition to the macroeconomic indicators outlined in the Maastricht criteria, we discuss some other important factors in the following paragraphs.

Trade and Financial Integration with the EMU

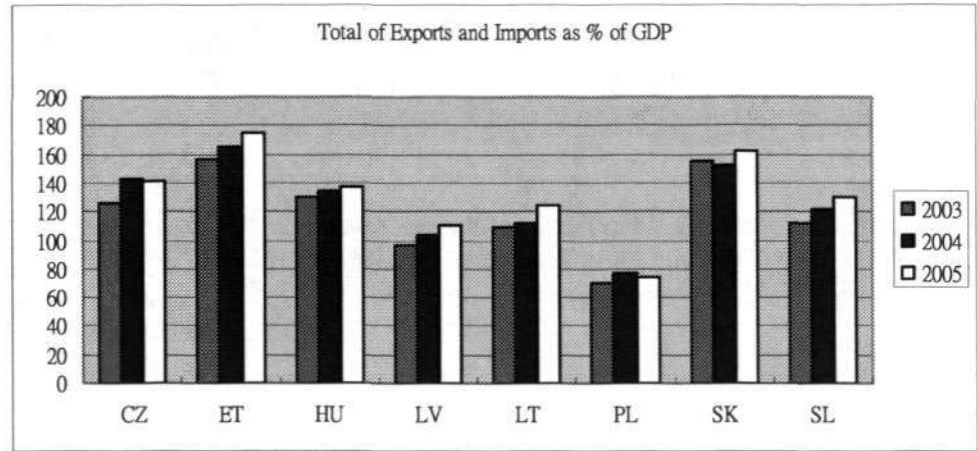


Figure 1-9 The Degree of Openness for the CEE Countries  
Source: International Financial Statistics

With the partial exception of Poland, the CEE countries are small and highly open economies, as can be observed from Figure 1-9. We can also see that the degree of openness is gradually increasing in the past three years for most of the CEECs.

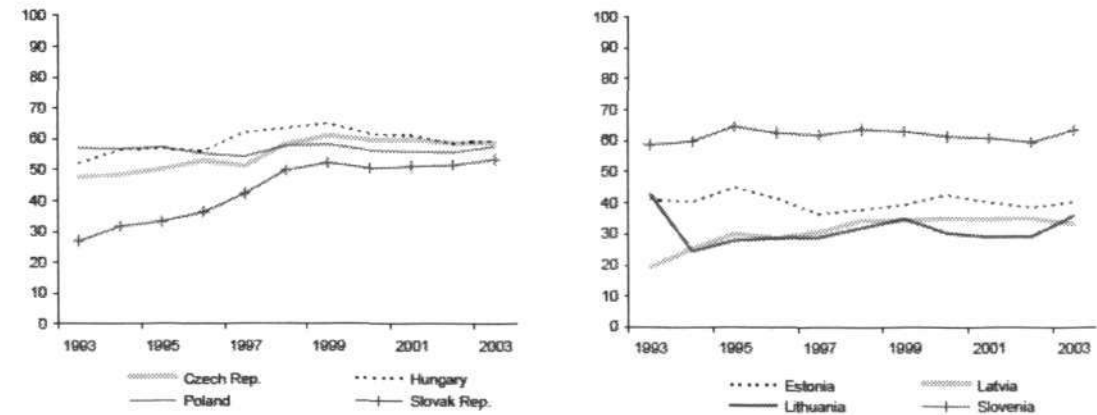


Figure 1-10 Share of Trade Flows with the Eurozone as a Percentage of Total Trade Flows (Imports+Exports)  
Source: Bussiere et al. (2005)

From Figure 1-10, it can be observed that the Eurozone represents

the most important trading partner for the CEE countries. In the case of the Czech Republic, Hungary, Poland, Slovakia and Slovenia, for instance, trade with the Eurozone amounts to nearly 60% of their total trade in recent years. This trade integration trend is expected to continue in the future.

As for capital flows, almost all CEE countries have experienced large and increasing inflows in recent years, in which the largest component is foreign direct investment. The FDI, mostly from the EMU member states, has accounted for approximately two-thirds of all capital flows to these countries. As a consequence, cross-border ownership has increased substantially both in the real sector and in the financial sector. Another basic feature of the CEE countries' financial markets is the dominance of the banking sector over capital markets. One other noticeable characteristic of financial systems in the CEE countries is substantial foreign ownership, which can be observed in all market segments.

**Labour Market**

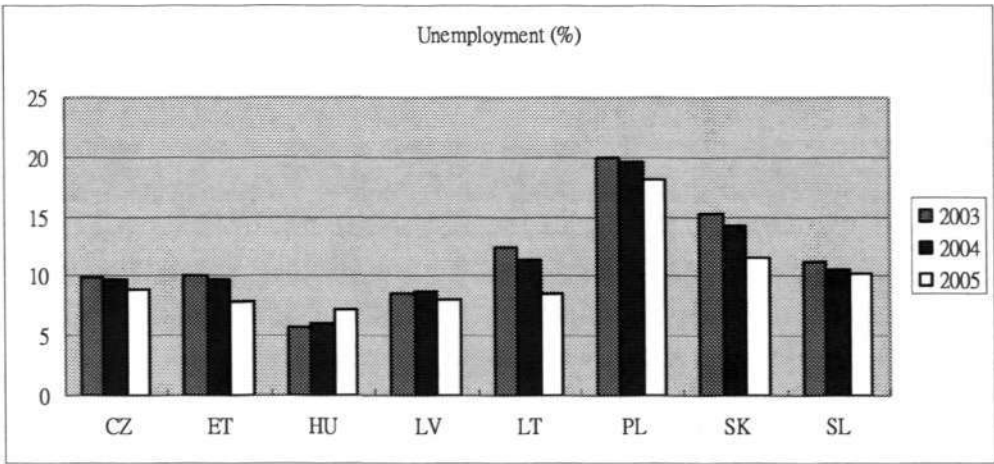


Figure 1-11 CEEC Unemployment Rates  
Source: National Statistical Office and EU-Commission

Labour markets throughout the CEE countries have been gradually



improving over the past three years (except for Hungary), as can be observed from Figure 1-11. The unemployment rate in Poland and Slovakia is much higher than the rest of the CEE countries. Except them, the unemployment rates ranges from 7.2% in Hungary to 10.2% in Slovenia in Year 2005, which is close to the average rate of the EMU (approximately 7.5%). The flexibility of labour markets is quite difficult to assess and quantify, however, the degree of labour turnover and the strictness of the employment protection legislation in place have shed more positive light on the situation (See Fidrmuc (2002)). In addition, there has also been a rapid wage growth in the CEE countries, which may threaten their ability to compete with other places (e.g., China and India) for FDI. However, the increasing productivity has helped them to maintain regional competitiveness so far.

All in all, the CEE economies display some commonalities with the Eurozone that may bode well for future monetary integration. On their way to fulfill the convergence criteria, however, benefit-cost analysis is needed for these economies to decide whether or not to hasten their steps. Without a formal opt-out provision, the CEE countries (especially the three ERM-outsiders) may prefer to stay out of the EMU by following the Swedish example which fails to fulfil all Maastricht criteria deliberately, as some say. Therefore, in the next section we discuss the potential benefits and costs of joining a monetary union.

### **1.3 Potential Benefits and Costs of a Monetary Union**

There are a number of potential benefits and costs when joining a monetary union, as discussed in this section.

## Potential Benefits

One of the most cited benefits of the single currency area is the elimination of transaction costs incurred by enterprises and households, who do not have to convert their domestic currencies into each other any more. There are mainly two kinds of transaction costs.

- Financial costs like the bid-ask spreads, fees accompanying foreign exchange operations and costs of hedging against exchange rate risk. O'Shea and Keane (1999) found that these direct savings in transaction costs could amount to as much as 0.5 percent of EU GDP. It should be noted that these benefits may not be fully realized as long as national currencies circulate along the single currency.
- Administrative costs incurred by companies as a result of committing resources to activities related to foreign exchange operations. Such activities usually cost more for small and medium-sized enterprises than for international corporations (European Commission 1990).

It should be noted that the openness of an economy is one of the primary factors affecting the transaction costs. A more open economy (towards other currency union members) usually benefits more from the elimination of transaction costs than the less open one. In addition, how effectively the labor and capital resources are relocated to conduct foreign exchange operations, significantly affects the benefits brought by the elimination of transaction costs.

Another potential benefit of the single currency area is the elimination

of exchange rate risk. Such risk may lead to a decrease in the value of assets or an increase in the value of liabilities denominated in domestic currency as compared with its expected value, due to the unexpected fluctuations in the exchange rate. A stable exchange rate removes the uncertainty for the exporters and importers and hence generally results in foreign trade expansion. Elimination of exchange rate risk also reduces the investment risk from the foreign countries and hence may encourage foreign direct investment inflow. In addition, relinquishing the domestic currency usually decreases domestic interest rate because of the elimination of the currency risk premium. As a consequence, it may also lead to increasing domestic investment due to the decreased capital cost. Moreover, a stable exchange rate can help to stabilize the overall price level (based on the Commission's macroeconomic model) and thus makes investment decisions more accurate and capital allocation more efficient.

A monetary union may also lead to an enhancement of policy discipline. That is, a country may reap the benefits of a credible anti-inflation policy after adopting a common currency (Bean (1992)). This reduction of inflation can thus lead to an improvement of economic performance.

### **Potential Costs**

It is obvious that the most significant cost of the adoption of the *euro* is the loss of independent monetary policy to respond to region-specific macroeconomic disturbances (Obstfeld and Rogoff (1996)). National currency can be helpful in conducting domestic economic policy



according to its own need, but with the entry into a currency union, individual governments lose the authority to revise its exchange rate and interest rate for national economic adjustment. Monetary policy in a monetary union is agreed upon by all Member States and has to be a compromise between the needs of all countries. In other words, monetary policy fully designed for domestic needs of one country will not be endorsed by others. This is especially a problem for the CEE economies as their small sizes limit their impact on the set-up of the monetary policy of the entire union. One of the most severe problems brought by the loss of independent monetary policy will be the lack of instruments when facing asymmetric shocks.

From a political point of view, the entry into a monetary union may also affect the national security of a country in extreme cases such as wars because it does not have the option to use inflation to reduce the real burden of public debt. Glasner commented that "governments most likely to relinquish control over the creation of money are ones with no defense responsibilities". This can be regarded as a special aspect of sovereignty loss.

Finally, another minor cost when entering a monetary union is the loss of the taxable currency conversion income to the banking system of the country.

## **1.4 Objectives and Contributions of the Thesis**

Given the above potential benefits and costs for a monetary union in the general case, in this dissertation, we focus on the specific case of the CEE countries, intending to study to what extent will entering the EMU be

beneficial or harmful for them from various aspects. The objectives and contributions of the three empirical studies conducted in this dissertation are shown as follows.

The objective of the first essay (presented in Chapter 2) is to investigate the impact of the real exchange rate volatility on the exports of the three key CEE economies (Czech Republic, Hungary and Poland) to the Eurozone. This issue is of particular interest because these countries still stay outside of the ERM II after joining the EU in May 2004. By joining EMU, these CEE countries would escape exchange rate volatility on trade with the Euro zone. If exchange rate volatility were to impede export flows, commonly perceived as the engine of economic growth in developing countries, their motivations for adopting the *euro* and hence for making a greater effort to meet the Maastricht convergence criteria should increase.

This empirical study contributes to the literature in several aspects. First, despite the rising concern of exchange rate regime and the future EMU membership, the impact of exchange rate volatility on the exports, which has attracted the interests of researchers and policy makers since early 1970s, has rarely been studied for these CEE countries. To the best of our knowledge, this essay is the first complete study to tackle the effects of exchange rate volatility vis-à-vis *euro* on bilateral trade between CEE countries and the Eurozone. Second, given the obvious non-stationarity of the data, we use Johansen's multivariate procedure to obtain the estimates of the co-integration relationships and the constrained error correction model (general to specific) to obtain the



estimates of the short-run dynamics. Third, most previous studies have presumed (either explicitly or implicitly) that the co-integration relationship is stable, which may not be the case in practice. That is, there is no reason to believe a priori that the relative importance of factors influencing the relationship between real exports and their determinants has remained unchanged. According to Haug and Lucas (1996), credible evidence of such a relationship should be ascertained, not only by testing for statistical cointegration, but also by investigating whether the cointegrating relationship has been structurally stable over the sample period. For this purpose, several tests proposed by Hansen (1992b) are employed, which provide new evidence on the stability of the cointegrating relationship. Last, but not least, the conditional variances of exchange rate measures (GARCH model) have been used to calculate the proxy of exchange rate volatility.

Our results indicate that great exchange rate volatility has significantly reduced the volume of exports for the economies concerned. Therefore, we can conclude that the elimination of real exchange rate volatility vis-à-vis *euro* associated with the prospective EMU membership will lead to a rise in the CEE countries' exports to the Eurozone, which is beneficial for these CEE countries.

As entering the Eurozone eliminates not only the exchange rate volatility between the CEE countries and the Eurozone, but also the one among CEE countries themselves, it is also interesting to investigate the impact of exchange rate volatility on the intra-CEE trade, which is the focus of our second essay (presented in Chapter 3). The classical gravity

model is utilized to study the relationship of the eight CEE economies for the quarterly period from 1995 to 2005. Unlike many other studies that assume the stationarity of the panel data, the recently developed panel unit root tests and panel cointegration tests are used to detect whether the panel data are stationary and whether there is long run relationship between these non-stationary data. We then apply dynamic OLS methodology in our study to estimate the parameter in the gravity model. Our results indicate that the exchange rate volatility exerts a significant negative effect upon bilateral trade among these CEE countries. This means that the future prospective membership of EMU also increases the trade volume among the CEE countries, in addition to increasing trade between the CEE countries and the Eurozone, as the first essay indicates.

Different from the above two essays discussing joining the EMU from the potential benefit perspective, in Chapter 4, our third essay examines the *euro* adoption problem from the cost perspective. According to the Optimum Currency Area (OCA ) theory, joining a monetary union results in the loss of independent monetary policy and hence the loss of a flexible exchange rate acting as an asymmetric shock absorber for an acceding country. Therefore, we are interested in finding out whether the exchange rate actually serves as a significant shock absorber for the CEE economies. Our analysis is based on the well-known structural vector auto-regression (VAR) models. As opposed to others, however, in our VAR model, we not only analyze the contribution of different sources to the fluctuations of real exchange rate,

but also try to figure out the importance of the Eurozone shocks on these CEE economies. We include four variables in our model: the EU growth rate, the CEE growth rate, the CEE inflation rate and the CEE exchange rates vis-à-vis *euro*. Finally, we derive our long-run restrictions from the AS-AD model and embed it in the structural VAR framework. Our results show that the Eurozone shocks play a substantial role in driving the output fluctuations of the three CEE ERM-outsiders, and the adoption of *euro* generally does not pose substantial economic problems for them.

## **2. Essay I: Exchange Rate Volatility and Exports from CEE Economies to the Eurozone: Evidence from the Error Correction Model**

### **2.1 Overview**

Since the breakdown of the Bretton-Wood agreement in 1973, most trading nations have abandoned fixed exchange rate regimes and have adopted various forms of flexible exchange rate arrangements. This transition has caused an extensive debate over the exchange rate volatility and its impact on international trade, which seems to be one of the major dilemmas in international economics and has been the subject of numerous studies. The theoretical literature on this issue indicates that there is no clear-cut relationship between exchange rate volatility and trade flows. The presumption that trade is adversely affected by exchange rate volatility depends on a number of assumptions and does not necessarily hold in all cases. Therefore, it is important to investigate the relationship between exchange rate volatility and trade flows empirically.

The impacts of exchange rate volatility on trade are of particular interests for the three key CEE countries (i.e., Hungary, Czech Republic and Poland), because these countries still stay outside of the ERM II after joining the EU in May 2004. As introduced in the last chapter, joining



the EU means they have to adopt the *euro* at some time in the future. The fundamental question is when is the best time to take this move, which has been discussed a lot both by the academia and the policy-makers in recent years. By joining EMU, these CEE countries would escape exchange-rate volatility on trade with the Euro zone. If exchange rate volatility were to hinder export flows, commonly perceived as the engine of economic growth in developing countries, their motivations for adopting the *euro* and hence for making a greater effort to meet the Maastricht convergence criteria should increase considerably. Despite the rising concern, however, the impact of exchange rate volatility on exports for the CEE countries has rarely been studied. To the best of our knowledge, this is the first study to address the effects of exchange rate volatility vis-à-vis *euro* on bilateral trade between CEE countries and the Eurozone.

## **2.2 Literature Review**

McKenzie (1999) surveyed both the theoretical and the empirical studies in the literature that were dedicated to the relationship between exchange rate volatility and trade flows. In this section, we present some examples to illustrate the mixed characteristic of the research on this topic.

### **2.2.1 The Theoretical Literature**

Theory does not give us unambiguous answers for the effects of the exchange rate volatility on trade flows.

The traditional trade models assume that risk-averse exporters would reduce their output when faced with an increase in exchange rate

volatility brought by the move to floating exchange rate mechanisms. Even when the traders are able to avoid foreign exchange risk, the higher costs associated with it may have the same effect as an increase in tariffs, i.e., might reduce international trade. In this view, the exchange rate volatility is defined as a risk for international trade. Such adverse effects from exchange rate volatility have been the driving force for the monetary unification in Europe. Similarly, this kind of effect also provides motivations for currency market intervention by central banks (Klaassen 2002).

In his well-known article in this area, Clark (1973) put forward the following assumptions: the firm is perfectly competitive, producing output only for the foreign market; inputs are all from domestic markets; the foreign price for the exports is fixed; payments for the exports are in foreign currency; the only available forward contract is shorter than the trade contract and the firm's decision whether or not to engage in international trade depends on its assessment of the long-term prospects for profit. Therefore, greater variation in profits forces the risk-averse exporters to charge a higher price for every unit of output, hence reducing the volume of international trade. Clark emphasized that the role of perfect forward markets could alleviate the effect of variations in profits, but they would not eliminate the exposure to the risk of the exporting firms.

Either (1973) investigated the effect of forward exchange rate on international trade. He calculated the exchange rate uncertainty as the standard deviation of the spot exchange rate and modeled the decision

of risk-averse importers on the basis of both the volume of the goods to be imported and the amount of forward exchange rate cover. He found that if firms know how their revenues depend on the future exchange rates, the exchange rate uncertainty affects only the degree of forward cover, not the level of trade. However, he argued that it is unlikely that a firm possesses profit information, so the level of trade responds adversely to the exchange rate volatility.

Baron (1976) showed that, irrespective of whether invoicing is done in the exporter's or importer's currency, the exporter's exchange risk is unavoidable and therefore affects the volume of trade. The exporter is supposed to be in an oligopolistic market, selling goods abroad only. He also assumed that the import price for the transaction is pre-established over a period of time. The actual trade occurs in the future according to the "effective price" to the importer. If the sale is invoiced in the exporter's currency, the effective price is the price converted with the spot exchange rate when the transaction occurs. This leads to uncertain quantity demand for the exporter since the effective price is unknown until the actual transaction. Because of this, both revenues and costs become uncertain. On the other hand, if exports are invoiced in the importer's currency, the effective price is simply the trading price. Therefore, there is no uncertainty about quantity demand from the importer. However, the exporter faces risk in converting the sale to domestic currency, since the exchange rate at time of price-setting may differ from that at time of sale. Hence, total revenues at time of sale must be converted to the exporter's currency at an unknown spot exchange



rate. The profits become random and uncertain again. It is shown that with risk-aversion and freely floating exchange rates, the total value of exports and the expected profit are lower when compared to a fixed exchange rate regime.

In order to examine the theoretical impacts of exchange rate volatility on trade flows and import and export prices, Hooper and Kohlagen (1978) developed a complicated model of market equilibrium from traded goods. In this model, the importers, who utilize the imports for domestic final goods production, analyze their demand for output and order imports of intermediate inputs. Next, they receive and pay for the imports, thereafter producing and receiving payment for their output. A portion of the contract is denominated in the exporter's currency and the other part in the importer's currency such that risk-bearing is shared; Foreign exchange rate uncertainty is specified as the variance of the future spot exchange rate and is considered as the only risk. The model also allows for differences in risk preferences or risk bearing between importers and exporters. Hooper and Kohlagen argued that if traders are risk-averse, higher exchange rate volatility leads to higher cost for risk-averse traders and to less foreign trade. This is because the exchange rate is agreed upon at the time of trade contracts, but payment is not made until the future delivery actually takes place. Exporters are regarded as risk-averse agents and unable to hedge against exchange risk due to the cost considerations. However, they found that an increase in exchange rate volatility has an uncertain effect on price, depending upon who are bearing the risk. If importers bear the risk, the price will fall as import

demand falls, whereas if exporters bear the risk, the price will increase as exporters charge an increasingly higher risk premium.

Akhtar and Hilton (1984) argued that exchange rate volatility affects trade flows through two different channels. The first one is a direct channel effect in which the volume of goods is affected by prices and profits that are not precisely determined due to the exchange rate uncertainty. Suppose that the exchange risk cannot be perfectly hedged by the forward market and that the product price is denominated in foreign currency term; the firm would prefer a domestic product over to an import. Under the same circumstances, the exchange rate risk could adversely affect export volume. Suppose that the product price is quoted in domestic currency terms; then foreign suppliers will bear exchange rate risk of converting receipts from the importers' currency to their own. In order to compensate for the risk, foreign suppliers may impose a premium in the form of a higher sales price. Importers will reduce their import volume corresponding to higher price. The second channel that Akhtar and Hilton pointed out explains the less straightforward ways that uncertainty may affect trade. Most of these indirect effects stem from decisions, which affect trade flows over a longer period. Beyond the contract period, the ability of a firm to anticipate its future income stream could be impaired by doing business with foreign sellers and buyers rather than the available domestic ones. If it is costly to change, the buyers will refrain from switching between domestic and foreign producers to avoid incurring adjustment expenses. Under these conditions, international trade could be discouraged.

The early work primarily showed significant negative impacts of the exchange rate variability on exports. However, starting from the late 1980's, the research community started to look for theoretical models with non-negative effects of the exchange rate variability on exports, as shown in the following paragraphs.

Giovannini (1988) developed a partial equilibrium model of the determination of domestic and export prices by a monopolistic competitive firm. He assumed that firms must commit to prices at the beginning of every period and that production changes to meet the demand. The main focus of this work is the choice of currency in which to invoice exports. His model proposes that when export prices are set in foreign currency, increasing exchange rate risk leaves domestic and export prices unaffected; when export prices are set in domestic currency, increasing exchange rate risk has in general ambiguous effects on the level of domestic and export prices; when both demand and cost functions are linear, increasing exchange rate risk lowers export prices quoted in foreign currency. The proposition indicates that when financial markets are perfect and goods markets are imperfect, increases in exchange rate volatility do not necessarily lead firms to restrict supply. He suggested that firms can insulate expected profits from export fluctuations and face only uncertainty in unit revenues by charging export prices in foreign currency.

De Grauwe (1988) showed that effects of the exchange rate uncertainty on exports depend on the degree of risk aversion. If producers exhibit only a slight degree of risk aversion, they will produce



less for export as the higher exchange rate risk reduces the expected marginal utility of export revenues. However, if producers are extremely risk averse, they will worry about the worst possible outcome. Then an increase in exchange rate risk will raise expected marginal utility of export revenues as producers will want to export more to avoid a severe decline in their revenues. These results are based on the fact that the total effect of an increase in risk consists of a substitution and an income effect. The substitution effect makes firms move away from risky activities. An income effect, however, leads firms to increase their export activities to compensate for the decline in expected revenues. For large value of risk aversion, the income effect dominates the substitution effect, and greater exchange rate risk thus leads to increase in export. The theoretical study in the literature showed mixed results regarding the effect of exchange rate risk on trade flows.

Franke (1991) developed a model to analyze the direct effects of exchange rate volatility on the export strategy of a firm in an inter-temporal infinite horizon setting. The export strategy is associated with transaction costs. The entry (exit) costs associated with entering (abandoning) a foreign market are evaluated against profits (losses) created by exports by a firm. There are a variety of behavioral assumptions, such as the firm is risk-neutral operating in a monopolistic competition framework, and maximizes the net present value of expected cash flows from exports, which is an increasing function of the real exchange rate; the uncertainty is modeled by the real exchange rate, which is assumed to follow a mean-reverting process. A weaker (stronger)

exchange rate increases (decreases) both the cash flows from exporting and entry and exit costs. The latter are assumed to be a concave function of the exchange rate. If the exchange rate volatility causes expected cash flow from exporting to grow faster than expected entry and exit costs, then the value of the option to export will increase. This will be the case if cash flow is convex in the exchange rate. Then it is possible that any given firm would, on average, enter sooner and exit later when there is a rise in exchange rate volatility, thus increasing the average number of trading firms.

Sercu (1992) explored the same problem in a very different setting. He argued that friction here is brought about not by entry and exit costs, as stated in Franke's paper, but by standard duties and /or transportation costs. Additionally, a short-term "market period" perspective is adapted as risk-neutral firms produce in the current period for sales in the next period. Firms start producing at time zero for sales at time one, and may end up import-competing, exporting, or not trading at all depending on the end of period exchange rate. Sercu (1992) showed that under perfect competition and under complete monopoly an increase in exchange rate volatility has similar effects on prices and production as decreased tariffs.

Sercu and Vanhulle (1992) analyzed the behavior of an existing exporter who has incurred sunk costs to enter the market. Exchange rate is assumed to follow a random walk. When the exchange rate drops, firms can either exit the market without any prospect of re-entry or they can suspend trade temporarily (incurring costs if they invoke this option). The results showed that increase in exchange risk would raise the value

of the exporting firm in this work.

Viaene and de Vires (1992) provided a theoretical explanation for the empirical anomalies regarding the relationship between the volume of trade and exchange rate volatility, both with and without well developed forward markets. Under a partial equilibrium framework, they showed that in the absence of forward market, an increase in exchange rate volatility reduces both imports and exports. When a forward market was incorporated into the equations of this model, the effects of a change in exchange rate volatility on imports and exports are opposite the each other. The intuition behind these opposing effects is that exporters and importers are on opposite sides of the forward markets, depending on the net currency position of a country.

Dellas and Zilberfarb (1993) modeled the uncertain nature of the impact of exchange rate risk by using an asset portfolio model. Their definition of volatility differs from most of the other studies where the volatility is described as the variance of the exchange rate. The others specify unanticipated fluctuations in the exchange rate as constituting risk. The asset in their model is a nominal unhedged trade contract, which contains a risk element in the form of an exposure to changes in the exchange rate. The authors examined a single individual who consumes as well as imports and exports both available goods. Their results indicated that an increase in the risk of the return on these assets may increase or decrease investment depending on the nature of the risk aversion parameter assumed. If a convex function is assumed, then an increase in risk causes the level of exports to rise, if concavity is



assumed, the reverse is true. Their results are robust to the presence of a forward market with non zero transaction costs and the introduction of production.

Barkoulas et al. (2002) developed a simple signal extraction framework to investigate the effects of exchange rate uncertainty on the volume and volatility of trade flows. This framework identifies the effects of three different sources of exchange rate uncertainty, which are associated respectively with general microstructure shocks, the behavior of exchange rate fundamentals, and the signaling process of future policy innovations. They showed that the variance of the general microstructure shock in the exchange rate process negatively affects both the level of trade and the variability of trade flows. However, the variances of exchange rate fundamentals and the noise of the signal of future policy innovations have a positive and negative effect on the variability of trade flows respectively.

Sercu and Uppal (2003) developed a model of a stochastic general-equilibrium economy with international commodity markets that are partially segmented due to shipping costs. In contrast to existing work on the effects of exchange rate volatility on trade, the exchange rate is determined endogenously in their model in a complete financial market. They showed it is possible to have a negative or a positive effect of the exchange rate volatility on international trade. If the source of increase in exchange rate volatility is due to an increase in the volatility of the endowment process, then trade will increase with a rise in exchange rate volatility. But, if the increase in the exchange rate volatility is due to an

increase in the degree of segmentation of commodity markets, then trade will fall with a rise in exchange rate volatility.

In sum, from the above literature review, we can observe that: (1) an increase in risk does not necessarily lead to a reduction in the risky activity; (2) the availability of hedging techniques makes it possible for traders to avoid most exchange risk at little cost; (3) exchange rate volatility may actually offset some other forms of business risk; and (4) exchange rate volatility can create profitable trading and investment opportunities. As a result, we can conclude that an unambiguous relationship between exchange rate uncertainty and trade does not exist. The relationship between uncertainty and exports seems to be quite sensitive to the assumptions of the particular model. Therefore, it is necessary to conduct empirical study on this issue.

### **2.2.2 The Empirical Literature**

The results of the empirical research on the relationship between exchange rate volatility and exports are rather diverse. Some of them found significant negative impacts of exchange rate volatility on exports; some others discovered significant positive effects, where there were also certain research results showing insignificant relationship between the two terms.

One of the earlier empirical studies by Hooper and Kohlhagen (1978) yielded conflicting results on the effect of exchange rate volatility on trade. They examined the effects of exchange rate volatility on trade flows and export prices from 1965 to 1975. Their regression analysis covered the

bilateral trade of Germany and the United States with other industrial countries, and they used mean weekly absolute differences between current spot exchange rates and past forward rates to represent nominal exchange rate volatility. They found no significant impact on the volume of trade.

Akhtar and Hilton (1984) provided the first empirical evidence that supported the negative hypothesis. They studied the effect of exchange rate volatility on trade volume between the United States and West Germany between 1973 and 1983. They concluded that exchange rate uncertainty, as measured by the standard deviation of effective exchange rates, had significant negative impact on the imports and exports of the two countries.

Thursby and Thursby (1987) found that exchange rate risk had negative effects on trade performance for 15 out of 17 countries over the period 1974-82. The effect was statistically significant for ten of those countries. The measure of variability they used was the variance of the spot exchange rate around its predicted trend. These scholars used both nominal and real exchange rates to estimate the equation. By estimating a gravity type bilateral trade model using annual data, they found strong evidence that supported the hypothesis that exchange rate risk affects the value of bilateral trade negatively.

Baliley, Tavlas, and Ulan (1987) argued that, theoretically, the exchange rate volatility could have an impact on trade in either negative or positive direction. They used quarterly data over the period from 1962 to 1985 for the OECD, Big Seven, and four other countries, providing



empirical results. The data were divided into a pre and post-floating series. Both nominal and real measures of exchange rates were used in two specifications of volatility: absolute percentage changes and standard deviations. In general, their results failed to provide any real substantive evidence to support the hypothesis that exchange rate volatility impedes export performance. Of the seven equations tested for the pre-1973 period, six produced a positive volatility coefficient. For the floating period, 35 equations were tested and only 3 were able to support the negative hypothesis.

Koray and Lastrapes (1989) differed from previous studies in the use of a different estimation technique. They investigated the relationship between real exchange rate volatility and bilateral trade flows in the context of Vector Auto-regression (VAR) model, in which real exchange rate volatility, trade, and other macro variables were employed. This method has two major advantages over the extant empirical research on this issue. First, it imposes no theoretical restriction, such as exogeneity, on the variables in the system. Second, the VAR methodology can accommodate general dynamic relationship among economic variables. The major finding of the study suggested that the effect of real exchange rate volatility on imports was weak under fixed exchange rates; however, permanent shocks to volatility did have negative impact on imports over the flexible period.

Asseery and Peel (1991) investigated the influence of the volatility on multilateral export volumes of five industrial countries. The novelty in their study is the use of an error-correction framework. It is argued that

the non-robust results in previous empirical work may be generated by the fact that the export variable and some of its determinants are potentially non-stationary integrated variables. The volatility measure was based on the residuals from an ARIMA process for the real exchange rate. Asseery and Peel discovered that the volatility had a significant positive effect on exports for all countries except the United Kingdom.

Pozo (1992) examined exports from Britain to the United States from 1900-1940. She adopted two different volatility measures to estimate the real exchange rate volatility: the rolling standard deviation of percentage changes in the exchange rate, and the conditional variance of the exchange rate series modeled as a GARCH process. The results of the regressions using the two measures of exchange rate volatility supported the hypothesis that the exchange rate volatility has a depressing effect on the volume of trade.

Chowdhury (1993) took the stationary-nonstationary issue into consideration and supported the negative impact of exchange rate volatility on international trade, in the context of multivariate error-correction model, sampling data for the OECD G-7 group of countries over the period from 1973-1990. Exchange rate volatility was measured as an eight period moving sample standard deviation of the growth rate of the real exchange rate. He argued that the weak volatility effect reported in previous studies was due to insufficient attention to the properties of the relevant time series.

Almost all volatility-trade studies in 1990s took the stationary issue

into consideration. Arize (1995) used a multivariate error correction model to investigate the effects of exchange rate volatility on U.S. exports. He argued that his study was different from most previous studies in three aspects. First, the dynamic model of export demand behavior does not follow the restrictive simple stock adjustment mechanism. Instead, a less stringent process was used on basis of a modified error correction procedure. Second, his study initially established the properties of the individual time series prior to testing for co-integration. In the second step, this study employed the maximum likelihood framework for estimating co-integrating vectors between integrated series suggested by Johansen (1988). A third feature of the study was related to the measurement of exchange rate volatility. Three separate versions of nominal exchange rate volatility were computed. However, only the autoregressive conditional heteroscedasticity (ARCH) computed volatility results were reported. Arize claimed that the empirical results that he found lend strong support to the negative impact of exchange rate uncertainty upon U.S. real export demand.

Bretin et al (2003) analyzed the long-run and short-run relationship between Irish merchandise export volume and its determinants, foreign income, relative prices and real exchange rate volatility. They found that the real exchange rate volatility had no effect on the volume of trade in the short run but had significant positive effects in the long run.

Most of the empirical studies focused on developed countries. This is explainable because the bulk of international trade is between developed nations. However, a number of studies such as Caballero and Corbo



(1989), Hasan and Tufte (1998), Arize (2000) chose to concentrate on the experiences of developing countries. It is expected that the exchange rate volatility should matter for less developed countries (LDC) even more than for developed countries (DC) because the exchange rate risk is not hedged for LDC's generally as forward markets are not accessible to all traders. Arize et al (2000) noted that in the case of many less developed countries (LDCs), traders lack easy access to forward markets and are unable to hedge against exchange risk. The size of the contracts is generally large, the maturity is relatively short, and it is hard to plan the magnitude and timing of all international transactions to benefit from the advantage of the forward market. This creates an uncertainty about potential profits and therefore results in depressed volume of international trade as risk-averse traders reallocate production towards domestic markets. (For further details on the difficulties of hedging in LDC's, see Medhora 1990). The major results of Arize's study showed that an increase in the volatility of real effective exchange rate exerted significant negative effects on export demand in both short run and long run in each of the 13 LDCs.

Doroodian (1999) investigated the trade effect of exchange rate volatility in some developing countries (India, South Korea, and Malaysia) for the quarterly period from 1973:2 to 1996:3. He used an ARMA-GARCH approach to calculate the exchange rate volatility. The main result in these studies showed that increases in the volatility of the real effective exchange rate exerted a significant negative effect on export demand in both the short-run and the long run.

Hasan and Tufte (1998) investigated the effect of real exchange rate volatility on aggregate export growth in Bangladesh model as depending on world trade volume, Bangladesh and world export prices, and the exchange rate volatility. Their research results suggested that in the long run Bangladeshi export growth was driven by the volume of world trade and was negatively and inelastically related to the volatility of Bangladeshi exchange rates in the long run.

Another study, this time of Sri Lanka was conducted by Weliwita et al. (1999). They examined the effects of exchange rate volatility on Sri Lanka's exports to six developed countries. Strong evidence suggested that Sri Lanka's exports to the countries under investigation were adversely affected by the increased volatility in bilateral real exchange rates during the sample period.

Sauer and Bohara (2001) also found that the volatility of real effective exchange rate had significant negative effects on exports from the developing countries, especially in Latin America and Africa, but not on exports from the less developing or industrialized countries in Asia.

To summarize, we could conclude that the impacts of exchange rate uncertainty on exports are rather ambiguous. This problem seems to be more of an empirical issue rather than of a theoretical one.

## **2.3 Model Specification and Empirical Methodology**

In this study, we use Johansen's multivariate co-integration approach and error correction model to investigate the relationship between the exchange rate volatility and exports in the long run and in the short run.

The conditional variances of exchange rate measures have been used to calculate the proxy of exchange rate volatility. In addition to the above, we also test the structural stability of the cointegration relationship using the methods proposed in Hansen (1992b).

### 2.3.1 Model Specification

Using an approach similar to previous studies (e.g., Asseery and Peel, 1991; Chowdhury, 1993; Arize, 1995, 1997 and Arize et al 2000), we specify the model of export demand function in log-linear format as follows:

$$LX_t = \alpha_0 + \alpha_1 LWY_t + \alpha_2 LREP_t + \alpha_3 LV_t + \varepsilon_t \quad (2.1)$$

where  $X_t$  is the real exports of goods and services from each CEE country to six countries<sup>4</sup> in the Eurozone (bilateral exports in domestic currency deflated by export prices);  $WY_t$  is the real income of the Eurozone calculated as a time-varying weighted average of industrial production index in six Eurozone countries and the *weight* for each of the six Eurozone countries is calculated as the exports from the CEE country to it over the total exports from the CEE country to all the six countries (Note that choosing the weighted average of the income levels of the most important trading partners is a standard procedure widely utilized in the literature, e.g., Chowdhury 1993). Because monthly GDP data is not available, we use the Industrial Production Index as a replacement (similar to Dorrodian 1999, Doganlar 2002, and De Vita and Abbott 2004).

---

<sup>4</sup> They are Germany, France, Austria, Italy, Netherlands and Spain. More than 90% of these CEE countries' exports to the Eurozone go to these six countries.



$REP_t$  is relative price (as a measure of one country's export competitiveness), calculated as the ratio of export price index of each CEE country to the weighted average of export price indices of the six Eurozone countries. The weights are identical to those used in the construction of the income variable. Finally,  $V_t$  is the real exchange rate volatility proxy.

All the above variables are expressed in natural logarithm format. Economic theory suggests that income in trading partner countries is a major determinant of a nation's export performance. If foreign income rises, the demand for exports will rise so we expected  $\alpha_1 > 0$ . If relative prices rise, the demand for exports will fall, and we expected  $\alpha_2 < 0$  and the effect of exchange rate uncertainty of export demand cannot be determined a priori, therefore  $\alpha_3$  needs to be determined empirically, which is the main theme of this study.

### 2.3.2 Unit Root Test

Many early studies employed the simple stock adjustment mechanism whereby the entire adjustment is represented by adding a lagged dependent variable as a regressor to allow for the adjustment of export demand to changes in the regressors. However, several researchers have criticized this methodology because of its restrictive assumptions. Moreover, it is subject to estimation problems such as the "spurious regression phenomenon", which refers to the possibility that inferences based on ordinary least-squares parameter estimates in such regressions are invalid because the usual  $t$ - and  $F$ -ratio test statistics

do not converge to their limiting distribution as the sample size increases (Arize, 1995). Their use in such case generates spurious inferences if the levels of the nonstationary variables included in Equation (2.1) are not co-integrated.

Under the light of the preceding discussion, the presence of non-stationary behavior in the autoregressive representation of the variable of interest has been examined by deploying the Augmented Dickey-Fuller (ADF) test and Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) test.

#### **Augmented Dickey-Fuller (ADF) test**

The computation of the ADF  $t$ -type test is based on the application of the following general auxiliary regressions:

$$\Delta Z_t = \gamma + \rho Z_{t-1} + \sum_{i=1}^p \alpha_i \Delta Z_{t-i} + \varepsilon_t \quad (2.2)$$

$$\Delta Z_t = \gamma + \rho Z_{t-1} + \delta t + \sum_{i=1}^p \alpha_i \Delta Z_{t-i} + \varepsilon_t \quad (2.3)$$

where  $Z_t = (LX_t, LWY_t, LREP, LV_t)$  for Hungary, Czech and Poland.  $\varepsilon_t$  is a sequence of independent random variables with zero mean and constant variance  $\sigma^2$ . Equations (2.2) and (2.3) permit the examination of the unit root null against the most general alternative hypothesis, with constant but no trend, and constant with trend, respectively. The null hypothesis of non-stationary will be rejected if the estimated coefficient of  $Z_{t-1}$  is statistically different from zero. The maximum lag length  $p$  required for serial correlation correction in the associated ADF auxiliary regressions is determined on the basis of evidence provided by

Akaike Information Criterion (AIC).

### **Kwiatkowski, Phillips, Schmidt, and Shin test (KPSS) test**

The KPSS test statistics  $\eta_t(q)$ , which test the null of trend stationarity against the alternative of non-stationarity, are calculated as

$$\eta_t(q) = T^{-2} \sum_{t=1}^T s_t^2 / \sigma^2(q) \quad (2.4)$$

where  $s_t^2$  is the partial sum process of the residuals from the regression of the variables (time series) on an intercept and a time trend,  $\sigma^2(q)$  is a consistent estimate of the error variance from the same regression,  $q$  is the lag truncation parameter, and  $T$  is the number of observations. The long-run variance is calculated following the Newey and West (1987) procedure, which utilizes Bartlett windows adjustment using the first  $q$  sample autocovariances. A test for the null of the level stationarity can be performed by utilizing the error term from the regression of the variable on an intercept alone and calculating the test statistics as above. Kwiatkowski et al. (1992) showed that the asymptotic validity of this test holds even for small samples. In addition, Lee and Schmidt (1996) showed that KPSS test are also consistent against the stationary fractional alternative. Moreover, Lee and Amsler (1997) showed that KPSS tests are able to consistently distinguish short memory from stationary long memory, and these processes from nonstationary long memory and unit root. However, they are not able to consistently distinguish between nonstationary long memory and unit root. The critical values required in the KPSS tests are provided by Kwiatkowski et al. (1992).



### 2.3.3 Co-integration Test

We next test for co-integration between exports and the three forcing variables in estimating their long-run relationship. Although the variables may drift apart in the short-run, economic processes force the values back to the long-run equilibrium paths. According to Johansen (1988, 1991) and Johansen and Juselius (1990), maximum likelihood estimation procedure provides estimates of the co-integration vectors and derives a likelihood ratio test for the hypothesis that there are a given number of these co-integrating vectors. How to choose the co-integration technique is based on the justification provided by Phillips (1991) who found that the Johansen approach was optimal in terms of symmetry, unbiasedness, and efficiency. Moreover, Gonzalo (1994) supported the superior properties of the Johansen technique relative to several other single and multivariate techniques after conducting a Monte Carlo experiment<sup>5</sup>. In the Johansen framework, all variables, including exchange rate volatility, are treated as endogenous. The treatment of volatility as an endogenous variable is particularly important in the context of the selected CEE countries where the policy makers have attempted to stabilize the nominal exchange rates against the Euro systematically.

We consider a 4-dimensional vector autoregressive (VAR) model:

$$Z_t = \Gamma_0 + \sum_{i=1}^k \Gamma_i Z_{t-i} + \mu_t \quad (2.5)$$

where  $Z_t$  is a  $4 \times 1$  vector of  $I(1)$  variables,  $\Gamma_i$  is a  $4 \times 4$  matrix of

---

<sup>5</sup> It is now well established that the Jonhansen (1988) cointegration procedure is superior to the residual-based model.

parameters,  $\Gamma_0$  is a  $4 \times 1$  vector of constant terms, and vector  $\mu_t$  denotes the white noise, which may be contemporaneously correlated.

We rewrite Equation (2.5) into error correction model (ECM) as follows:

$$\Delta Z_t = \Gamma_0 + \Gamma_1 \Delta Z_{t-1} + \dots + \Gamma_{k-1} \Delta Z_{t-k+1} + \Pi Z_{t-1} + \mu_t \quad (2.6)$$

where  $\Delta Z_t$  is the vector of changes in period  $t$  and,

$$\Gamma_m = -I + \sum_{i=1}^m \Gamma_i, \quad m = 1, 2, \dots, m-1 \quad (2.7)$$

$$\Pi = -I + \sum_{i=1}^k \Gamma_i \quad (2.8)$$

where  $\Gamma$  is the short-run dynamics and  $I$  is an identity matrix.  $\Pi$  is the long-run matrix and the rank  $r$  determines the number of co-integrating vectors of  $Z_t$ . For  $0 < r < n$ , there exists  $r$  co-integrating vectors. In that case,  $\Pi$  can be factorized as  $\alpha\beta'$ , where both  $\alpha$  and  $\beta$  are  $n \times r$  matrices. This model reflects a dynamic equilibrium relation, in which the expression  $\beta Z_{t-1}$  represents the extent the system deviates from the long-run export equilibrium relationship.

As proposed by Johansen (1988, 1991), to estimate the long-run relationship between a set of variables, the maximum eigenvalue and trace test statistics are applied. The trace test is a likelihood ratio test for maximum  $r$  co-integrating vectors against the alternative equals to  $n$ . The maximum eigenvalue test has an identical null hypothesis as the trace test, with its alternative hypothesis of  $(r+1)$  co-integrating vectors. Both tests have a non-standard asymptotic distribution and the critical values for the rank tests are tabulated in Johansen and Juselius (1990) and Osterwald-Lenum (1992). A likelihood ratio test and the AIC are used

to select the number of lags required in the cointegration test.

### 2.3.4 Hansen Stability test

The test statistics proposed by Hansen (1992b) are designed to test the hypothesis of no regime shift against the alternative of a regime shift. Hansen's (1992b) tests are joint tests on all regression parameters in a cointegrating regression. A statistically significant test statistic is taken as evidence against the standard cointegration in favor of the regime shift model.

Under the null hypothesis of cointegration, we assume that the generating mechanism for  $X_t = (x_{1t}, x_{2t})'$  is the cointegrated system

$$x_{1t} = \alpha' x_{2t} + u_{1t} \quad (2.9)$$

$$x_{2t} = \prod t + S_{2t} \quad (2.10)$$

$$\Delta S_{2t} = u_{2t} \quad (2.11)$$

$u_t = (u_{1t}, u_{2t})'$  is p-vector stationary series. Equation (2.9) can be thought of as a stochastic version of the linear long-run equilibrium relationship  $x_{1t} = \alpha' x_{2t}$  with  $u_{1t}$  representing stationary derivations from equilibrium. Equations (2.10) and (2.11) are reduced forms which specify  $x_{2t}$  as a general integrated process. Then the shock  $u_{2s} (s \leq t)$  influences the process period after period.

Since the asymptotic distributions of the test statistics depend on the nature of the trends in the regressors  $x_{2t}$  (Hansen 1992b), there are two kinds of models. One is an unrestricted model:

$$x_{1t} = \mu + \beta t + \alpha' x_{2t} + u_{1t} \quad (2.12)$$



and the other is a restricted model:

$$x_{1t} = \mu + \alpha' x_{2t} + u_{1t} \quad (2.13)$$

For simplicity, we rewrite Equations (2.12) and (2.13) as

$$x_{1t} = AX_{2t} + u_{1t} \quad (2.14)$$

where  $X_{2t} = (\text{constant}, t, x_{2t})$ .

The constancy tests require an estimation of  $A$  in Equation (2.14) that has a mixed normal asymptotic distribution so estimators can be the fully modified (FM) estimator of Phillips and Hansen (1990), the maximum likelihood estimator (MLE) of Johansen (1998b, 1991), or the “leads and lags” estimator of Saikkonen (1991) and Stock and Watson (1993). The test statistics using these asymptotically equivalent estimators would have the same asymptotic distributions. Following Hansen (1992b), we also consider the FM estimator of Phillips and Hansen (1990), which uses semiparametric methods for serial correlation and for endogeneity.

The LM tests for parameter stability are  $L_c$ , MeanF and SupF tests<sup>6</sup>. The three proposed tests are all tests of the same null hypothesis of cointegration with stable parameter but differ in their choice of alternative hypothesis. The SupF test is appropriate to discover whether there is a swift shift in regime. The other two statistics capture the notion of an unstable model that gradually shifts over time. If the parameter variation is relatively constant throughout the sample, the  $L_c$  is the appropriate choice. In practice, all of the tests will tend to have power in similar

---

<sup>6</sup> For constructing these statistics, see Hansen (1992b).

directions.

### 2.3.5 Error Correction Model

Based on the Granger representation theorem, the ECM exists for a co-integrating vector. The ECM shows how the system converges to the long-run equilibrium by the co-integrating regression. As noted by Engel and Granger (1987), if two series (say,  $X_t$  and  $Y_t$ ) are individually I (1) and co-integrated, a causal relationship exists in at least one direction. If these variables are co-integrated, the finding of non-causality in either direction is ruled out. In this case, the dynamic relationship among the selected variables is more correctly specified by an ECM of the following form:

$$\Delta Z_t = \Gamma_0 + \Gamma_1 \Delta Z_{t-1} + \dots + \Gamma_{k-1} \Delta Z_{t-k+1} + \theta \varepsilon_{t-1} + \mu_t \quad (2.15)$$

The ECM expresses changes in the dependent variable as a function of the level of disequilibrium in the co-integrating relationship (captured by the error correction term) as well as changes in the explanatory variables.  $\varepsilon_{t-1}$  is the lagged value of the  $\varepsilon$  from the co-integrating equation and  $Z_t$  is a vector containing both dependent and explanatory variables, which consists of four selected variables for the chosen countries. The coefficient of the lagged error correction term represents the response of the dependent variable in each period departure from equilibrium. It makes it easier to distinguish between the short-run and long-run exports function.

### 2.3.6 Measurement of Exchange Rate Volatility

Several approaches have been used to measure exchange rate

volatility. The two most widely used approaches are: (1) moving-average standard deviation (e.g., Cushman (1988), Koray and Lastrapes (1989), Bahmani-Oskooe and Payesteh (1993). Chowdhury (1993), Arize (1998), Hassan and Tufte (1998), and Hurley and Santos (2001)).

$$V_t = \left[ (1/m) \sum_{i=1}^m (RER_{t+i-1} - RER_{t+i-2})^2 \right]^{1/2} \quad (2.16)$$

Where  $RER$  is the natural logarithm of the real exchange rate; and  $m$  is the order of the moving average; (2) autoregressive conditional heteroscedastic (ARCH) or generalized ARCH (GARCH) (e.g., Bah and Amusa (2002), Hook and Boon (2000) and Fabiosa (2002)).

According to Jansen (1989), the unconditional measure of volatility lacks a parametric model for the time varying variance of a time series. Therefore, in this study, we employ GARCH methodology to measure real exchange rate volatility.

The ARCH-GARCH approach has been used in many previous studies to measure volatility. It was first introduced by Engle (1982) and generalized by Bollerslev (1986). Engle (1982) modeled a serially uncorrelated process with non constant variances conditioned on the past and uses his model to estimate the means and variances of inflation in the UK. Engle used ARCH (4) model for the quarterly inflation data. Bollerslev (1986) pointed out that the empirical application of the ARCH (q) model requires a relatively long lag in the conditional variance and a fixed lag structure, which is called for in order to avoid problems with negative variance parameter estimates. Bollerslev suggested a generalized autoregressive conditionally heteroskedastic (GARCH)



model which allows for both past sample variances and lagged conditional variances. The intention of GARCH is that it can parsimoniously represent a higher order ARCH process.

First difference of the real exchange rate can be presented by the GARCH (p, q) model as follows:

$$y_t = \mu + \varepsilon_t \quad (2.17)$$

$$\varepsilon_t / \Omega_{t-1} \sim N(0, h_t) \quad (2.18)$$

$$h_t = \omega + \sum_{j=1}^q \beta_j h_{t-j} + \sum_{j=1}^p \alpha_j \varepsilon_{t-j}^2 \quad (2.19)$$

where  $y_t$  is equal to  $\log(e_t / e_{t-1})$ ,  $e_t$  is the real exchange rate vis-à-vis *euro*,  $\mu$  is the mean of  $y_t$  conditional on past information ( $\Omega_{t-1}$ ) and the following inequality restrictions  $\omega > 0$ ,  $\beta_j > 0$  and  $\alpha_j > 0$  are imposed to ensure that the conditional variance ( $h_t$ ) is positive. The size and significance of  $\alpha_j$  indicates the magnitude of the effect imposed by the lagged error term ( $\varepsilon_{t-1}$ ) on the conditional variance ( $h_t$ ). In other words, the size and significance of the  $\alpha_j$  indicates the presence of the ARCH process in the residuals (volatility clustering in the data). The estimated  $h_t$  (conditional variance) from the GARCH (p, q) model is applied in the estimation of Equation (2.17). In a GARCH (p, q) model different combinations of p and q may be applied but, as indicated by Bollerslev et al. (1992), which contains an overview of some of the developments in the formulation of the ARCH models and a survey of the numerous empirical applications using financial data, Bollerslev et al. emphasized that in most applications  $p=q=1$  is found to be sufficient for

most financial and economic series. West et al (1993) also showed that GARCH (1, 1) relatively performs better than other alternative ARCH-type models. Therefore, we used GARCH(1,1) model in this study too (Note that we have tried different combinations of p and q with p=q=2 being the maximum lag length. Results based on log likelihood function and likelihood ratio tests indicate that the best combination is p=q=1.) .

Czech/Euro real exchange rate			
$y_t = -0.003962^{***} + \varepsilon_t$	$h_t = 0.0000053 + 0.1759^{**} \varepsilon_{t-1}^2 + 0.7209^{***} h_{t-1}$		
(-3.452)	(1.412)	(2.6467)	(14.0387)
$L = 394.69, \alpha_1 + \beta_1 = 0.896, LB(6)SSR = 1.623, LB(6)SR = 2.147$			
Hungary/Euro real exchange rate			
$y_t = 0.001491^{***} + \varepsilon_t$	$h_t = 0.0000049^{***} + 0.1032^{**} \varepsilon_{t-1}^2 + 0.7794^{***} h_{t-1}$		
(6.328)	(7.714)	(2.314)	(21.384)
$L = 386.87, \alpha_1 + \beta_1 = 0.882, LB(6)SSR = 1.223, LB(6)SR = 6.012$			
Poland/Euro real exchange rate			
$y_t = 0.002405^{**} + \varepsilon_t$	$h_t = 0.0000075 + 0.2228^{*} \varepsilon_{t-1}^2 + 0.7243^{***} h_{t-1}$		
(2.084)	(1.228)	(1.866)	(4.78)
$L = 323.47, \alpha_1 + \beta_1 = 0.947, LB(6)SSR = 2.458, LB(6)SR = 4.066$			
<i>Notes: t -statistics in the parentheses. L = log likelihood function value, LB = Ljung–Box statistics at 6 lags, SSR = standardized squared residuals, SR = standardized residuals.</i>			
<i>*Significant at the 10% level.</i>			
<i>**Idem., 5%.</i>			
<i>***Idem., 1%.</i>			

Table 2-1 GARCH(1,1) Results

Table 2-1 shows the results from the GARCH(1, 1) models for all three countries. In all cases the ARCH coefficient ( $\alpha_1$ ) is found to be significant implying volatility clustering. According to Engle and Bollerslev (1986), if  $\alpha_1 + \beta_1 = 1$  in a GARCH (1, 1) model, this implies two things:

persistence of a forecast of the conditional variance over all finite horizons and an infinite variance for the unconditional distribution of  $\varepsilon_t$ . In other words, when  $\alpha_1 + \beta_1 = 1$ , a current shock persists indefinitely in conditioning the future variance. Such a model is known as the integrated-GARCH (IGARCH) model. As the sum of  $\alpha_1$  and  $\beta_1$  approaches unity, the persistence of shocks to volatility (conditional variance) is greater and the decay rate of the shock is slower. For the real exchange rate between the Eurozone and the Czech Republic, Hungary and Poland, their half lives of the shock<sup>7</sup> are 8 months, 7 months and 14 months, respectively. In all the tests the Ljung-Box Q-statistics fails to indicate any serial correlation in the standardized residuals and the standardized squared residuals using 6 lags<sup>8</sup>.

---

<sup>7</sup> The half-life of a shock to volatility is given by  $1 - \left[ \log 2 / \log(\alpha_1 + \beta_1) \right]$ . Half-life measures the period of time (number of months) over which a shock to volatility reduces to half its original size.

<sup>8</sup> There remains the practical problem of choosing the order of lag to use in the test. If you choose too small a lag, the test may not detect serial correlation at higher order lags. However, if you choose too large a lag, the test may have low power since the significant correlation at one lag may be diluted by insignificant correlations at other lags. For further discussion, see Ljung and Box (1997) or Harvey (1990, 1993).



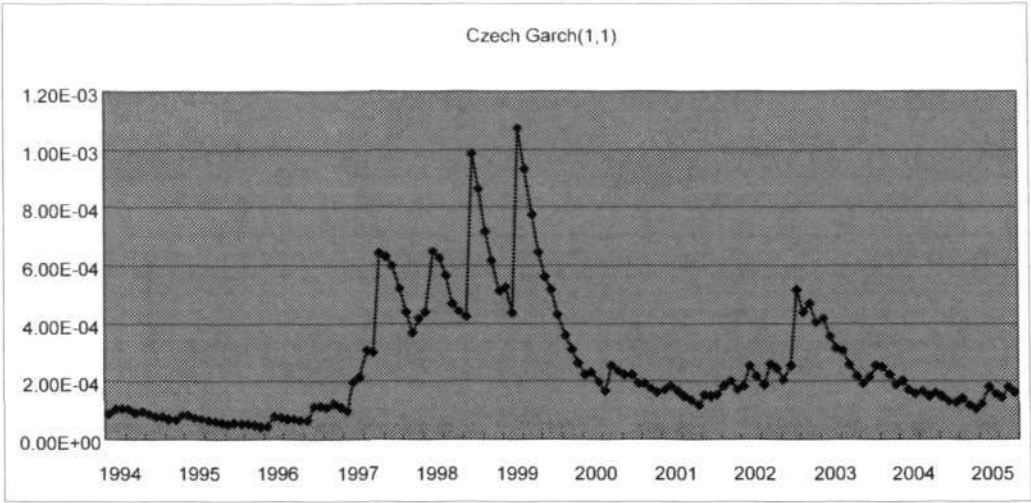


Figure 2-1 Czech Rep./Eurozone Exchange Rate Volatility

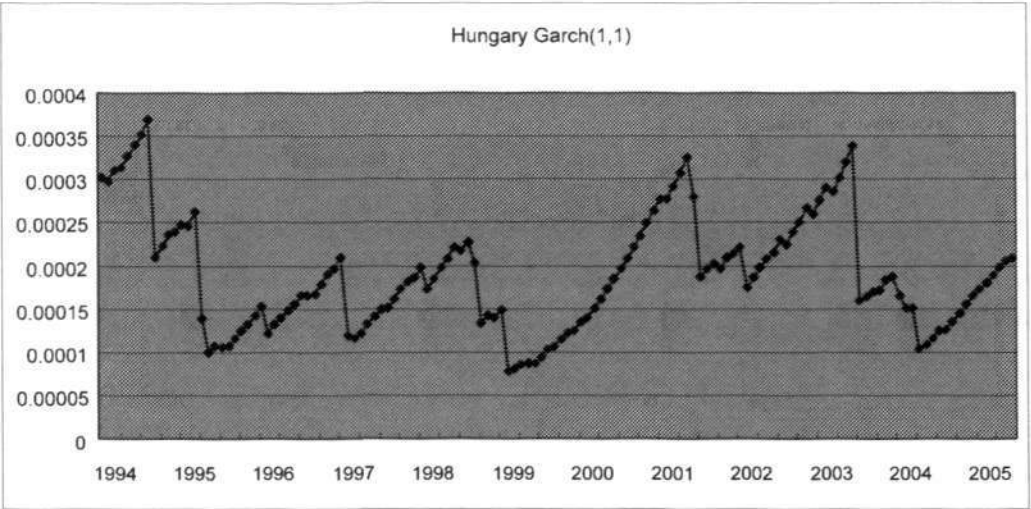


Figure 2-2 Hungary/Eurozone Exchange Rate Volatility

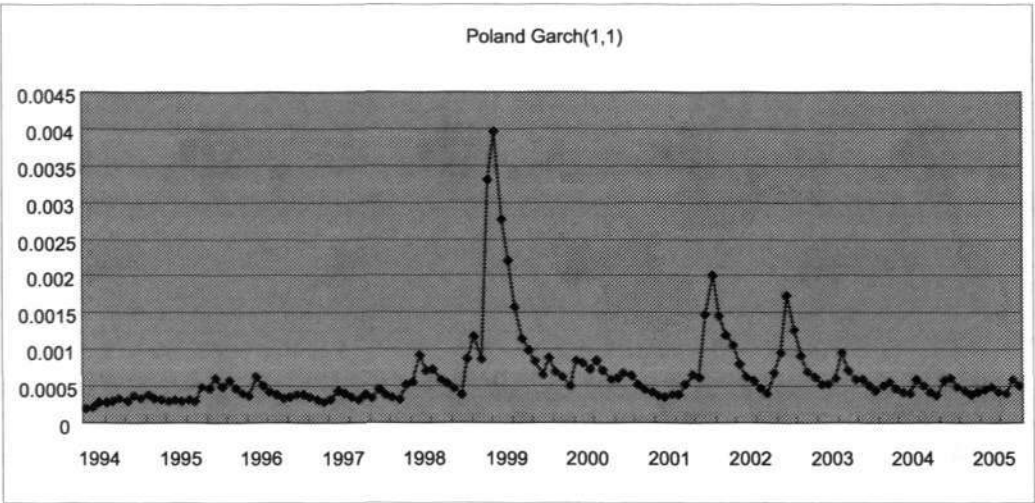


Figure 2-3 Poland/Eurozone Exchange Rate Volatility

2.4 Data Analysis and Empirical Results

2.4.1 Variables and Data Sources

Data in this study are mainly collected from the International Financial Statistics issued by the IMF and Data-stream database. The export prices data of Czech Republic is from statistical office of Czech Republic. We acquired monthly data in the sample period from 1994:01 to 2005:06 from these databases, whenever possible. For some data that are not available monthly, e.g., the export prices series of Czech and Hungary, quarterly data are converted to monthly data using the quadratic interpolation method recommended by Goldstein and Khan (1978). In addition, for exports and the foreign income data series, seasonally adjusted series were used; for relative prices and exchange rate volatility, unadjusted data were used since a preliminary investigation does not show any seasonal fluctuations with these data.

2.4.2 Unit Root Test and Co-integration Test Results

In this study, we consider two specific models for each unit root test for level data: (1) with a constant and trend and (2) with an intercept without trend. While for first difference data, we use the model with an intercept without trend only.

Variable	ADF Test		KPSS test	
	$\tau_{\mu}$	$\tau_{\tau}$	$\phi_{\mu}$	$\phi_{\tau}$
Czech Republic				
<i>LX</i>	-1.729	-1.317	1.142***	0.264***
<i>LWY</i>	-0.863	-1.133	1.118***	0.178**
<i>LREP</i>	-1.174	-3.617**	1.365***	0.082

<i>LVgarch</i>	-1.712	-1.687	0.358*	0.227***
	$\tau_\mu$			$\phi_\mu$
$\Delta LX$	-4.581***			0.147
$\Delta LWY$	-2.346**			0.054
$\Delta LREP$	-7.609***			0.171
$\Delta LVgarch$	-10.162***			0.130

Table 2-2 Unit Root Test for Czech Republic

Variable	ADF Test		KPSS test	
	$\tau_\mu$	$\tau_\tau$	$\phi_\mu$	$\phi_\tau$
Hungary				
<i>LX</i>	-2.173	-0.766	1.378***	0.325***
<i>LWY</i>	-0.864	-1.134	1.396***	0.147**
<i>LREP</i>	-1.490	-1.125	0.731**	0.182**
<i>LVgarch</i>	-2.542	-2.778	0.318	0.265***
	$\tau_\mu$			$\phi_\mu$
$\Delta LX$	-3.755***			0.241
$\Delta LWY$	-2.885**			0.151
$\Delta LREP$	-7.234***			0.057
$\Delta LVgarch$	-8.167***			0.096

Table 2-3 Unit Root Test for Hungary

Variable	ADF Test		KPSS test	
	$\tau_\mu$	$\tau_\tau$	$\phi_\mu$	$\phi_\tau$
Poland				
<i>LX</i>	-1.137	-2.408	1.454***	0.121*
<i>LWY</i>	-1.443	-1.651	1.412***	0.243***
<i>LREP</i>	-1.979	-2.017	1.045***	0.208**
<i>LVgarch</i>	-3.416**	-2.081	0.486**	0.221***
	$\tau_\mu$			$\phi_\mu$
$\Delta LX$	-3.237**			0.337
$\Delta LWY$	-5.579***			0.154
$\Delta LREP$	-2.954**			0.454*
$\Delta LVgarch$	-6.336***			0.062

Table 2-4 Unit Root Test for Poland

With an initial maximum lag of twelve months, the auxiliary lags were selected on the basis of the AIC test. From the above test, we found that generally all series tested are non-stationary in their level form, that is,



we cannot reject the null hypothesis of non-stationarity. After first differencing, the test statistics demonstrated that all the series are stationary. Therefore, it is concluded that all series are  $I(1)$  variables and this allows us to proceed with the Johansen and Juselius multivariate cointegration test.

The next table reports the results of Johansen's maximum likelihood method for co-integration of export demand function. For both the trace test statistics and the Maximum Eigenvalue test, for all countries under examination, the hypothesis of zero cointegration vectors is comfortably rejected in each case at the 1 percent significance level. The tests, however, do not reject the null hypothesis of  $r \leq 1$ . This implies the evidence of a single vector at the same significance level for all countries. The presence of the cointegrating vector in all countries indicates that any deviations from the relationship between exports and the selected determinants are temporary.

Country	Trace Statistics				Maximum Eigenvalue			
	$r = 0$	$r \leq 1$	$r \leq 2$	$r \leq 3$	$r = 0$	$r \leq 1$	$r \leq 2$	$r \leq 3$
Czech	57.33*	23.24	4.80	0.04	38.09*	15.43	4.76	0.04
Hungary	47.93*	22.37	9.01	0.09	28.86*	13.35	8.92	0.09
Poland	55.25*	21.22	3.2	0.08	33.21*	10.78	2.26	0.08

Notes: This test is conducted under the assumption of deterministic and trend in the data. The lag length is selected on the basis of the AIC and Sim's likelihood ratio test.  
\*Significant at least at the 5% level

Table 2-5 Johansen and Juselius Cointegration Test Results

Starting with the Maximum Eigenvalue test results, the null

hypothesis  $r = 0$  (no cointegration) is rejected in favor of  $r = 1$  in each country. The calculated test statistics range from a low of 28.86 in Hungary to a high of 38.09 in Czech. Furthermore, the null hypothesis of  $r \leq 1$ ,  $r \leq 2$ , and  $r \leq 3$  can not be rejected in favor of the alternative hypothesis of  $r = 2$ ,  $r = 3$  and  $r = 4$ , respectively. These results indicate the presence of one cointegration relationship among the variables for every country.

For the trace test results, similar conclusions are obtained when the null hypothesis  $r=0$  is tested against the alternative hypothesis of  $r \geq 1$  in each country. Note that  $r \leq 1$ ,  $r \leq 2$ , and  $r \leq 3$  cannot be rejected in all countries. From here on, the presence of one cointegrating vector is assumed for each country in the sample.

Both findings suggest that there is a long run equilibrium relationship among real exports, foreign economic activity, relative price, and exchange rate volatility for all the three countries.

2.4.3 Long-run Relationship and Hansen’s Stability Test

Country	Normalized Cointegrating Vector				Hansen’s Stability Test		
	<i>LX</i>	<i>LWY</i>	<i>LREP</i>	<i>LVgarch</i>	<i>L<sub>c</sub></i>	<i>MeanF</i>	<i>SupF</i>
Czech	-1	5.50 (1.37)	0.67 (0.86)	-0.28 (0.10)	0.28 (0.20)	3.12 (0.20)	8.39 (0.20)
Hungary	-1	3.41 (0.46)	-1.34 (-0.31)	-0.16 (0.06)	0.74 (0.08)	8.45* (0.03)	15.28 (0.10)
Poland	-1	2.69 (0.39)	-0.59 (-0.11)	-0.24 (0.05)	0.26 (0.20)	3.42 (0.20)	8.05 (0.20)

Notes: Standard errors are shown in parenthesis for normalized cointegrating vector.  
\* indicates significance at the 5 percent level. A low p-value, say below 0.05

for a particular test statistic is interpreted as the instability of the parameters of the cointegrating vector.

Table 2-6 Estimates of Cointegrating Relationship

Table 2-6 provides parameter estimates that represent long-run elasticities, together with Hansen's stability test results. The elasticities are obtained by normalizing the estimates of the unconstrained co-integrating vectors on real exports.

From the above table, the estimated foreign economic activity elasticity carries the expected positive sign and is significantly different from zero in all the countries in the sample. There are several explanations for the relatively high foreign income elasticities. Adler (1970) suggested that different income elasticities reflect the extent to which exports have been adapted to the importing country's local tastes, with higher elasticity providing evidence of greater adaptation. Krugman (1989) claimed that the observed higher income elasticity for exports reflects either product quality or expanding product variety of that country. Arize (1990) argued that an increased penetration of world markets over the sample period can, in part, be attributed to the income elasticities of developing economies being some function of the income elasticities of the exports of the importing countries. This is plausible if exports are largely composed of semi-finished products, which are used to produce final products in other countries.

Our estimates of relative price for Hungary and Poland are negative as expected. However, it is positive but insignificant at the 10% level for the Czech Republic.

Finally, the signs of the exchange rate volatility term for all the three



countries show significant negative relationship between exports and exchange rate volatility vis-à-vis *euro* in all cases. Therefore, the exchange rate volatility vis-à-vis *euro* imposes cost on bilateral export of CEE economies to the Eurozone.

As can be also observed in Table 2-6, the LC test results for parameter constancy in the co-integration relationship indicate that all the normalized equations capture stable relationships. These results are also confirmed by *MeanF* and *SupF* statistics, except for the case of Hungary *MeanF* test. Therefore, we can conclude that generally a constant parameter, long-run equilibrium relationship exists for every country.

#### **2.4.4 Short-run Relationship**

Using the co-integrating vector normalized on exports, we estimate an error correction model that provides us with information on the short run export function. Following Hendry's (1995) general-to-specific modeling approach, we first include 6 lags of the first-difference of each variable in equation (2.15), a constant term and lagged error-correction term generated from the Johansen procedure, and then gradually eliminate the insignificant variables.

Before we discuss the results, we need to determine the adequacy of the ECM. Several diagnostic tests were performed and reported in the last column of Table 2-7. Diagnostic tests indicate that the model is correctly specified. These values compare well with those reported in other studies for regressions based on first differences in variables (see for example Arize, 1995; Doyle, 2001; and Bredin et al., 2003).

The results of the short-run models for these three CEE countries are demonstrated in Table 2-7. The estimated coefficients of the error correction term (ECT) of all the countries are negative and significant, which implies that part of the changes in exports represent an adjustment to its last-period deviations from its long-run steady-state equilibrium, so that the time paths of these variables do not diverge in the long run. The values of the estimated coefficients of ECT are -0.095, -0.049 and -0.153 for the Czech Republic, Hungary and Poland, respectively. Among them, Hungary has the lowest value (speed of adjustment), which indicates that any deviations in exports resulting from the selected variables take longer time to fine-tune back to its long-run equilibrium.

The estimated coefficients of the foreign income of all the countries are positive and statistically significant. The ratio of the relative price levels for Poland and Hungary shows significant negative effects in affecting exports. The ratio of the relative price levels for Czech, however, suggests a positive relationship. The estimated coefficient of the exchange rate volatility is negatively correlated with exports in all the three countries in the short term.

Country	Lag	ECT	$\Delta L X$	$\Delta L W Y$	$\Delta L R E P$	$\Delta L V g a r c h$	Statistics Summary
Czech	0	-0.095*** (-2.79)		1.893*** (3.14)		-0.129*** (-3.28)	$\bar{R}^2 = 0.69$
	1		-0.586*** (-4.47)			-0.083** (-2.43)	NORM=1.26
	2		-0.274*** (-3.49)	0.876*** (2.83)			AR(4)=1.23
	3		-0.087*** (-3.11)				ARCH(4)=0.89
	4						RESET=0.70
	5				0.012*** (3.59)		
Hungary	6						
	0	-0.049* (-1.96)					$\bar{R}^2 = 0.53$
	1		-0.377*** (-6.21)	1.766* (1.82)		-0.060** (1.97)	NORM=1.29
	2		-0.527*** (-5.22)	1.045*** (3.42)	-0.334*** (-2.97)		AR(4)=0.84
	3		-0.539*** (-6.11)				ARCH(4)=0.49
	4		-0.211** (-2.18)				RESET=0.57
Poland	5		-0.134*** (-2.77)				
	6						
	0	-0.153*** (-3.61)		0.656** (2.12)	-0.036*** (-3.11)	-0.072** (-2.19)	$\bar{R}^2 = 0.58$
	1		-0.406*** (-4.322)	1.496*** (3.49)			NORM=2.16
	2		-0.276*** (-3.165)	0.402*** (2.56)			AR(4)=1.63
	3				-0.125* (-1.90)	0.014* (1.88)	ARCH(4)=0.71
	4		0.277*** (4.01)				RESET=1.06
	5						
	6						

Notes: t-statistics are shown in parenthesis.  $\bar{R}^2$  is adjusted coefficient of determination. AR(4) is 4<sup>th</sup> order LM test of residual serial correlation. ARCH(4) is 4<sup>th</sup> order LM test of autoregressive conditional heteroscedasticity. RESET is Ramsey's RESET test. Norm is a test for residual normality. The asterisks (\*), (\*\*) and (\*\*\*) indicate the rejection of null hypothesis at the 10 percent, 5 percent and 1 percent level of significance, respectively.

Table 2-7 Regression Results for Error Correction Models



## 2.5 Summary

There has been a lot of work (both empirical and theoretical ones) studying the relationship between exchange rate volatility and the export volume. While the majority of the models imply a negative relationship between exchange rate volatility and trade flows, some other models imply a positive relationship. Our objective is to provide some new evidence on volatility-trade flow relationship for the CEE economies.

From this aspect, it is interesting to explore the potential benefit of the future elimination of exchange rate volatility due to the adoption of the *euro* on the exports of the CEE countries to the Eurozone. In this essay, we studied this relationship for the three key CEE economies that are still outside of ERM II (i.e., Czech Republic, Hungary and Poland), based on the Johanson cointegration theory and error correction representations of the cointegrated variables (similar to Arize (1995)). The Johansen method applies the maximum likelihood method to determine the presence of cointegrating vectors in nonstationary time series, and is utilized to detect the long-run relationship in the export demand function for the three CEE countries. Unlike many other studies that assume the relationship is stable, we also apply Hansen's stability tests in our study. Error correction model is then utilized to study the short-run relationship in the export demand function.

There are three main findings from our empirical results. First, we found that all variables are co-integrated in all the three countries over the sample period and at the same time the cointegration relationships are stable. This suggests that the macroeconomic variables are not

drifted far apart in the long run and they are dependent on each other. Second, the Eurozone real incomes have a large impact on the real exports from the three CEE countries. Third, the relationship between real exports and exchange rate volatility of the CEE countries is generally negative and statistically significant in both the short and long run.

Based on the above, large exchange rate volatility in the CEE countries has significantly reduced the volume of exports for the economies concerned. In other words, the elimination of real exchange rate volatility vis-à-vis *euro* associated with the prospective EMU membership will lead to a rise in the CEE countries' exports to the Eurozone. Therefore, we can conclude that the entry of EMU is beneficial for the three CEE countries that are still ERM-outsiders through trade effect.

### 3. Essay II: Exchange Rate Volatility and Intra-CEE Trade: Evidence from the Gravity Approach

#### 3.1 Overview

Before 1991, most CEE countries were part of the same economic organization, i.e., the Council for Mutual Economic Assistance (CMEA) led by the Soviet Union, and the trade volume among these countries was large at that time. With the dissolution of this organization, the trade among these countries reduced significantly. Some researchers attribute the bad GDP performances in early 1990s to this issue. In the past decade, the CEE countries have signed free trade agreements among themselves to encourage intra-CEE trade, as shown in Table 3-1 and Table 3-2.

Country	Date of Entry into force	
	CEFTA	BFTA
Czech	1-Mar-93	
Estonia		1-Apr-94
Hungary	1-Mar-93	
Latvia		1-Apr-94
Lithuania		1-Apr-94
Poland	1-Mar-93	
Slovakia	1-Mar-93	
Slovenia	1-Jan-96	

Source: [http://www.wto.org/english/thewto\\_e/whatis\\_e/tif\\_e/agrm1\\_e.htm](http://www.wto.org/english/thewto_e/whatis_e/tif_e/agrm1_e.htm)

Table 3-1 Free Trade Agreements among CEE Countries



Country	Date of entry into force					
	Estonia	Hungary	Latvia	Lithuania	Poland	Slovakia
Czech	12-Feb-98		1-Jul-97	1-Jul-97		1-Jan-93
Estonia		1-Mar-01				
Hungary			1-Jan-00	1-Mar-00		
Latvia						
Lithuania						
Poland			1-Jun-99	1-Jan-97		
Slovakia	12-Feb-98		1-Jul-97	1-Jul-97		
Slovenia	1-Jul-97		1-Aug-96	1-Mar-97		

Source: [http://www.wto.org/english/thewto\\_e/whatis\\_e/tif\\_e/agrm1\\_e.htm](http://www.wto.org/english/thewto_e/whatis_e/tif_e/agrm1_e.htm)

Table 3-2 Free Trade Bilateral Agreements among CEE Countries

Even with the above free trade agreements, the issue of exchange rate volatility still exists among the CEE countries. The future EMU membership for the CEE countries, however, not only eliminates the exchange rate volatility with current Eurozone members (as discussed in the first essay), but also eliminates the intra-CEE exchange rate volatility. The impact on trade of this elimination is the focus of the empirical study conducted in this essay.

### 3.2 Literature Review

We utilize the gravity model to estimate the effects of exchange rate volatility on intra-CEE trade in this essay. This section reviews the literature on the gravity model in international economics.

In its simplest version, the gravity model states that trade between two countries is proportional to their national incomes, and at the same time is inversely related to the distance between them. The gravity model

was first presented by Stewart (1947), who found strong correlations for traffic, migration, and communications between two places with the product of their population size divided by their squared distance; afterwards, it has been widely used in the social sciences to explain social flows, primarily migration, in terms of the “gravitational forces of human interaction”. Its name is derived from Newtonian physics in which the attraction between bodies is proportional to the product of their masses and inversely related to the distance between them.

Using the gravity equation to study bilateral trade flows was first introduced independently by Tinbergen (1962). He stated that “the value of total exports from one country to another is explained by a small number of variables. The explanatory variables that play a preponderant role are: (i) the Gross National Product (GNP) of the exporting country; (ii) the GNP of the importing country; and (iii) the distance between the two countries.” He proposed that transportation cost is roughly approximated by distance and it has a negative impact on trade flows. He also indicated some additional explanatory variables (such as special trade arrangements and adjacent countries), incorporating them as dummy variables determinants of trade volumes.

Poyhonen (1963) suggested that the volume of trade could be estimated as an increasing function of the national incomes of the trading partners and a decreasing function of the distance between them, in which distance is again substituted for a cost of transport function. The rationale for the explanatory variables is as follows:

- the amount of exports a country is able to supply will depend on its economic size (i.e., its GDP or GNP);
- the amount that can be sold to a particular country will depend on the size of that partner country's market (i.e., the GDP or GNP of the importer country); and
- the volume of trade will depend on transportation costs (these are assumed to correspond roughly with the geographic distance between the two countries)

The gravity model has been widely used in international economics; its empirical success has made it the work-horse for research on the geographical patterns of trade. However, its use as an instrument to model bilateral trade flows had its origin in intuitive theorizations without theoretical foundations; for this reason the gravity model has been criticized: "... the model tells us something important about what happens in international trade, even if it does not tell us why" (Deardorff, 1984) "(there is a)..... weak link between theory and empirical work. The gravity models are strictly descriptive." (Leamer and Levinsohn, 1995).

De Melo and Grether (1997) stated that the gravity model is important for two reasons:

- It explains an important proportion of the variation of the global trade among countries.
- It captures at least indirectly the empirical regularities that escape from the traditional models.

The gravity equation in its simplest form can be expressed as:

$$X_{ij} = \beta_0 Y_i^{\beta_1} Y_j^{\beta_2} D_{ij}^{\beta_3} \quad (3.1)$$



where  $X_{ij}$  is the flow from origin  $i$  to origin  $j$ , (or it can also represent total volume of trade between  $i$  and  $j$ ),  $\beta_0$  is a constant,  $Y_i$  and  $Y_j$  are the national incomes of country  $i$  and  $j$  respectively, and  $D_{ij}$  is the distance (resistance) between country  $i$  and country  $j$ . The exponents  $\beta_1$ ,  $\beta_2$ ,  $\beta_3$  indicate that there is not necessarily direct proportionality between the explanatory variables and the trade flow.

The gravity equation has the particularities of general validity. That is, it is equally applicable to any two countries, and it is symmetric because it gives the trade flows in both directions.

The gravity model can be thought as a short-hand representation of supply and demand forces. If country  $i$  is the origin, then  $Y_i$  represents the amount it supplies,  $Y_j$  represents the amount country  $j$  demands; the gravity model does not relate trade directly to prices, which are endogenous and adjust to equate supply and demand. We can think of the distance between the two countries as a sort of tax wedge, imposing trade costs, and resulting in lower bilateral trade flows.

The multiplicative nature of the basic gravity equation lets us express (3.1) in log-linear form

$$\log X_{ij} = \log \beta_0 + \beta_1 \log Y_i + \beta_2 \log Y_j + \beta_3 \log D_{ij} \quad (3.2)$$

Following Linneman (1966), population is introduced as an additional measure of country size, in what has been called the augmented gravity model; when holding constant GNP, the effect of population on trade flows is generally negative, representing the fact that large countries tend to be less open to international trade as a percentage of GNP (Frankel

1997), the augmented gravity equation can be expressed as:

$$X_{ij} = \beta_0 Y_i^{\beta_1} Y_j^{\beta_2} N_i^{\beta_3} N_j^{\beta_4} D_{ij}^{\beta_5} \quad (3.3)$$

where  $N_i$  and  $N_j$  are the populations in countries  $i$  and  $j$  respectively.

It has been common to instead specify the augmented model using per capita income, which captures the same effect. Examples of this use include Sanso, et. al (1993), Frankel and Wei (1998), Frankel et al. (1995, 1998) and Eichengreen and Irwin (1998). The rationale for the inclusion of per capita income can be explained by the fact that higher income countries trade more in general, probably reflecting that high-income countries tend to have superior transportation infrastructure, and trade is liberalized in a high degree. This formulation is expressed by:

$$X_{ij} = \gamma_0 Y_i^{\gamma_1} Y_j^{\gamma_2} YH_i^{\gamma_3} YH_j^{\gamma_4} D_{ij}^{\gamma_5} \quad (3.4)$$

where  $YH_i$  and  $YH_j$  are GDP per capita of countries  $i$  and  $j$  respectively. The models (3.3) and (3.4) are equivalent and the coefficients are expressed as  $\beta_3 = -\gamma_3$ ;  $\beta_4 = -\gamma_4$ ;  $\beta_1 = \gamma_1 + \gamma_3$ ;  $\beta_2 = \gamma_2 + \gamma_4$ .

In their survey of the empirical evidence on international trade, Learner and Levinsohn (1995) suggested that the identification of distance effects on bilateral trade was one of the “clearest and most robust findings in economics”. The importance of distance in international trade has been justified by the following three major explanations:

- 1) Distance is a proxy for transport costs,
- 2) Distance indicates the time elapsed during shipment, and

3) Distance impedes communication thereby leads to “transaction costs”.

The simple or augmented gravity model is the standard to judge the normal pattern of trade between pairs of countries. To capture if other factors (e.g., regional integration, common geographical borders, languages spoken, geographic similarity) are aiding or preventing trade between pairs of countries, dummy variables representing those factors are added to the model.

Even though distance is included in the basic gravity model, common border or adjacency is also included in many studies. Adjacency is included because center to center distance overstates the effective distance between neighboring countries that have a large amount of border trade. When adjacency is included we should expect a decrease in the distance coefficient. Frankel (1997) found that two countries that share a border are engaged in 82 percent more trade than two otherwise similar countries. Engel and Rogers (1996) in a study for Canada and the USA found that distance between two North American cities has a significant effect on the variability of their relative prices.

As mentioned above, the gravity model has been criticized by its lack of theoretical foundations. The empirical success of the gravity equation sparked theoretical work on the micro-foundations of the gravity equation, and has led Frankel (1997) to say that the gravity model has “gone from an embarrassing poverty of theoretical foundations to an embarrassment of riches”.

Theoretical support for the gravity model was originally very poor, but



since the mid 1970s there have been various attempts to provide theoretical foundations to the gravity equation. One of the first attempts to provide formal theoretical foundations to the gravity equation was provided by Linnemann (1966), who extended the model to include the population of the countries as explanatory variables. Linnemann specified a Walrasian general equilibrium model, with each country having its own supply and a set of demand for the goods of all other countries, but the model has too many explanatory variables for each flow to be reduced to a gravity equation. According to Linneman, the gravity model is a reduced form of a four-equation partial equilibrium model of the supply of exports and demand for imports. The main problem of this model has been the absence of an explanation for the multiplicative form of the equation.

Anderson (1979) introduced significant theoretical improvements to the gravity model in terms of constant elasticity of substitution (CES) preferences and distinguished goods by country of origin. First, Anderson showed that the gravity model could be derived from the pure expenditure system model by assuming that “products are differentiated by place of origin.” According to Anderson, the differentiation of products indicates that in the production process “each country is completely specialized in the production of its own good.” He also stated that the gravity model should be fully consistent with the generalized trade-share expenditure system model and noted that “trade shares should increase with income per capita and decreases with size (population).” He concluded that it is appropriate to use and refine the gravity model.

Bergstrand (1985) proposed a manifest theoretical foundation of bilateral trade for the gravity model, which can be derived from assumptions of monopolistic competition and product differentiation. In addition, Bergstrand (1989) applied the microeconomic foundations for the gravity equation to the factor endowment variables and also included exporter and importer income and per capita incomes as exogenous variables, with the assumption of perfect substitutability of products across countries. He emphasized the importance of per capita incomes in bilateral trade flows, pointing out that exporter and importer per capita income has largely been ignored, even though Anderson (1979), Bergstrand (1985), and Helpman and Krugman (1985) estimated bilateral trade flows in terms of exporter and importer incomes.

Deardorff (1998) derived the gravity style from two extreme cases of the Heckscher-Ohlin model that can characterize a variety of other models, including the Ricardian, Specific-factor and Imperfect Competition models. The first case assumes frictionless trade, in which the absence of all barriers to trade in homogeneous products causes producers and consumers to be indifferent among trading partners. This indeterminacy is typically solved by random drawing technique. The second case considers a Heckscher-Ohlin model with differentiated goods; expressions for the gravity equation are derived with Cobb-Douglas and CES preferences. In the case of Cobb-Douglas preferences, the simple frictionless gravity equation is easily derived; with CES preferences, bilateral trade flows are centered on the same values found in the Cobb-Douglas case, but they are smaller for

countries that are a greater than average distance apart as measured by transport costs and larger for countries that are closer than average. He also concluded that “the gravity equation appears to characterize a large class of models”, and therefore the empirical success of the gravity equation does not necessarily support a specific model of international trade.

### **Application of the Gravity Model to the Effect of Exchange Rate Volatility**

Frankel and Wei (1993) found some tentative cross-section evidence that bilateral exchange rate stability may have a (small) effect on trade. A sample calculation suggested that if real exchange rate variability within Europe were to double, as it would if it returned from the 1990 level to the 1980 level, the volume of intra-regional trade might fall by an estimated 0.7 percent.

Dell'Ariccia (1999) analyzed the effects of exchange rate volatility on bilateral trade flows. Through use of gravity model and panel data from Western Europe, exchange rate uncertainty was found to have a negative effect on international trade.

Baak (2004) used annual data for the period from 1980 to 2002 to investigate the impact of exchange rate volatility on exports among 14 Asia pacific countries, detecting a significant negative impact of the exchange rate volatility on the volume of exports.

### **Application of the Gravity Model on CEE Economies**

In view of their simplicity and high explanatory power, gravity models have been applied to studying the CEE economies in several works



Hamilton and Winters (1992) and Baldwin (1994), two of the most influential early studies in the field, showed that trade of the CEE countries with developed countries has been only a fraction of potential trade. Baldwin (1994) suggested that the actual trade with the EU12 was up to 20 percent of the potential trade for Bulgaria and former Czechoslovakia in 1989. Some CEE transition economies were found to be much closer to equilibrium (this is the case of Hungary, with a ratio of potential to actual trade of 1.8), while countries like Romania and Albania, which did not participate in the Council of the Mutual economic Assistance, started trade liberalization with regional trade structures closer to the gravity predictions estimated by Baldwin. Egger (2003) and Fidrmuc and Fidrmuc (2003) found that trade between the EU15 and the CEE countries was close to the predicted level at the end of the 1990s.

**Some other uses of the gravity model include:**

- Test of the regional trade agreement (RTA) effects, that is, if a particular RTA helps the intra-bloc trade. (Aitken 1973)
- Test of the Domino Effect, that is, if increasing integration among countries leads to increase in the number of potential candidates interested in becoming members of a particular regional agreement (Sapir 1997).
- Test of the Linder Hypothesis: Is trade in manufactured goods more intense among countries with high and similar income per capita? (Gruber and Vernon, 1970, and Thursby and Thursby, 1987)

- Rose (2000) found that trade among countries in a monetary union is three times the size of trade among countries that are not in a monetary union, holding other trade costs constant.

### 3.3 Model Specification and Empirical Methodology

#### 3.3.1 Model Specification

To isolate the effects of exchange rate volatility on trade, one must first control the other factors that impinge upon trade flows. To guide the selection of control variables, the gravity model of international trade is taken as a starting point. It predicts that the bilateral trade flows should depend on factors such as economic size or “mass”, distance, and other related considerations. The basic panel equation can be expressed as follows:

$$\ln(\text{Trade}_{ijt}) = \gamma_{ij} + \tau_t + \beta_1 \ln(Y_{it}Y_{jt}) + \beta_2 \ln(y_{it}y_{jt}) + \beta_3 \text{Area} + \beta_4 \text{ADJ} + \beta_5 D + \beta_6 V + \varepsilon_{ijt} \quad (3.5)$$

where  $\gamma_{ij}$  represents the fixed effect in trade between partner countries  $i$  and  $j$ . The fixed effect is intended to capture all individual fixed factors-including unobservable characteristics- associated with a given country pair that have affected bilateral trade flows historically.  $\tau_t$  represents common time effects for a particular period. The time effects are intended to capture common time developments with respect to bilateral trade across all trading partners in the panel. For example, the special case of a linear time trend in trade shares (e.g., increasing global integration) would be captured by the inclusion of time effects.  $Y_i Y_j$  and

$y_i y_j$  represent gross domestic product in level and per capita terms. If the economic size of the countries (GDP in this case) increases and the countries become richer (increase in GDP per capita), then the countries are expected to trade more. *Area* is dummy variable taking the value of one if both partners belong to the same *Area* and zero otherwise. *Area* is derived according to free trade agreements CEFTA and BFTA between trading partners  $i$  and  $j$ . Generally the countries belong to the same *Area* will trade more, so we expect the sign of  $\beta_3$  to be positive. *ADJ* is the adjacent dummy variable. If the countries are neighbors of each other, then it equals one, zero otherwise. As a result, we expect  $\beta_4$  to be positive too.  $D$  denotes the distance between countries.  $V$  is the measurement of exchange rate risk; the coefficient  $\beta_6$  in equation (3.5) is the central parameter of interest. Finally,  $\varepsilon$  is the error term.

Fixed effects estimation is utilized in our study. Its advantage over other methods that use specific variables is that it is able to control for omitted variables bias, at the expense of isolating the individual contribution of time-invariant factors like geographical distance and etc. (See Micco et al. (2003) and UK treasury (2003) for further discussions of the advantages of fixed effects in the gravity trade model.)

As discussed above, with fixed effects models we cannot directly estimate variables that do not change over time. However, these variables, including geographical distance and common border and area variables, can be easily estimated in our study using a second step, i.e., running another regression with the country-pair effects from the fixed



effects model as the dependent variable and distance and dummies that remain constant overtime as independent variables

$$\gamma_{ij} = \alpha_0 + \alpha_1 area + \alpha_2 D + \alpha_3 ADJ + e \quad (3.6)$$

### 3.3.2 Panel Unit Root Test

We have chosen a panel framework to estimate the effect of exchange rate volatility on trade volume among CEE countries. The benefits of this method include:

- With the help of panel data framework, one can control for heterogeneity in individual behavior.
- The availability of larger degrees of freedom in panel data, without having to resort to longer time series, will led to less collinearity among regressors and more efficient estimators.
- Panel data intrinsically present fewer measurement error problems than other frameworks.
- Several investigations that can not be carried out with pure cross-section or time series data become possible in a panel framework because of the two dimensions of variation-over time and across members.
- One of the major concerns in econometric studies, the omitted variable bias, is mitigated when panel data are used. Especially in the case of omitted variables that change slowly over time, the introduction of fixed effects will alleviate the bias significantly.
- Adopting a panel estimation technique reduces the need for long time series, which is an advantage. The longer the time series, the more severe the endogeneity problem.

Given the variables entering the gravity model, the possibility of unit roots may be relevant. The panel test procedure pools cross section time series data and its null hypothesis imposes a cross-equation restriction, thus the panel procedure yields higher power than standard unit root test based on individual time series. In this study, we apply three commonly used panel data unit root tests: the Levin, Lin and Chu test (LLC test, 1992, 1993, 2002), the Im, Pesaran, and Shin test (IPS test, 1997, 2003), and the Hadri test (2000).

Levin, Lin and Chu consider pooling cross-section time series data as a means of generating more powerful unit root tests. They develop the asymptotic theory for a model which allows for individual specific intercepts and time trends. The LLC test procedures are designed to evaluate the null hypothesis that each individual in the panel has integrated time series versus the alternative hypothesis that all individual's time series are stationary. The LLC test considers the following basic ADF specification:

$$\Delta y_{it} = \beta y_{it-1} + \sum_{j=1}^{p_i} \rho_{ij} \Delta y_{it-j} + \alpha_{mi} d_{mi} + \varepsilon_{it}, \quad m=1, 2, 3. \quad (3.7)$$

where  $d_{mi}$  indicates the vector of deterministic variable and  $\alpha_m$  indicates the corresponding vector of coefficients for a particular model  $m=1,2,3$ . Thus,  $d_{1i} = \emptyset$  (the empty set), when the model includes no individual-specific mean and time trend;  $d_{2i} = \{1\}$ , when the model has an individual-specific mean but does not contain a time trend; and  $d_{3i} = \{1, t\}$  when the model has an individual-specific mean and time trend. The lag order  $p_i$  may be different for individual cross-section

units.

The LLC test assumes that there is a common unit root process so that  $\beta$  is identical across sections, But it allows the lag order for the difference terms,  $p_i$ , to vary across sections. The null and alternative hypothesis for the panel unit root test can be written as  $H_0 : \beta = 0$  and  $H_1 : \beta < 0$ . Under the null hypothesis, there is a unit root, while under the alternative, there is no unit root.

To implement the test, first regress  $\Delta y_{it}$  and  $y_{it-1}$  against  $\Delta y_{it-j} (j = 1, \dots, p_i)$  and the appropriate deterministic variables,  $d_{mt}$  and get residuals from these regressions:

$$\hat{e} = \Delta y_{it} - \sum_{j=1}^{p_i} \hat{\pi}_{ij} \Delta y_{it-j} - \hat{\alpha}_{mi} d_{mt} \quad (3.8)$$

$$\hat{v}_{it-1} = y_{it-1} - \sum_{j=1}^{p_i} \hat{\pi}_{ij} \Delta y_{it-j} - \hat{\alpha}_{mi} d_{mt} \quad (3.9)$$

An estimate of the coefficient  $\beta$  is obtained from the pooled proxy equation:

$$t_{\beta}^* = \frac{t_{\beta} - \tilde{N} \tilde{T} \hat{S}_N \hat{\sigma}_{\varepsilon}^{-2} STD(\hat{\beta}) \mu^*}{\hat{\sigma}_{mT}^*} \xrightarrow{mT} N(0,1) \quad (3.10)$$

$$\tilde{e}_{it} = \beta \tilde{v}_{it-1} + \tilde{\varepsilon}_{it} \quad (3.11)$$

where  $\tilde{e}_{it} = \frac{\hat{e}_{it}}{\hat{\sigma}_{\varepsilon i}}$ ,  $\tilde{v}_{it-1} = \frac{\hat{v}_{it-1}}{\hat{\sigma}_{\varepsilon i}}$  are residuals that are normalized by the

regression standard error from Equation (3.11) to control for heterogeneity across individuals. The conventional regression t-statistic for testing  $\beta = 0$  is given by



$$t_{\beta} = \frac{\bar{\beta}}{STD(\bar{\beta})} \quad (3.12)$$

The Monte Carlo simulation shows that the test is appropriate for panels of moderate size.

The second panel unit root test applied in this study is the Im, Pesaran, and Shin (IPS) test. The IPS testing procedure is based on averaging individual unit root test statistics for panels. In particular, the test proposes a standard t-bar test statistic based on the average of (augmented) Dickey-Fuller (Dickey-Fuller, 1979) statistics computed for each group in the panel.

The IPS test starts by specifying a separate ADF regression for each cross section:

$$\Delta y_{it} = \alpha_i + \beta_i y_{i,t-1} + \Delta \sum_{j=1}^{p_i} \rho_{ij} \Delta y_{i,t-j} + \varepsilon_{it} \quad (3.13)$$

It allows for individual unit root processes so that  $\beta_i$  may vary across sections. The test is characterized by the combining of individual unit root tests to derive a panel-specific result. The null and alternative hypothesis for the panel unit root test can be written as  $H_0: \beta_i = 0$  for all  $i$  and  $H_1: \beta_i < 0, i = 1, 2, \dots, N_1, \beta_i = 0, i = N_1 + 1, N_1 + 2, \dots, N$ .

This formulation of the alternative hypothesis allows for  $\beta_i$  to differ across groups and is more general than the homogeneous alternative hypothesis, such as the above LLC test. It also allows for some (but not all) of the individual series to have unit roots under the alternative hypothesis. This is considered as a condition necessary for the consistency of the panel unit root test.

The ADF regressions are estimated for each  $i$ , the standardized

t-bar statistic has an asymptotic standard normal distribution and is given by:

$$Z_{tbar} = \frac{\sqrt{N} \left\{ t - bar_{NT} - \frac{1}{N} \sum_{i=1}^n E[t_{iT}(p_i, \rho_i)] \right\}}{\sqrt{\frac{1}{n} \sum_{i=1}^N Var[t_{iT}(p_i, \rho_i)]}} \rightarrow N(0,1) \quad (3.14)$$

$E[t_{iT}(p_i, \rho_i)]$  and  $Var[t_{iT}(p_i, \rho_i)]$  are the expected mean and variance of the ADF regression t-statistics. Their value for different values of T and p and different test equation assumptions are tabulated in the paper.

The third panel unit root test used in this paper is the Hadri test (2000). The Hadri panel unit root test is akin to the KPSS stationarity test and has the null hypothesis of no unit root in any of the series in the panel. As with the KPSS test, the Hadri test is based on the residuals from the individual OLS regression of  $y_{i,t}$  on a constant or constant and a trend. Such a regression can be defined as:

$$y_{i,t} = \delta_i + \eta_i t + \varepsilon_{i,t} \quad (3.15)$$

In particular, an LM statistic can be constructed from the residuals,  $\hat{\varepsilon}$ , estimated from the individual regressions,

$$LM = \frac{1}{N} \left( \sum_{i=1}^N \left( \sum_t S_i(t)^2 / T^2 \right) / \bar{f}_0 \right) \quad (3.16)$$

where  $S_i(t)$  are the cumulative sums of the residuals,  $S_i(t) = \sum_{s=1}^t \hat{\varepsilon}_{i,s}$ , and  $\bar{f}_0$  is the average of the individual estimators of the residual spectrum at

frequency zero,  $\bar{f}_0 = \sum_{i=1}^N f_{i0}$ . Hadri then demonstrated, with mild assumptions, that

$$Z = \frac{\sqrt{N}(LM - \xi)}{\varsigma} \sim N(0,1) \quad (3.17)$$

where  $\xi = 1/6$  and  $\varsigma = 1/45$ , if the model includes constants and  $\xi = 1/15$  and  $\varsigma = 1/6300$ , otherwise. Such a stationarity test can be considered a viable alternative to the above two unit root tests because it allows the researcher to investigate the autoregressive nature of the panel in a diverse way in comparison to the ADF methodology. As such, it helps build power to the conclusions made with respect to the panel members individually and as a group.

### 3.3.3 Panel Co-integration Test

If all variables were stationary, one could safely use the conventional econometrics framework of estimation. However, since mostly they are not, we have to ensure that our model is not spurious. Usually regression involving  $I(1)$  variables tend to be spurious unless it can be demonstrated that there exists a linear combination of these variables that is stationary. Thus, to test for cointegration it is necessary to verify that the model residuals do not contain a unit root and are white noise.

We use the framework developed by Pedroni (1999, 2000), which is the least restrictive one in terms of assumptions imposed<sup>9</sup>. It is based on seven residual-based statistics that are constructed to test for the null hypothesis of no cointegration in panels. Four of the seven

---

<sup>9</sup> for surveys on panel cointegration see Banerjee (1999), and Baltagi and Kao (2000).



residual-based statistics (called panel statistics) are based on pooling along the within-dimension, whereas three of them referred to as group mean statistics are constructed by pooling along the between-dimension. The first set of tests pools the autoregressive coefficient across cross-sectional units for the unit root tests on the estimated residuals. The second set of tests is based on averaging individually computed statistics for each cross-sectional unit, thus allowing for a high degree of parameter heterogeneity. The salient distinction in the testing of the null hypothesis of no cointegration for these two types of statistics is that for the within-dimension test ( $H_0 : \gamma_i = 1$  for all  $i$  versus  $H_1 : \gamma_i = \gamma < 1$  for all  $i$ ), a common value for the autoregressive coefficient of the disturbance term for the OLS residuals is assumed under the alternative hypothesis. No such restriction is imposed for the between-dimension test ( $H_0 : \gamma_i = 1$  versus  $H_1 : \gamma_i < 1$  for all  $i$ ). Once these tests are computed, they are then normalized by appropriate scaling moments (means and standard deviation) representing Brownian motion processes for the individual statistics, which are obtained via Monte Carlo simulations and tabulated in Pedroni (1999). Fortunately, these statistics converge asymptotically to the standard normal distribution  $N(0,1)$ .

We use the four statistics from Pedroni (1999) that have the most power. They can be expressed as follows:

$$panelpp-statistics = \left( \sigma_{N,T}^{-2} \sum_{i=1}^N \sum_{t=1}^T \hat{L}_{li}^{-2} \hat{e}_{i,t-1}^{*2} \right)^{-1/2} \sum_{i=1}^N \sum_{t=1}^T \hat{L}_{li}^{-2} \hat{e}_{i,t}^* \hat{e}_{i,t}^* - \hat{\lambda} \quad (3.18)$$

$$paneladf - statistics = \left( s_{N,T}^{-2} \sum_{i=1}^N \sum_{t=1}^T \hat{L}_{1i}^{-2} e_{i,t-1}^2 \right)^{-1/2} \sum_{i=1}^N \sum_{t=1}^T \hat{L}_{1i}^{-2} (\hat{e}_{i,t}^* \Delta \hat{e}_{i,t_i}^*) \quad (3.19)$$

$$Grouppp - statistic = N^{-1/2} \sum_{i=1}^N \left( \hat{\sigma}_i^2 \sum_{t=2}^T \hat{e}_{it-1}^2 \right)^{-1/2} \sum_{t=2}^T \left( \hat{e}_{i,t-1}^* \Delta \hat{e}_{it} - \hat{\lambda}_i \right) \quad (3.20)$$

$$Groupadf - statistic = N^{-1/2} \sum_{i=1}^N \left( \hat{s}_i^2 \sum_{t=2}^T \hat{e}_{it-1}^2 \right)^{-1/2} \sum_{t=2}^T \left( \hat{e}_{i,t-1}^* \Delta \hat{e}_{it} \right) \quad (3.21)$$

Where Panel *pp* , Panel *adf* , Group *pp* , Group *adf* are respectively the within and between versions of the non-parametric Phillips-Perron t-statistics and the Augmented-Dickey-Fuller statistic for unit root tests on the estimated residuals. For a definition of the various nuisance parameters see Pedroni (1999). Note that the Group *adf* test is equivalent to the IPS residual based test for unit root in the previous section.

### 3.3.4 Panel Dynamic OLS Estimator

In this section, we turn to the issue of correctly estimating the long-run parameters of the cointegration equations. It is now commonly acknowledged that parameter estimations by OLS of cointegration vectors, though superconsistent (i.e. they approach their true values at a rate proportional to  $T^{-1}$  instead of  $T^{-1/2}$ ), are asymptotically biased because of possible endogeneity of the  $I(1)$  regressors under the usual assumption regarding cointegrated systems and serial correlation in the data. This in turn causes finite sample bias and efficiency loss (Davidson and MacKinnon, 1993). Pedroni (1996) showed that the bias problem is

further compounded in panel data because the cross-section dimension introduces a potential for second order bias that is an amplification of the original bias due to the size of the cross-section. In addition, the nuisance parameters on the off-diagonal elements of the covariance matrix remain pervasive in the asymptotic distribution of the unit root tests causing undesirable data dependencies in residual-based cointegration tests, which invalidates standard hypothesis testing in the OLS framework. This finding is in agreement with Kao (1999) who found that in panel OLS regression involving  $I(1)$  variables, the t-statistic neither converges to the standard normal distribution nor has a zero mean even for  $T=30$ .

To cope with this problem, Pedroni (1996) proposed the use of the panel Fully Modified Ordinary Least Square (FMOLS) estimator, first employed by Philips and Hansen (1990) in the single equation case, to correct the asymptotic bias and free the asymptotic distribution of the estimators from the nuisance parameters. The FMOLS is asymptotically normally distributed with zero mean. Kao and Chiang (1999) investigated the properties of the FMOLS, OLS and DOLS (dynamic ordinary least square) estimators. They found that the OLS has a significant downward bias in finite sample that makes it the most biased estimator of them all. The FMOLS hardly did much better. It was more biased than the OLS in homogeneous panels under certain conditions (when both the serial correlation and endogeneity parameters were positive) and severely biased in heterogeneous panels in all instances.

Part of the problem with the FMOLS is that the non-parametric factor



necessary for the endogeneity correction depends on the prior estimation of some nuisance terms by OLS which itself is biased. Kao and Chiang (1999) showed that DOLS approach is superior to the OLS and the FMOLS in terms of smallest mean-bias both in homogenous and heterogeneous panels. Part of the appeal of the DOLS is that it provides asymptotically efficient and unbiased estimates and has standard asymptotic distributions that are close approximation to the exact distribution in small samples, which permits standard hypothesis testing. Furthermore the DOLS requires neither initial estimator nor non-parametric correction. Its major drawback however is that it can be sensitive to the number of lags and leads over the FMOLS, because in their view the failure of the non-parametric correction for the FMOLS to reduce estimation bias is far more damaging than the possible lack of robustness of DOLS to the exact choice of lags and leads.

Given the above considerations, we decided to estimate the long-run cointegration relationships of our model using DOLS. To ensure the robustness of our results, we perform sensitivity analysis to ensure that the results are robust to various lags and leads. The DOLS estimator is obtained by running OLS on the following regression:

$$y_{it} = \alpha_i + x'_{it}\beta + \sum_{j=-q}^q c_{ij}\Delta x_{it+j} + v_{it} \quad (3.22)$$

which is in fact the cointegration equation with additional regressors in the form of lags and leads of the first difference of the variables considered. The purpose of including additional regressors in the

equation is to remove the undesirable nuisance parameters<sup>10</sup>.

### 3.4 Data Analysis and Empirical Results

#### 3.4.1 Variables and Data Sources

Data are mainly collected from the International Financial Statistics and the Direction of Trade Statistics issued by the IMF and Data-stream database in this study. We acquire quarterly data in the sample period from 1995:01 to 2005:02 from these databases. We build the panel for the eight CEE countries that joined EU. The total number of country pairs (combinations) is hence  $N = 28$ , the number of times series is  $T = 42$ , yielding a total number of observations  $NT = 1176$ .

In particular, some of the variables are built as follows:

- Real exports: The real exports between countries is the product of real exports from country  $i$  to country  $j$  ( $EXP_{ijt}$ ) and real exports from country  $j$  to country  $i$  ( $EXP_{jit}$ ), which is calculated as follows:

$$Trade_{ijt} = EXP_{ijt} * EXP_{jit} = \ln \left[ \left( \frac{EX_{ijt}}{USGDP_t} * 100 \right) * \left( \frac{EX_{jit}}{USGDP_t} * 100 \right) \right] \quad (3.22)$$

where  $EX_{ijt}$  is the quarterly nominal exports of country  $i$  to country  $j$  in US dollar;  $EX_{jit}$  is the quarterly nominal exports of country  $j$  to country  $i$  in US dollar; and  $USGDP_t$  denotes the US GDP deflator.

---

<sup>10</sup> For good reviews of panel DOLS estimators see Kao and Chiang (1999), and Mark and Sul (2002)

- Real GDP: The real GDP is the product of GDPs ( $GDP_{it} * GDP_{jt}$ )

which is calculated as follows:

$$Y_{it}Y_{jt} = GDP_{it} * GDP_{jt} = \ln \left[ \left( \frac{GDPN_{it}}{USGDPD_t} \times 100 \right) * \left( \frac{GDPN_{jt}}{USGDPD_t} \times 100 \right) \right] \quad (3.23)$$

where  $GDPN_{it}$  is the nominal GDP of country  $i$  measured in US dollar and  $GDPN_{jt}$  is the nominal GDP of country  $j$  in US dollar.

- Real GDP per capita: The real GDP per capita is the product of GDP per capital of country  $i$  and country  $j$ .
- Real exchange rate volatility: GARCH (1, 1) average monthly exchange rate volatility, as discussed in Essay One.

3.4.2 Panel Unit Root Test Results

Tables 3.3 and 3.4 present the panel unit root test results in level and first difference. It can be observed from Table 3-3 that the test statistics are suggestive for the presence of unit roots in our panel. This observation regarding possible non-stationarity in the panel data is not surprising when considering that the key variables which include  $\ln(Trade_{ijt})$ ,  $\ln(Y_{it}Y_{jt})$  and  $\ln(y_{it}y_{jt})$  between trading partners. From Table 3-4, however, we can see that the variables are stationary in first difference generally.

	LLC	IPS	Hadri
$\ln(Trade_{ijt})$	-1.36	-0.17	11.31*
$\ln(Y_{it}Y_{jt})$	-1.34	0.13	14.42*
$\ln(y_{it}y_{jt})$	-1.62	-3.31*	9.44*



$V_{ijt} - Garch$	-1.33	1.09	8.38*
-------------------	-------	------	-------

Table 3-3 Panel unit root test results – Level

	<i>LLC</i>	<i>IPS</i>	<i>Hadri</i>
$\ln(Trade_{ijt})$	-12.84*	-13.94*	0.93
$\ln(Y_{it}Y_{jt})$	-10.62*	-11.49*	1.16
$\ln(y_{it}y_{jt})$	-9.72*	-11.58*	3.48*
$V_{ijt} - Garch$	-13.58*	-15.92*	1.26

Table 3-4 Panel unit root test results - 1<sup>st</sup> Difference

3.4.3 Panel Co-integration Test Results

Given the possibility of unit roots in the panel data, panel cointegration tests were also conducted, as shown in Table 3-5. These tests strongly suggest that bilateral trade, GDP, GDP per capita and bilateral exchange rate volatility between country trading pairs are cointegrated.

Standard Case	
Panel pp-statistic	-4.34*
Panel adf-statistic	-2.73*
Group pp-statistic	-6.18*
Group adf-statistic	-4.64*
Heterogeneous Case	
Panel pp-statistic	-9.36*
Panel adf-statistic	-4.72*
Group pp-statistic	-11.92*
Group adf-statistic	-8.43*

Note: all test are one tailed tests with  $N(0,1)$  distribution  
A \* indicates the rejection of the null hypothesis of no cointegration at least on the 0.05 level of significance.  
All tests were executed using RATS codes for panel cointegration graciously provided by Peter Pedroni

Table 3-5 Panel Cointegration Tests

3.4.4 Panel DOLS results

The panel DOLS result<sup>11</sup> is shown in Table 3-6. As can be seen, the coefficients of  $\ln(Y_{it}Y_{jt})$  and  $\ln(y_{it}y_{jt})$  are all positive, which are as expected. The coefficient of  $\ln(V_{ij})$  is negative, which implies the future EMU membership is beneficial for intra-CEE trade.

Time-variant Variables	Coefficient
$\ln(Y_iY_j)$	0.74 (0.24)
$\ln(y_iy_j)$	0.43 (0.13)
$\ln(V_{ij})$	-0.18 (-0.04)

Notes: all specifications include fixed effects and time effects. Standard errors given in parentheses; OLS standard errors are only indicative under the null of non-stationarity.

Table 3-6 DOLS Estimation Result

Time-invariant Variables	Coefficient
$c$	9.63 (5.18)
$D$	-1.69 (-0.54)
$Area$	1.12 (0.34)

<sup>11</sup> We have also conducted OLS estimation for robust tests and the results are similar.

<i>ADJ</i>	0.43 (0.12)
<i>R</i> <sup>2</sup>	0.31

Notes: Standard errors given in parentheses.

Table 3-7 Individual Effects on Distance, Adjacent and Area.

Table 3-7 presents the result for the individual effects of the time-invariant variables. It can be observed that the coefficient for distance *D* is negative, which means that, as expected, the farther the distance between countries, the less the trade volume. The coefficient for adjacency *ADJ* is positive, meaning that the countries that are adjacent to each other have more trade. Finally, the country belongs to the same area also trade more, as denoted by the coefficient of *area*. They also conform to our expectation.

### 3.5 Summary

In Essay One, we discussed the impact of exchange rate volatility on the trade effects between the CEE countries and the Eurozone, and it is shown that the three CEE ERM-outsiders can benefit from their adoption of the *euro*. As entering the Eurozone eliminates not only the exchange rate volatility between the CEECs and the Eurozone, but also the one among CEE countries themselves. It is also interesting to investigate the effect of the future elimination of exchange rate volatility on the intra-CEE trade, which is the focus of this essay.

We utilize the classical gravity model to study the relationship of the eight CEE economies. Unlike many other studies that assume the stationarity of the panel data, the recently developed panel unit root tests and Pedroni's cointegration methods are used to detect whether the



panel data are stationary and whether there exists a long run relationship between the non-stationary panel data. We then apply dynamic OLS in our study to estimate the parameter in the gravity model, which has been suggested by Kao and Chiang (2000). Compared to panel estimators that address endogeneity bias, they found that DOLS outperforms the Phillips-Hansen “fully-modified” OLS (FMOLS) approach in finite samples.

We apply the above methodology for the quarterly data from 1995:01 to 2005:02. There are three main findings from our empirical results. First, we find that all variables are co-integrated in all the three countries over the sample period. This suggests that the macroeconomic variables are not drifted far apart in the long run and, therefore, may not consider independent of each other. Second, all the parameters are as expected. GDP and GDP per capita, area, border are significantly positive; while the distance is significantly negative. Third, the relationship between real exports and exchange rate volatility of the CEE countries is negative and statistically significant.

From the above findings, the future prospective membership of EMU is able to increase the trade volume among the CEE countries themselves, in addition to increasing trade between the CEE countries and the Eurozone, as the first essay indicates. Therefore, we conclude that the entry of EMU in an earlier date for the CEE countries should be encouraged based on trade effects.

## **4. Essay III: The OCA Theory and the Role of Exchange Rate in CEE Economies: Evidence from VAR Model**

### **4.1 Overview**

An Optimum Currency Area (OCA), as defined by Mundell<sup>12</sup>, is a region where exchange rates among countries should be fixed. Nations choosing to participate in a currency union are generally believed to prefer achieving certain economic goals such as lower transaction costs (no market segmentation or no currency conversion costs) and less difficulty of completing international transactions within the union; elimination of exchange rate uncertainty and larger market areas.

These transaction advantages, however, come with some cost as well. According to the OCA theory, the main cost of joining a currency area is the loss of monetary policy instruments at a national level (e.g., the exchange rate) as stabilization mechanisms against macroeconomic disturbances that affect the area in different manners. As these kind of macroeconomic disturbances, known as “asymmetric shocks”, cannot be dealt with a common monetary policy, alternative adjustment mechanisms are needed to achieve macroeconomic stabilization. In an independent monetary policy regime, the exchange rate will act as a shock absorber when facing such asymmetric shocks.

---

<sup>12</sup> Professor Mundell's innovative and profound analysis of the Optimum Currency Area (OCA) and exchange rate regime won him Nobel Prize in 1999.

In addition to considering the potential benefits of the adoption of the *euro* on the exports of the CEE countries (discussed in the previous two essays), in this essay, we try to understand the role of the exchange rate in the adjustment of the potential asymmetric shocks. We also investigate the contribution of the Eurozone shocks to the macroeconomic fluctuations of the three CEE ERM-outsiders (i.e., again, the Czech Republic, Hungary and Poland) in this study.

## **4.2 Literature Review**

### **4.2.1 Optimum Currency Areas Theory**

The OCA is an optimal geographic domain of a common currency, or of several currencies, whose exchange rates are irrevocably pegged and unified. The common currency, or the pegged currencies, can fluctuate only in unison against the rest of the world. The domain of an OCA is given by the sovereign countries choosing to adopt a single currency or to irrevocably peg their exchange rates. Optimality is defined in terms of several criteria, including the mobility of labor, the economic openness, the diversification in production, the similarity of supply and demand shocks and business cycles, etc. Meeting the above criteria makes exchange rate adjustments unnecessary within the currency area by fostering internal and external balance, reducing the impact of some types of shocks or facilitating the adjustment thereafter.

The OCA theory started with the seminal works by Mundell (1961), McKinnon (1963), and Kenen (1969). We introduce some of the main OCA criteria as follows:

- *The Factor Mobility.* The intellectual origins of the optimum



currency area literature began with Mundell (1961, 1968). Mundell observed that, in cases where nations are within the same domain forming a currency area, an exchange rate adjustment is of little use if the degree of production factor mobility (e.g. labor and capital) across countries is high. To illustrate his theory, Mundell used Canada and the United States as an example. He observed that high factor market integration and sufficient factor mobility within a group of partner countries can reduce the need to alter real factor prices, and the exchange rate, between countries in response to disturbances. If one country suffers from depression due to a negative shock, factors of production may move from this country to another which is hit by a positive shock. Hence, prices of these factors do not need to fall so sharply in the depressed country and rise in the booming country. The factor mobility is then able to compensate for the exchange rate changes. He reasoned that the leading advantages of creating a currency area tied by a fixed exchange rate between two nations were to reduce the exchange rate risk and to diminish transaction cost.

- *The Degree of Economic Openness.* The second criterion, designated by McKinnon (1963), is the degree of economic openness. The higher the degree of openness, the more changes in international prices of tradable are likely to be transmitted to the domestic cost of living. Also, devaluation would be more rapidly transmitted to the price of tradable and the cost

of living, negating its intended effects. Hence, the exchange rate would be less useful as an adjustment instrument for small and open economies.

- *The Diversification in Production and Consumption.* Kenen (1969) outlined the third criterion: the diversification in production and consumption. A high diversification in production and consumption diminishes the possible impact of shocks specific to a particular sector. Therefore diversification reduces the need for changes in terms of trade via the nominal exchange rate and provides “insulation” against a variety of disturbances. More diversified partner countries are more likely to endure small costs from forsaking exchange rate changes amongst them and find a common currency beneficial.
- Similarity of supply and demand shocks and business cycles. This is an important criterion. Monetary and exchange rate policy in a common currency area cannot be used as a stabilization tool when a member country is, for example, hit by an asymmetric shock. Hence, business cycles of countries considering creation of a currency area must be correlated to a maximum extent.

#### **4.2.2 Previous Work**

A number of empirical studies have used structural vector auto-regressions (SVARs) to analyze the relative importance of different shocks in explaining exchange rate fluctuations.

Clarida and Gali (1994) examined the importance of nominal shocks in explaining real exchange rate fluctuations. They used a long run

triangular identification scheme proposed by Blanchard and Quah (1989) and King et al. (1991). The nominal shocks are identified by assuming that such shocks do not affect real variables, i.e. the real exchange rate or output, in the long run. They found that demand shocks were able to explain the majority of the variance in the real exchange rate and that the exchange rate acted as a shock absorber. These results are confirmed by Funke (2000) for the UK versus the Euro area.

Chadha and Prasad (1997) applied the Clarida and Gali (1994) approach to the Japanese yen-US dollar exchange rate and also found that demand shocks play a crucial role in explaining fluctuations, although supply shocks are also important. Clarida and Gali's restrictions are based on a small open macro model inspired by Dornbusch (1976) and Obstfeld (1985).

Artis and Ehrmann (2000) estimated structural VARs and identified monetary policy and exchange rate shocks using short-run zero restrictions. More specifically, they assumed that all nominal shocks have no immediate effect on outputs. This study found that the exchange rate seems mostly to reflect shocks originating in the foreign exchange market itself, i.e., the exchange rate is a source of shocks rather than simply a shock absorber.

Canzoneri et al (1996) reached a similar conclusion. They estimated VARs for a number of European countries and checked whether the most important shocks in explaining the output variance decomposition are also the most important in explaining exchange rate fluctuations. Supply shocks explained most of the movement in output but could hardly



explain any variation in exchange rates. This, in turn, suggested that the loss of exchange rate flexibility in a monetary union is less costly in terms of macroeconomic stability. Overall, there is no consensus on this issue.

As data quality improved with the progress of economic transition in the CEE countries, SVAR methodology has also been extensively applied for CEE countries when studying their macroeconomic fluctuations. We list a few examples in the following paragraphs.

Frenkel et al. (1999) found that the correlation between shocks in the Euro area and in the nonparticipating EU member states was quite high – as it was for the remaining EFTA countries. The correlation of shocks was quite different between the Euro area (proxied by Germany and France) and the CEECs. Unfortunately, there were difficulties in interpreting the results. Perhaps the most serious caveat related to data used for estimation. Frenkel et al. used quarterly data from the first quarter of 1992 to the second quarter of 1998. The time period is quite short – a problem that really cannot be avoided in such studies. More importantly, the first two or three years in the sample belong to the period of transformational recession for some CEECs, i.e., output losses related to the change in the economic system. This can make the interpretation of economic shocks problematic.

Csajbók and Csermely (2002) compared economic dynamics in the EU and CEE accession countries and estimated supply and demand shocks for a relatively long period (1992–2000). The comparative country is derived as the principal component for EU countries, which may cause deviations between their results and those of the other studies. Most

importantly, in their work, the Czech Republic displayed strong correlation with the comparative country for both demand and supply shocks, while the previous studies showed zero or even negative correlation for the two shocks.

Korhonen (2003) examined monthly indicators of industrial production in the Euro area and nine CEECs. The correlation was assessed with the help of separate VARs for the first difference of the Euro-area production and production in each of the analyzed countries. The correlation of impulse responses to a Euro area shock was taken as evidence of symmetry of the business cycles. Korhonen found that some CEE countries (especially Hungary) exhibited a high correlation with the Euro-area business cycle. Correlation seemed to be at least as high as in some smaller EMU members (e.g. Portugal and Greece).

More recently, Ramos and Suriñach (2004) introduced monetary shocks with structural VAR models. The authors discussed two possible ways to include monetary shocks: real interest rates (following Artis, 2003), or real effective exchange rate (similar to Clarida and Galí, 1994), to the structural VAR model of the previous variables (growth and inflation). For data reasons, the second model was estimated for only four new member states (Czech Republic, Hungary, Poland, and Slovakia). Surprisingly, the monetary shocks implied by the Artis decomposition were very similar for the CEE countries and the Euro area. Correlation coefficients (computing for three two-year windows) reached 0.78 in the case of Hungary (2001–2002). The Czech Republic and Poland during the currency float (1998–2000) also displayed high

positive correlations (above 0.5 in both cases). In fact, no CEE countries showed negative correlations between 1998 and 2002.

## 4.3 Model Specification and Empirical Methodology

### 4.3.1 Model Specification

VAR analysis, pioneered by Sims (1980), is basically a time series approach for macroeconomic modelling, which grew out of the discontent with standard large-scale macro-econometric models. Typically, these large-scale models are constructed based on various economic theories and often are composed of many behavioural equations with lots of exclusion restrictions imposed on the lagged variables. Dissatisfied with the “incredible” restrictions, Sims offered the VAR approach as an alternative to the standard macro-econometric modelling. Under this approach, it is no longer necessary to impose many identification restrictions and presuppositions of any particular structural form. Rather, the data are allowed to “speak for themselves”. If there is any dynamic relationship among a set of variables to be captured, the VAR approach will distinguish that.

Basically, a vector auto-regression is a system of regression equations where independent variables are merely lagged values of the dependent variables in the system; no current variables are included in the VAR system. To illustrate, we write a  $n$ -variable VAR as:

$$B(L)Y_t = \beta_0 + e_t \quad (4.1)$$

where  $\beta_0$  is a  $n \times 1$  vector of constants,

$B(L) = I_n - B_1L - B_2L^2 - \dots - B_kL^k = I_n - \sum_1^k B_kL^k$  is  $n \times n$  matrix of



polynomials in the lag operator  $L$  of finite order  $k$ , and  $e_t$  is a  $n \times 1$  vector of error terms or residuals. This  $e_t$  has a zero mean,  $E(e_t) = 0$ , and a variance-covariance matrix,  $Cov(e_t) = \Sigma$ . Normally, this variance-covariance matrix is non-diagonal; which means the error terms are contemporaneously correlated.

One can also interpret a VAR as follows:

$$A(L)Y_t = \alpha_0 + \varepsilon_t, \quad (4.2)$$

where  $A(L) = A_0 - A_1L - A_2L^2 - \dots - A_kL^k = A_0 - \sum_{i=1}^k A_iL^i$  is a  $n \times n$  matrix of polynomials in the lag operator  $L$ ,  $Y_t$  contains the  $n \times 1$  vector of endogenous variables,  $\alpha_0$  is a  $n \times 1$  vector of constants, and  $\varepsilon_t$  is a  $n \times 1$  vector of random structural disturbances or shocks that can be given some structural economic interpretation. In addition, the elements of  $\varepsilon_t$  are assumed to be serially uncorrelated and independent of each other; it has a diagonal variance-covariance matrix,  $Cov(\varepsilon_t) = \Omega$ . These structural shocks represent the movements in the variables that are unanticipated by the system; in a sense, they can also be referred to as forecast errors. In VAR studies, the selection of variables to be included in the vector  $y_t$  is based on the subject of study and normally relies on a priori economic theorizing, or strong empirical relationships.

In our study, we will include four variables in the VAR system, which can be written as

$$x_t = A(L)\varepsilon_t, \quad (4.3)$$

where  $x = [y^{EU}, y, p, e]$ , in which  $y^{EU}$ ,  $y$ ,  $p$ , and  $e$  represent

trade-weighted Eurozone industrial production index (a proxy for regional output in monthly frequency), each CEE economy's industrial production index, consumer price index and real exchange rate vis-à-vis Euro, respectively.  $\varepsilon_t = [\varepsilon_{st}^{EU}, \varepsilon_{st}, \varepsilon_{dt}, \varepsilon_{nt}]$ , in which  $\varepsilon^{EU}$ ,  $\varepsilon_{st}$ ,  $\varepsilon_{dt}$ , and  $\varepsilon_{nt}$  denote Euro-area (regional) shocks, supply shocks, demand shocks and nominal shocks.  $\varepsilon_t$  is serially uncorrelated and  $E[\varepsilon_t \varepsilon_t']$  is normalized to the identity matrix.  $A(L) = A_0 + A_1 L + A_2 L^2 + \dots$  is the matrix polynomial in the lag operator.

### 4.3.2 Lag length Selection

After selecting the desired variables to be included in the system, one must also select the appropriate lag length for the system. In order to preserve symmetry in the system, equal lag length is set in every equation of the VAR model. This constitutes an unrestricted VAR. The selection of lag length  $k$  must be given some attention so that the dynamic relationship among variables can be sufficiently captured and serial correlation can pose no serious threat to the specification of the model. On the other hand, if a VAR system contains many variables, and if a large lag length is chosen for this system, the number of coefficients to be estimated will be enormous. This can exhaust degrees of freedom. To resolve this dilemma, the appropriate lag length is frequently determined by satisfying some statistical selection criteria; usually involves testing the longest length (selected a priori) against a few other shorter lag lengths. In our own empirical investigation, two different tests will be carried out. The first is the maximum likelihood ratio while the

second is the AIC.

To perform the maximum likelihood ratio, we estimate two models: model A and model B with  $n$  variables each. The basic difference between these two models is the number of lags, where model B is assumed to have a shorter lag length ( $p_0$ ) than model A ( $p_1$ ) since we are restricting parameters of some lags to be zero. Thus, model A can be seen as the unrestricted estimation and model B as the restricted estimation. Let  $L(A)$  and  $L(B)$  be the likelihood functions for the two models, then twice the log likelihood ration is defined as:

$$Ratio = -2 \log \lambda = \log \left[ \frac{L(A)}{L(B)} \right] = T [\log |\Omega_B| - \log |\Omega_A|] \quad (4.4)$$

where  $|\Omega_A|$  and  $|\Omega_B|$  are the determinants of the variance-covariance matrices of the residual from the regressions of models A and B, respectively (Hamilton, 1995) and  $T$  is the number of observations. Sims (1980) suggested a slight modification to the likelihood ratio test to consider small sample bias. He recommends substituting Equation (4.4) by

$$Ratio = (T - k) [\log |\Omega_B| - \log |\Omega_A|] \quad (4.5)$$

where  $k$  = the number of deterministic parameters +  $np_1$ . That is,  $k$  is the number of parameters estimated per equation in model A.

The statistic *Ratio* has a  $\chi^2$  distribution with degrees of freedom equal to the number of restrictions imposed under the null hypothesis.

### 4.3.3 Identification of the VAR System

Identification in VAR is basically the setting of enough restrictions



on the matrix  $A_0$  so that estimates of the structural model and subsequently the structural shocks, can be derived. The restrictions usually are exclusion restrictions, based on economic theories, which assume some elements in the matrix  $A_0$  are zero. It is well known that if all the variables in an unrestricted VAR are contemporaneously correlated with each other (i.e., all elements in  $A_0$  are non-zero), the system will be under-identified and hence can not be estimated. This is easily understood when we compare the number of parameter estimates in VAR (4.1) with the structural model (4.2). In VAR (4.1), the number of parameters or elements to be estimated are  $n^2k$  in  $B(L)$  and  $n(n+1)/2$  in  $\Sigma$ . There are, however, far more parameters in the structural model (4.2); precisely,  $n^2(k+1)$  elements in  $A(L)$  and  $n$  elements in the variance-covariance in  $\Omega$  matrix (here, we restrict  $\Omega$  to be diagonal since we assume the structural shocks to be independent in the first place). The difference is  $n(n+1)/2$  more elements in the structural model than in the VAR. Since each structural equation is normalized on a particular variable, the principal diagonal of matrix  $A_0$  has ones running down it. This imposes  $n$  restrictions and brings the total number of identifying restrictions down from the earlier  $n(n+1)/2$  elements to  $n(n-1)/2$  elements to achieve exact identification or just identification. The rest of the remaining  $n(n-1)/2$  restrictions will have to rely on plausible economic assumptions of how variables in the system are to react to one another. Incidentally, restrictions are typically exclusion restrictions that bar certain variables

in the system from having any influence on the rest of the variables.

Most early VAR studies followed Sims'(1980) approach, and found identification and estimation of the matrix  $A_0$  most conveniently achieved by utilizing a mathematical transformation of the variance-covariance matrix of the error term ( $e_t$ ),  $\Sigma$ . This mathematical transformation is known as the Choleski decomposition. Not only common in other areas of empirical studies, this Choleski approach found its way into the shock transmission studies as demonstrated by Genberg et al. (1987), Lastrapes and Koray (1990), Kouparitsas (1998), this approach requires imposing a recursive structure on the contemporaneous relationship among the variables, and forces the matrix  $A_0$  to be lower triangular and the system to be exactly identified. Technically, based on a particular ordering (according to economic intuition), the Choleski decomposition will transfer the variance-covariance matrix of the error term to yield a particular lower triangular matrix  $A_0$  that will solve  $\Sigma = A_0^{-1}\Omega A_0^{-1'}$  and at the same time diagonalize the variance-covariance matrix of the structural shocks into an identity matrix:  $E[\varepsilon_t \varepsilon_t'] = A_0 \Sigma (A_0)' = I$  However, using the Choleski decomposition approach to elicit the structural impulse response functions and variance decompositions is not impeccable as Cooley and LeRoy (1985), Leamer (1985), and Bernanke (1986) had pointed out. Particularly, they criticized the way that a recursive structure is presupposed when rarely is it congenial with economic theory. In addition, they also criticized that because different orderings of the

variables will yield different results, inferences based on the impulse response functions and variance decompositions can be unreliable and controversial. Sims (1986) and Bernanke (1986) propose modelling the innovations using economic analysis. Blanchard and Quah (1989) provide an alternative way to obtain a structural identification. Their aim is to reconsider the Beveridge and Nelson (1981) decomposition of real GNP into its temporary and permanent components. Toward this end, they develop a macroeconomic model such that real GNP is affected by demand-side and supply-side disturbances. In accord with the natural rate hypothesis, demand-side disturbances have no long-run affect on real GNP. On the supply side, productivity shocks are assumed to have permanent affects on output.

In order to motivate the restrictions embedded in the structural VAR framework, we start with a dynamic open economy aggregate supply – aggregate demand (AS-AD) model with infinite capital mobility.

$$y_t^{EU} = y_{t-1}^{EU} + \varepsilon_t^{EU} \quad (4.6)$$

$$y_t^s = y_{t-1}^s + \theta \varepsilon_t^{EU} + \varepsilon_t^s \quad (4.7)$$

$$y_t^d = d_t - \gamma[i_t - E_t(p_{t+1} - p_t)] + \eta(s_t - p_t) \quad (4.8)$$

$$d_t = d_{t-1} + \varepsilon_t^d \quad (4.9)$$

$$E_t s_{t+1} - s_t = i_t - i_t^* \quad (4.10)$$

$$m_t^d = p_t + \varphi y_t - \lambda i_t \quad (4.11)$$

$$m_t^s = m_{t-1}^s + \varepsilon_t^m \quad (4.12)$$

$$y_t^s = y_t^d = y_t \quad (4.13)$$

$$m_t^s = m_t^d = m_t \quad (4.14)$$



where  $y^{EU}$  is Eurozone output,  $y^s$  is domestic output,  $i$  is the domestic nominal interest rate,  $i^*$  is the foreign interest rate,  $s$  is the exchange rate expressed as the domestic currency price of foreign currency,  $p$  is the domestic price level<sup>13</sup>,  $m$  is the money stock,  $d$  is autonomous aggregate demand,  $E_t$  is the expectations operator conditional on information available at time  $t$ . All variables except interest rates are in natural logarithms, and all parameters are assumed positive.

Equation (4.6) is the evolution of the Eurozone output, which is assumed to follow a random walk. Equation (4.7) express the aggregate supply, which depends on the previous period's domestic output, and EU supply shocks according to the assumption of small open economy. Moreover, Equation (4.8) is an aggregate demand (IS) expression, where total spending is a function of the expected real interest rate, and the real exchange rate. Here, the Marshall-Lerner condition is assumed to hold, so any increase in the real exchange rate is assumed to increase aggregate demand. In Equation (4.9), autonomous spending,  $d_t$ , is assumed to be a unit root process. Equation (4.10) is the uncovered interest parity condition, and is assumed to hold due to perfect capital mobility. Equation (4.11) is a conventional money demand equation. Equation (4.12) expresses the evolution of money supply. For simplicity, it is assumed to follow a random walk. Finally, the model is closed with the goods and money market equilibrium, expressed in Equations (4.13)

---

<sup>13</sup> For the sake of simplicity, foreign prices are normalized to unity.

and (4.14), and is to be solved under the assumption of rational expectations.

To properly solve the model, we eliminate the interest rate from equation (4.8) and equation (4.11), and use equation (4.10) to obtain the following system:

$$\begin{bmatrix} \lambda & 1 \\ \gamma + \eta & -\gamma - \eta \end{bmatrix} \begin{bmatrix} s_t \\ p_t \end{bmatrix} = \begin{bmatrix} \lambda & 0 \\ \gamma & -\gamma \end{bmatrix} \begin{bmatrix} E_t s_{t+1} \\ E_t p_{t+1} \end{bmatrix} + \begin{bmatrix} m_t - \phi y_t \\ y_t - d_t \end{bmatrix} \quad (4.15)$$

The system can be rewritten in a compact form as  $AY_t = BE_t Y_{t+1} + W_t$ , or,  $Y_t = \Pi E_t Y_{t+1} + CW$ , where  $C = A^{-1}$  and  $\Pi = A^{-1}B$ . The eigenvalues of matrix  $\Pi$  are  $\{\lambda/(1+\lambda), \gamma/(\gamma+\eta)\}$ , which are both within the unit circle for finite values of the parameters; hence the forward looking solution is convergent. The forward looking solution to the system in (4.15) is

$$Y_t = C \sum \Pi^i E_t W_{t+i} \quad (4.16)$$

Given the stochastic processes for the exogenous variables, it is clear that  $E_t W_{t+i} = W_t$  for  $i=1,2,3...$ . The forward looking solutions for the nominal exchange rate, the price level, and the real exchange rate in terms of the exogenous variables are:

$$s_t = m_t - \phi y_t + 1/\eta(y_t - d_t) \quad (4.17)$$

$$p_t = m_t - \phi y_t \quad (4.18)$$

$$s_t - p_t = 1/\eta(y_t - d_t) \quad (4.19)$$

The observed movements in the vector of variables  $X_t = [y_t^{EU} \ y_t \ (s_t - p_t) \ p_t]'$  are due to four mutually uncorrelated "structural" shocks with finite variance,  $\varepsilon_t = [\varepsilon_t^{EU} \ \varepsilon_t^s \ \varepsilon_t^d \ \varepsilon_t^m]$ . They

are Eurozone output shocks,  $\varepsilon_t^{EU}$  ; domestic supply shocks,  $\varepsilon_t^s$  ; aggregate demand shocks,  $\varepsilon_t^d$  ; and money supply shocks,  $\varepsilon_t^m$  , respectively.

It can be shown the long-run impact of the structural shocks on the endogenous variables has a peculiar structure that is useful in identifying the shocks. To indicate the long run effect of structural shocks,  $\varepsilon_t$  , on  $X_t$  , we transform the solution to a model in first differences:

$$\Delta y_t^{EU} = \varepsilon_t^{EU} \quad (4.20)$$

$$\Delta y_t = \theta \varepsilon_t^{EU} + \varepsilon_t^s \quad (4.21)$$

$$\Delta(s_t - p_t) = 1/\eta(\theta \varepsilon_t^{EU} + \varepsilon_t^s) - (1/\eta)\varepsilon_t^d \quad (4.22)$$

$$\Delta p_t = -\phi(\theta \varepsilon_t^{EU} + \varepsilon_t^s) + \varepsilon_t^m \quad (4.23)$$

It can be written as an infinite moving average representation in the structural shocks:

$$\begin{bmatrix} \Delta y_t^{EU} \\ \Delta y_t \\ \Delta(s_t - p_t) \\ \Delta p_t \end{bmatrix} = \begin{bmatrix} a_{11}(L) & a_{12}(L) & a_{13}(L) & a_{14}(L) \\ a_{21}(L) & a_{22}(L) & a_{23}(L) & a_{24}(L) \\ a_{31}(L) & a_{32}(L) & a_{33}(L) & a_{34}(L) \\ a_{41}(L) & a_{42}(L) & a_{43}(L) & a_{44}(L) \end{bmatrix} \begin{bmatrix} \varepsilon_t^{EU} \\ \varepsilon_t^s \\ \varepsilon_t^d \\ \varepsilon_t^m \end{bmatrix} \quad (4.24)$$

where  $a_{ij}(L)$  is an infinite polynomial in the lag operator  $L$  . Equation (4.24) can be equivalently expressed as:

$$\Delta X_t = \sum_{i=1}^{\infty} A_i \varepsilon_{t-i} = A(L) \varepsilon_t \quad (4.25)$$

Here,  $A(L)$  is a matrix whose elements are  $a_{ij}(L)$  . The time path of the effects of a shock in  $\varepsilon_j$  on variable  $i$  after  $k$  periods can be denoted  $\omega_{ij}(k)$  . In addition, we denote  $A(1)$  to be the matrix of long run effects



with elements  $a_{ij}(1)$ , where  $a_{ij}(1) = \sum_{k=0} \omega_{ij}(k)$  gives the cumulative response of variable  $i$  to shock  $\varepsilon_j$  over time. Similarly,  $A(0)$  is the matrix of the contemporaneous effects and consist of  $\omega_{ij}(0)$ .

To appropriately identify these structural shocks, we estimate the following reduced form VAR:

$$\Delta X_t = B_1 \Delta X_{t-1} + B_2 \Delta X_{t-2} + \dots + B_p \Delta X_{t-p} + e_t \quad (4.26)$$

where  $e_t$  is a vector of reduced form (composite) shocks, and  $B_i, i = 1, 2, \dots, p$  is the coefficient of autoregressor  $\Delta X_{t-i}$ . The variance-covariance matrix of  $e_t$  is given by:

$$E(e_t e_t') = \begin{bmatrix} \sigma_{11} & \sigma_{12} & \sigma_{13} & \sigma_{14} \\ \sigma_{21} & \sigma_{22} & \sigma_{23} & \sigma_{24} \\ \sigma_{31} & \sigma_{32} & \sigma_{33} & \sigma_{34} \\ \sigma_{41} & \sigma_{42} & \sigma_{43} & \sigma_{44} \end{bmatrix} = \Sigma \quad (4.27)$$

Given that  $\Delta X_t$  is stationary, it can be inverted to get the infinite moving average process in reduced form (composite) disturbance:

$$\Delta X_t = e_t + C_1 e_{t-1} + C_2 e_{t-2} + \dots = \sum_{i=1} C_i e_{t-i} = C(L) e_t \quad (4.28)$$

Since the relationship between composite innovations,  $e_t$ , and pure innovations,  $\varepsilon_t$ , is:

$$e_t = A(0)^{-1} \varepsilon_t \quad (4.29)$$

From equation (4.25) and (4.28), one can write:

$$C_1 \sum C(1)' = A(1) A(1)' \quad (4.30)$$

$A(1)$  can be obtained as the Choleski factor of  $C_1 \sum C(1)'$ .

Therefore,

$$A(0) = C(1)^{-1} A(1) \quad (4.31)$$

The objective of identification is to determine the 16 elements of  $A(0)$  (i.e.,  $4 \times 4$  symmetric matrix). Given the model structure above, the long run effect of the shocks on the system is

$$\begin{bmatrix} \Delta y_t^{EU} \\ \Delta y_t \\ \Delta(s_t - p_t) \\ \Delta p_t \end{bmatrix} = \begin{bmatrix} a_{11}(L) & 0 & 0 & 0 \\ a_{21}(L) & a_{22}(L) & 0 & 0 \\ a_{31}(L) & a_{32}(L) & a_{33}(L) & 0 \\ a_{41}(L) & a_{42}(L) & 0 & a_{44}(L) \end{bmatrix} \begin{bmatrix} \varepsilon_t^{EU} \\ \varepsilon_t^s \\ \varepsilon_t^d \\ \varepsilon_t^m \end{bmatrix} \quad (4.32)$$

Note that the matrix of long run effects is a lower triangular. Moreover, the long run effect of aggregate demand shocks on the price level is zero (i.e.,  $a_{43}(1) = 0$ ). Given the restrictions embedded in the variance-covariance matrix, the system in (4.32) provides seven restrictions toward identification in total, which means the system is overidentified.

#### 4.3.4 Estimation of the VAR System

There are two steps in the estimation of our structural VAR model, as suggested in Sims (1986) and exemplified in Canova (1991). The first step is the estimation of the VAR system by OLS; where the error term  $e_t$ , the variance-covariance matrix  $\Sigma$ , and the coefficients in  $B(L)$  are estimated for use as information in the second step. The second step involves using the estimated  $\Sigma$  from the first step as data to estimate the  $A_0$  matrix. This is achieved through maximum likelihood estimation, where the log likelihood function in terms of the VAR representation starts out as:

$$l(\theta) = -\frac{Tn}{2} \log(2\pi) - \frac{T}{2} (\log|\Sigma|) - \frac{1}{2} \sum_{t=1}^T [(B(L)Y_t - b_0)' \Sigma^{-1} (B(L)Y_t - b_0)] \quad (4.33)$$

where substitution and algebraic manipulation leads to:

$$l(A_0, \Omega) = -\frac{Tn}{2} \log(2\pi) - \frac{T}{2} (\log|A_0^{-1} \Omega A_0^{-1}|) - \frac{1}{2} \sum_{t=1}^T \hat{e}_t' A_0 \Omega A_0' \hat{e}_t, \quad (4.34)$$

where  $\hat{e}$  is the vector of error terms derived from the first step. With further substitution, the log likelihood function (excluding constants) to maximize is written as (see Hamilton (1994 pg 331-332):

$$l(A_0, \Omega) = -\frac{T}{2} \log|A_0|^2 - \frac{T}{2} \log|\Omega| - \frac{T}{2} \text{trace}(A_0 \Omega^{-1} A_0' \hat{\Sigma}) \quad (4.35)$$

where its maximization produces estimates of  $A_0$  and  $\Omega$  that satisfy

(due to Equation (4.29))  $\hat{\Sigma} = \hat{A}_0^{-1} \hat{\Omega} \hat{A}_0^{-1'}$  as best as possible. This last step requires solving a system of nonlinear equations and is computationally expensive.

### 4.3.5 Forecast Error Variance Decompositions

One can conduct VAR analysis by examining variance decompositions, which are derived from the moving average representation. Variance decompositions quantitatively show us the breakdown of the variation in the system attributed to the different shocks in the system. Results from these variance decompositions provide a comparison of which shocks play a more prominent role in affecting the variables in the system. These variance decompositions are computed in terms of in-sample forecast errors of the variables in the system. Hence, the occasional use of the term—forecast error



variance decomposition—in the VAR literature. To illustrate, we let our forecast of  $Y_t$  at time  $t-s$  be denoted as  $E_{t-s}(Y_t)$ . Since we do not have any information about the future, this forecast will only be based on all the current and past information available at that time. The forecast will be based on all the current and past shocks and algebraically, this can be written as:

$$E_{t-s}(Y_t) = \delta'_0 + \sum_{p=0}^{\infty} D_{t-s-p} \mathcal{E}_{t-s-p} \quad (4.36)$$

where  $\delta'_0$  is the forecast of the constant term made at time  $t-s$ . So at time  $t$ , the forecast error would be:

$$Y_t - E_{t-s}(Y_t) = \delta_1 + \sum_{p=0}^{\infty} D_p \mathcal{E}_{t-p} - \sum_{p=0}^{\infty} D_{t-s-p} \mathcal{E}_{t-s-p} = \sum_{p=0}^{s-1} D_p \mathcal{E}_{t-p} \quad (4.37)$$

where  $\delta_1 = \delta_0 - \delta'_0$  and the forecast error variance for the system will be:

$$E[Y_t - E_{t-s}(Y_t)]E[Y_t - E_{t-s}(Y_t)]' = \sum_{p=0}^{s-1} D_p \Omega (D_p)' \quad (4.38)$$

So for a certain  $i$ th variable in the system, we can write its overall forecast error variance as:

$$E[Y_{it} - E_{t-s}(Y_{it})] = \sum_{j=0}^n \left[ \sigma_j^2 \sum_{p=0}^{s-1} (d_{ij,p})^2 \right] \quad (4.39)$$

where  $n$  is the number of variables in the system,  $\sigma_j^2$  is the variance for the  $j$ -th shock ( $j=1\dots n$ ), and  $d_{ij,p}$  is the  $ij$  element in  $D_p$ . One can notice that the covariances of the shocks are not included in the above equation. This is because we had earlier assumed the shocks to be uncorrelated, so  $\Omega$  is restricted to be diagonal and hence, no covariances appear in the variance equation. Such a construction in a

way provides benefit because we are now able to separate the overall forecast error variances for any variable into components attributable to the various shocks in the system. So, for any variable  $Y_{it}$  at some horizon  $s$ , we are able to distinguish the importance of say, the  $h$ -th shock ( $\varepsilon_{ht}$ ), when we factor out its forecast error variance and subsequently dividing it by the overall forecast error variances. This yields the variance decomposition that can be written as:

$$\frac{\left[ \sigma_h^2 \sum_{p=0}^{s-1} (d_{ih,p})^2 \right]}{\sum_{j=1}^n \left[ \sigma_j^2 \sum_{p=0}^{s-1} (d_{ij,p})^2 \right]} * 100 \quad (4.40)$$

, also known as innovation accounting, variance decompositions are normally reported at different time horizons in percentage form.

## 4.4 Data Analysis and Empirical Results

### 4.4.1 Variables and Data Sources

Data are mainly collected from the International Financial Statistics issued by the IMF and Data-stream database in this study. We acquired monthly data starting from the onset of the inflation targeting period to 2005: 06 for the three CEE countries. We believe that by isolating the inflation targeting period, the major structural shifts in the stabilization policy of the government would not affect our analysis much, and hence the expected response of the exchange rate to different shocks can be observed easily.

In our model, in addition to the industrial production, the consumer price indices obtained from the IMF database and the real exchange

rates vis-à-vis Euro derived from Data-stream database, we construct the regional income as the weighted Euro-area industrial production with the six EU countries as in Essay 1. All variables are first seasonally adjusted and then transformed to logarithms format.

4.4.2 Empirical Results

Since the inflation target periods for all countries are quite short, we do not consider possible cointegration between the variables. We conduct unit root tests for the industrial production, prices and exchange rates in level and first difference. Similar to the results in previous essays, the tests strongly indicate that the level variables are non-stationary, while the first difference variables are all stationary. Therefore, we proceed to use the first difference form in our VAR model.

	step	$\varepsilon_t^{EU}$	$\varepsilon_t^s$	$\varepsilon_t^d$	$\varepsilon_t^m$
Czech Rep.	1	24.1	56.4	13	6.5
	6	32.3	47.2	13.5	7.0
	12	38.6	40.3	14	7.1
	24	39.1	38.9	14.8	7.2
	36	39.2	38.9	14.7	7.2
Hungary	1	8.1	72.8	11.4	7.7
	6	16.7	59.6	10.8	12.9
	12	22.4	53.4	10.6	13.6
	24	23.2	52.1	10.4	14.3
	36	23.3	51.7	10.4	14.6
Poland	1	7.0	76.1	10.7	6.2
	6	15.3	64.9	7.8	12
	12	16.6	63.0	6.9	13.5
	24	16.7	62.7	6.7	13.9
	36	16.7	62.8	6.6	13.9

Table 4-1 Proportion of the forecast error in domestic output growth (in percentage)  
 $\varepsilon^{EU}$  : EU shock;  $\varepsilon_{st}$  : Supply shock;  $\varepsilon_{dt}$  : Demand shock;  $\varepsilon_{nt}$  : Nominal shock.

Tables 4.1 and 4.2 indicate that the first-difference forecast error variance decomposition for the domestic output growth and real



exchange rate vis-à-vis Euro. They are reported at 1, 6, 12, 24, and 36-step forecasting horizons. We focus on these two variables only because they are sufficient to answer the question that we are interested in, i.e., whether joining EMU results in significant cost from an economic shock point of view.

Generally speaking, the larger the Eurozone shock (symmetric shock,  $\varepsilon_t^{EU}$ ), the more correlations between the country and the currency union. From Table 4-1, we can observe all the three country's domestic output growths are largely explained by its own shocks ( $\varepsilon_t^s$ ). However, at the same time, the regional Eurozone shocks for these countries are non-negligible, especially for the Czech Republic. As a result, adopting the Euro would not result in significant cost and hence it is appropriate for these CEE countries to join the EMU as early as possible.

	step	$\varepsilon_t^{EU}$	$\varepsilon_t^s$	$\varepsilon_t^d$	$\varepsilon_t^m$
Czech Rep.	1	2.6	9.8	69.8	17.8
	6	4.9	10.3	63.9	20.9
	12	5.6	10.6	61.6	22.2
	24	5.8	10.7	61.2	22.3
	36	5.8	10.7	60.8	22.7
Hungary	1	5.1	7.1	60.0	27.8
	6	8.9	6.8	58.4	25.9
	12	13.2	6.6	57.6	22.6
	24	13.4	6.5	57.4	22.7
	36	13.5	6.5	57.4	22.6
Poland	1	3.8	9.6	78.3	8.3
	6	4.4	9.8	75.6	10.2
	12	4.8	9.8	73.2	12.2
	24	4.9	9.9	72.8	12.4
	36	5.0	9.9	72.6	12.5

Table 4-2 Proportion of the forecast error in real exchange rates vis-à-vis Euro (in percentage)

$\varepsilon^{EU}$  : EU shock;  $\varepsilon_{st}$  : Supply shock;  $\varepsilon_{dt}$  : Demand shock;  $\varepsilon_{nt}$  : Nominal shock.

From Table 4-2, we can observe that the most important shocks in explaining the variance decomposition of exchange rate fluctuations is the self-driven real demand shocks ( $\varepsilon_t^d$ ), which is different from the one in explaining the variance decomposition of output growth, as shown in Table 4-1. This means, the exchange rate does not behave as an important economic shock absorber for the three CEE countries. In addition, the exchange rate itself may be actually an important independent source of shocks, when the nominal shock is relatively high in explaining the variance decomposition of exchange rate fluctuations. This is the case for the Czech Republic and Hungary.

## 4.5 Summary

According to the OCA theory, one of the most significant potential costs for a country joining a monetary union is the loss of its independent monetary policy and hence the loss of a flexible exchange rate as an important asymmetric shock absorber. After discussing the potential benefits of joining the EMU in terms of the benefits for the exports of the CEE countries in the previous two essays, in this essay, we examine the EMU-entry problem from the cost perspective. That is, we utilize the VAR model to show whether exchange rate actually behaves as a significant shock absorber for the three CEE ERM-outsiders. This will, again, give the implications on whether these countries should hasten their process of adopting the Euro.

The well-known structured VAR approach is utilized in our study.

Different from the other studies, however, in our VAR model, we not only analyze the contributions of the different sources to the fluctuations of real exchange rate, but also try to figure out the importance of the Eurozone shocks on these CEE economies. We include four variables in our model: the EU growth rate, the CEE growth rate, the CEE inflation rate and the CEE exchange rates vis-à-vis Euro. Finally, we derive our long-run restrictions from the AS-AD model and embed them in the structural VAR framework.

Our empirical results show that nominal shocks play non-negligible roles in explaining the exchange rate fluctuations for the three CEE ERM-outsiders, which means the exchange rate does not behave as an important economic shock absorber. In addition, our results also show the significant impact of the Eurozone shocks on these CEE economies. Based on the above findings, we can conclude that joining the EMU would not incur large cost for these CEE economies even when facing asymmetric economic shocks.



## 5. Conclusion

After joining the EU in May 2004, the eight CEE countries face the immediate decisions whether they should join the EMU as soon as possible. Although they do not have the “opt-out” option as Denmark and the United Kingdom, they have the full power to decide whether to increase their effort to fulfill the Maastricht Criteria based on their judgments on the benefits and costs to adopt the *euro*. While Estonia, Latvia, Lithuania, Slovakia, and Slovenia have already joined the ERM II scheme and work for stepping into the Eurozone steadily, the Czech Republic, Hungary and Poland seem to be still in the “hesitant” mood. This dissertation thus explores this interesting and relevant topic that analyzes the benefits and costs of EMU-entry for these three key CEE economies that are still ERM-outsiders.

Three empirical studies are conducted in this dissertation. Since entering the EMU eliminates the exchange rate volatility between the CEE economies and the Eurozone as well as the exchange rate volatility among CEE countries, Essay 1 and Essay 2 studied the impact of the exchange rate volatility on the exports of the CEE economies to the Eurozone and the trade among CEE countries, respectively. At the same time, according to the OCA theory, one of the most important potential costs for joining the Eurozone is the loss of a flexible exchange rate acting as an asymmetric shock absorber. Therefore, in Essay 3, we examined the relationship between the exchange rate and asymmetric economic shocks for the CEE economies from the cost perspective.

In the first essay, the Johansen's multivariate co-integration method

and the constrained error correction model are employed to investigate the relationship between the exports from the three CEE ERM-outsiders to the Eurozone and exchange rate volatility, in both the short run and the long run. Unlike many other studies that assume the relationship is stable, we have also applied Hansen's stability tests in our study. Based on our empirical results, the variables have strong cointegration relationships in all the three countries over the sample period, which means that the macroeconomic variables are not drifted far apart in the long run and hence is very likely to be dependent on each other. We have also found that the Eurozone real incomes have a large impact on the real exports from the three CEE countries. What's more, the relationship between real exports and exchange rate volatility of the CEE countries is generally negative and statistically significant in both the short run and the long run. Therefore, the entry into EMU is beneficial for the three CEE countries that are still ERM-outsiders based on the effects on their exports to the Eurozone.

In the second essay, we have employed the classical gravity model to study the effect of the exchange rate volatility on the intra-CEE trade. Unlike many other studies that assume the stationarity of the panel data, we have used the recently-developed panel unit root tests and panel cointegration tests to detect whether the panel data are stationary and whether there is long run relationship between these non-stationary data. We then apply dynamic OLS in our study to estimate the parameter in the gravity model. Based on our empirical results, the exchange rate volatility exerts significant negative effects upon bilateral trade among

these CEE countries, which means that the future prospective membership of EMU also increases the trade volume among the CEE countries.

Finally, in our third essay, structural VAR models are utilized not only to analyze the contribution of different sources to the fluctuations of real exchange rate, but also to figure out the importance of the Eurozone shocks on the CEE economies. We have also derived our long-run restrictions from the AS-AD model and have embedded them in the structural VAR framework. According to our empirical results, the most important shock in explaining the variance decomposition of exchange rate fluctuations is different from the one in explaining the variance decomposition of output growth. In fact, nominal shocks play an important role in explaining the exchange rate fluctuations for the three CEE ERM-outsiders, which means the exchange rate does not behave as an important economic shock absorber. We also found non-negligible impacts of the Eurozone shocks on these CEE economies. Therefore, the adoption of the *euro* would not pose substantial economic problems for the Czech Republic, Hungary and Poland.

Based on the above three essays, for the three CEE ERM-outsiders, the benefits of joining the Eurozone are significant, while the costs of joining it are not obvious. Therefore, we conclude that these countries should increase their efforts to join the ERMII first and then work hard to meet the Maastricht convergence criteria so that they can become member states of the Eurozone at an earlier date.



## Reference

- Aitken, N. (1973) "The Effect of the EEC and EFTA on European Trade: A Temporal Cross-section Analysis" *American Economic Review* 63, 881-892.
- Akhtar, M.A. and H.R. Spence (1984) "Effects of Exchange Rate Uncertainty on German and U.S. Trade" *Federal Reserve Bank of New York Quarterly Review* 9, 7-16
- Anderson, J.E. (1979) "A Theoretical Foundation for the Gravity Equation" *American Economic Review* 69, 106-116
- Anderson, James and Eric van Wincoop (2001) "Gravity with Gravitas: A Solution to the Border Puzzle" *NBER working paper* No.8079 Cambridge, MA.
- Aristotelous, K. (2001) "Exchange Rate Volatility, Exchange Rate Regime, and Trade Volume: Evidence from the UK-US Export Function (1889-1999)" *Economic Letters* 72, 87-94
- Arize, A.C. (1990) "An Econometric Investigation of Export Behavior in Seven Asian Developing Economies" *Applied Economics* 22, 891-904.
- Arize, A.C. (1995) "The Effects of Exchange Rate Volatility on U.S. Exports: An Empirical Investigation" *Southern Economic Journal* 62, 34-43
- Arize, A.C., T. Osang and D.J. Slottje (2000) "Exchange Rate Volatility and Foreign Trade: Evidence from Thirteen LDCs" *Journal of Business & Economic Statistics* 18, 10-17
- Asseery, A. and D.A. Peel (1991) "The Effects of Exchange Rate Volatility on Exports: Some New Estimates" *Economic Letters* 37, 173-177
- Artis, M. and M. Ehrmann (2000) "The Exchange Rate – A Shock Absorber or Source of Shocks? A Study of Four Open Economies" *CEPR Discussion Papers*, 2550.
- Astley, M.S. and A. Garratt (1998) "Exchange Rates and Prices: Sources of Sterling Real Exchange Rate Fluctuations 1973-94" *Bank of England. Working Paper No. 85*
- Baak, S. (2004) "Exchange Rate Volatility and Trade among the Asia Pacific Countries" *Econometric Society 2004 Far Eastern Meetings* 724, Econometric Society
- Bailey, M.J., G.S. Tavlas and M. Ulan (1987) "The Impact of Exchange

Rate Volatility on Export Growth: Some Theoretical Considerations and Empirical Results" *Journal of policy modeling* 9, 225-243

Balcerowicz, L. (2002) "The Way to EMU from a Candidate Country's Perspective" in Latschet, A. and F. Plüger eds., *Der Euro und Europa*

Baldwin, R. (1993) "Comment on Bagwatti" in Jaime De Melo and Arvind Panagariya eds., *New Dimensions in Regional Integration*, 52-53

Baltagi, B.H. and C. Kao (2000) "Nonstationary Panels, Cointegration in Panels and Dynamic Panels: A Survey" in B.H. Baltagi ed., *Nonstationary Panels, Panel Cointegration, and Dynamic Panels, Advances in econometrics* 15, 7-52

Banerjee, A. (1999) "Panel Data Unit Roots and Cointegration: An Overview" *Oxford Bulletin of Economics and Statistics* 61, 607-629

Barkoulas, J., Christopher F. B. and Mustafa C. (2002), "Exchange Rate Effects on the Volume and Variability of Trade Flows" *Journal of International Money and Finance*, 21, 481-496.

Baron, D.P. (1976), "Fluctuating Exchange Rates and Pricing of Exports" *Economic Inquiry*, 14, 425-438.

Baxter, M., and A.C. Stockman (1989) "Business Cycles and the Exchange Rate Regime" *Journal of Monetary Economics* 23, 377-400

Bayoumi, T. (1992) "The Effects of the ERM on Participating Economies", *IMF Staff Paper*, No. 39

Bayoumi, T. and B. Eichengreen (1993) "Shocking Aspects of European Monetary Integration" in Giavazzi, F. and F. Torres eds., *Growth and Adjustment in the European Monetary Union*, Cambridge University Press.

Bayoumi, T. and B. Eichengreen (1994) "Macroeconomic Adjustment under Bretton Woods and the Post-Bretton Woods Float: An Impulse Response Analysis" *Economic Journal* 104, 813-827

Bayoumi, T. and B. Eichengreen (1995) "Is Regionalism Simply a Diversion? Evidence from the EC and EFTA" *NBER Working Paper* No.5283, Cambridge, MA

Bergstrand, J.H. (1985) "The Gravity Equation in International Trade: Some Microeconomic Foundations and Empirical Evidence" *Review of Economics and Statistics* 67, 474-481.

Bergstrand, J.H. (1989) "The Generalized Gravity Equation, Monopolistic Competition, and the Factor-Proportions Theory in International Trade" *Review of Economics and Statistics* 71, 143-153.



Bernanke, B. (1986) "Alternative Explanations of the Money-Income Correlation" *Carnegie-Rochester Conference Series on Public Policy* 25, 49-99

Bini-Smaghi, L. (1991) "Exchange Rate Variability and Trade: Why Is It So Difficult to Find Any Empirical Relationship?" *Applied Economics* 23, 927-935.

Blanchard, J.O. and D. Quah (1989) "The Dynamic Effects of Aggregate Demand and Supply Disturbances" *American Economic Review* 7, 655-673

Bollerslev, T., R.Y. Chou, and K.F. Kroner (1992) "ARCH Modeling in Finance: A Review of the Theory and Empirical Evidence" *Journal of Econometrics* 52, 5-59

Bollerslev, T. (1986) "Generalized Autoregressive Conditional Heteroskedasticity" *Journal of Econometrics* 31, 307-327

Boreiko, D. (2002) "EMU and Accession Countries: Fuzzy Cluster Analysis of Membership" *Working Paper* No. 71. Oesterreichische Nationalbank, Vienna.

Bredin, D. and G.O' Reilly (2001) "An Analysis of the Transmission Mechanism of Monetary Policy in Ireland" Central Bank of Ireland, Technical Paper 1/RT/01

Broll, U. and B. Eckwert (1999) "Exchange Rate Volatility and International Trade" *Southern Economic Journal* 66, 178-185.

Brischetto, A. and G. Voss (1999) "A Structural Vector Autoregression Model of Monetary Policy in Australia" *Reserve Bank of Australia, Research Discussion Paper* 1999-11

Buiter, W. (2000) "Optimum Currency Areas" *Scottish Journal of Political Economy* 47, 213-250.

Buiter, W. and C. Grafe (2002) "Anchor, Float or Abandon Ship: Exchange Rate Regimes for Accession Countries" *CEPR Discussion Series*, No. 3184

Bailey, M.J., G.S. Tavlas and M. Ulan (1986) "Exchange Rate Variability and Trade Performance: Evidence from the Big Seven Industrial Countries" *Weltwirtschaftliches Archive* 122, 466-477.

Caballero, R. and Corbo V. (1989) "The Effect of Real Exchange Rate Uncertainty on Exports: Empirical Evidence," *World Bank Economic Review* 3(2), 263-278.

Calrida, R. and J. Gali (1994) "Sources of Real Exchange Rate



Fluctuations: How Important Are Nominal Shocks?" *NBER Working Paper* No. 4658.

Calvo G.A. and C.M. Reinhart (2000) "Fear of Floating" *NBER Working Paper* No 7993.

Campos, Nauro F., Coricelli, Fabrizio (2002) "Growth in Transition: What We Know, What We Don't, and What We Should." *Journal of Economic Literature* XL, 793-836.

Cazes, S. (2002): "Do Labour Market Institutions Matter in Transition Economies? An Analysis of Labour Market Flexibility in the Late Nineties", , *International Institute for Labour Studies Discussion paper* No. 140.

Cazoneri, B.M., J. Valles and J. Vinals (1996) "Do Exchange Rates Move to Address International Macroeconomic Imbalance?" *Centre for Economic policy research, Discussion Paper* No. 1498

Centre for European Policy Studies (2002): "The Euro at 25: Special Report of the CEPS Macroeconomic Policy Group", Brussels.

Chadha, B., and E. Prasad (1997) "Real Exchange Rate Fluctuations and the Business Cycle" *IMF staff papers*, 44(3), 328-355

Chen, I-H. and H.J. Wall (1999) "Controlling for Heterogeneity in Gravity Models of Trade" *Federal Reserve Bank of St. Louis Working Paper* 1999.

Cheung, Y.W., and K. S. Lai (1993) "Finite-Sample Sizes of Johansen's Likelihood Ratio Tests for Cointegration" *Oxford Bulletin of Economics and Statistics* 55, 313-328

Chowdhury, A.R. (1993) "Does Exchange Rate Volatility Depress Trade Flows? Evidence from Error-Correction Model" *Review of Economics and Statistics* 75, 700-706

Clark, P. K. (1973) "A Subordinated Stochastic Process Model with Fixed Variance for Speculative Prices". *Econometrica* 41, 135--156.

Corden, W. (1972): "Monetary Integration", *Essays in International Finance*, No. 93, Princeton University.

Coricelli, F. (2002): "Exchange Rate Arrangements in Transition to EMU: Some Arguments in Favour of Early Adoption of the Euro", in Tumpel-Gugerell, G., L. Wolfe and P. Mooslechner eds., *Completing Transition: The Main Challenges*, 203-14.

Cote, A. (1994) "Exchange Rate Volatility and Trade: A Survey." *Working paper* 5, Bank of Canada.

Csajbók, A and Á Csermely (eds; 2002) "Adopting the Euro in Hungary: Expected Costs, Benefits and Timing", *MNB Occasional Papers* No. 24.

Cushman, D. O. (1983) "The Effects of Real Exchange Rate Risk on International Trade" *Journal of international economics* 15, 45-63

Cushman, D. O. (1988) "U.S. Bilateral Trade Flows and Exchange Risk during the Floating Period" *Journal of International Economics* 25, 317-330.

Cushman, D. O. (1986) "Has Exchange Risk Depressed International Trade? The Impact of Third Country Exchange Risk" *Journal of International Money and Finance* 5, 361-378

Davidson, R., and J. G. MacKinnon (1993) "Estimation and Inference in Econometrics" *Oxford University Press, New York*.

De Grauwe, P. (1988) "Exchange Rate Variability and the Slowdown in Growth of International Trade" *IMF staff papers* 35, 63-84

De Grauwe, P. and Y. Aksoy (1999): "Are Central European Countries Part of the European Optimum Currency Area?", in De Grauwe, P. and V. Lavrac eds., *Inclusion of Central European Countries in the European Monetary Union*, 13-36.

De Grauwe, P. and Costa Storti, Claudia (2004) "Effects of Monetary Policy: A Meta-analysis" *Working Paper* No. 1224. CESifo.

De Melo J. and J.M. Grether (1997) "Commerce Internationale, theories et applications" De Boeck Universite.

De Menil, G. and M. Maurel (1994) "Breaking Up a Customs Union: The Case of the Austro-Hungarian Empire in 1919" *Weltwirtschaftliches Archive* 130, 553-575

De Vita G. and Abbott A. J. (2004) "The Impact of Exchange Rate Volatility on UK Exports to EU Countries" *Scottish Journal of Political Economy* 51, 62-81

Deardorff, A. (1984) "Testing Trade Theories and Predicting Trade Flows" in Ronald Jones and Peter B. Kenen eds., *Handbook of international economics*, vol. 1, Amsterdam: Elsevier Science Publishers.

Deardorff, A. (1988) "Determinants of Bilateral Trade: Does Gravity Work in a Neoclassical World?" in Jeffrey Frankel, ed., *Regionalization of the World Economy*, University of Chicago Press.

Dell' Ariccia. G. (1999) "Exchange Rate Fluctuations and Trade Flows: Evidence from the European Union" *IMF staff papers* 46, 315-334



Dellas, H. and B. Ziberfarb (1993) "Real Exchange Volatility and International Trade: A Reexamination of the Theory" *Southern Economic Journal* 59, 641-647.

Dickey, D.A. and W. A. Fuller (1979) "Distribution of the Estimators for Autoregressive Time Series with a Unit Root" *Journal of the American Statistical Association* 74, 427-431

Dornbusch, R. (1976) "Expectations and Exchange Rate Dynamics," *Journal of Political Economy* 84, 1161-1176.

Doroodian, K (1999) "Does Exchange Rate Volatility Deter International Trade in Developing Countries?" *Journal of Asian Economics* 10, 465-474.

Eaton J. and A. Tamura (1993) "Bilateralism and Regionalism in Japanese and US Trade and Direct Foreign Investment Patterns" *NBER Working Paper No. 4758*. Cambridge, MA.

Egger, P. (2000) "A Note on the Proper Econometric Specification of the Gravity Equation" *Economic Letters* 66, 25-31.

Eichengreen, B. and D. A. Irwin (1995) "Trade Blocs, Currency Blocs and the Reorientation of Trade in the 1930's" *Journal of International Economics* 38, 1-24

Eichengreen, B. and D.A. Irwin (1998) "The Role of History in Bilateral Trade Flows" in Jeffrey Frankel ed., *Regionalization of the World Economy*, University of Chicago Press.

Engle, R. F. and C. W. J. Granger (1987) "Co-Integration and Error Correction: Representation, Estimation and Testing" *Econometrica* 55, 251-276

Engle, R.F., D.F. Hendry and J.-F. Richard (1983) "Exogeneity" *Econometrica* 51, 277-304

Engle, R. (1982) "Autoregressive Conditional Heteroscedasticity with Estimates of the Variance of United Kingdom Inflation" *Econometrica* 50, 987-1007.

Engel, C. and John H.R. (1996) "How Wide is the Border?" *American Economic Review* 86, 1112-1125

Ethier, W. (1973) "International Trade and the Forward Exchange Market" *American Economic Review* 63, 494-503

Eurostat (2003): "Minimum Wages, EU Member States and Candidate Countries, January 2003" *Statistics in Focus*, Theme 3



Fidrmuc, J. (2002): "Migration and Regional Adjustment to Asymmetric Shocks in Transition Economies", ZEI, University of Bonn, mimeo.

Fidrmuc J. and J. Fidrmuc (2003), "Disintegration and Trade" *Review of International Economics*, 11(5), 811-829.

Fidrmuc, J. and I. Korhonen (2003): "Similarity of Supply and Demand Shocks between the Euro Area and the CEECs", *Economic Systems* 27, 313-334.

Fidrmuc, J. (2004) "The Endogeneity of the Optimum Currency Area Criteria, Intra-Industry Trade, and EMU Enlargement," *Contemporary Economic Policy* 22 (1), 1-12.

Fountas, S. and Aristotelous, K. (2000) "Does the Exchange Rate Regime Affect Export Volume" Evidence from bilateral exports in the U.S.-U.K. trade: 1900-1998" *Working paper* No. 43. Ireland: Department of Economics, National University of Ireland.

Franke, G. (1991) "Exchange Rate Volatility and International Trading Strategy" *Journal of International Money and Finance* 10, 269-287.

Frankel, J. A. (1997) "Regional Trading Blocs" Institute for International Economics. Washington, D.C.

Frankel, J.A. and S.J. Wei (1993) "Trading Blocs and Currency Blocs" *NBER Working Paper* No. 4335.

Frankel, J.A. and S.J. Wei (1998) "Regionalization of World Trade and Currencies" in Jeffrey Frankel eds., *Regionalization of the World Economy*, University of Chicago Press.

Frankel, J., A. E. Stein and S.J. Wei (1995) "Trading Blocs and the Americas: the Natural, the Unnatural and the Super-Natural" *Journal of Development Economics* 47, 61-95

Frankel, J. and A. Rose (1998): "The Endogeneity of the Optimum Currency Area Criteria", *Economic Journal* 108, 1009-1025.

Frankel, J. and A. Rose (2000): "Estimating the Effect of Currency Unions on Trade and Output", *CEPR Discussion Paper* No. 2631.

Frankel, J. and A. Rose (2002) "An Estimate of the Effect of Common Currencies on Trade and Income" *Quarterly Journal of Economics* 117, 437-466

Frenkel, M. and C. Nickel (2002) "How Symmetric are the Shocks and the Shock Adjustment Dynamics between the Euro Area and Central and Eastern European Countries?" *Working Paper* No. 02/222, International

Monetary Fund, Washington D.C.

Frenkel, M., C. Nickel and G. Schmidt (1999) "Some Shocking Aspects of EMU Enlargement" *Deutsche Bank Research Note* 99-4

Fidrmuc, J. and I. Korhonen (2002) "Similarity of Supply and Demand Shocks between the Euro Area and the CEECs" *Bank of Finland mimeo*

Funke, M. (2000) "Macroeconomic Shocks in Euroland vs. the UK: Supply, Demand or Nominal?" *European University Institute, Working Paper* No. 2000/37

Gali, J. (1992) "How Well Does the IS-LM Model Fit Postwar U.S. Data?" *Quarterly Journal of Economics* 107, 709-38

Gerlach, S. and F. Smets (1995) "The Monetary Transmission Mechanism: Evidence from the G-7 Countries" in *Financial structure and the monetary policy transmission mechanism*, Bank for International Settlements

Giovannini, A. (1988) "Exchange Rate and Traded Goods Prices". *Journal of International Economics* 24, 45-68.

Glick, R. and A. Rose (2002) "Does a Currency Union Affect Trade? The Times-series Evidence" *European Economic Review* 46, 1125-1151

Gotur, P. (1985) "Effects of Exchange Rate Volatility on Trade: Some Further Evidence" *IMF Staff Papers* 32, 475-511.

Gonzalo, J. (1994) "Five Alternative Methods of Estimating Long-Run Equilibrium Relationships" *Journal of Econometrics* 60, 203-233

Granger, C. W. J. and P. Newbold (1974) "Spurious Regressions in Econometrics" *Journal of Econometrics* 2, 111-120

Granger, C. W. J. and P. Newbold (1997) "On Modeling the Long Run in Applied Economics" *The Economic Journal* 107, 169-177.

Greene, William H. (1997) *Econometric Analysis* Third Edition Prentice Hall.

Gruber W. H. and R. Vernon (1970) "The Technology Factor in a World Trade Matrix" in R. Vernon (eds): *The Technology Factor in International Trade: A Conference of the Universities – National Bureau Committee for Economic Research* 233-272

Hadri, K. (2000) "Testing for Stationarity in Heterogeneous Panel Data" *Econometric Journal* 3, 148-161



Hamilton, C.B. and A.L. Winters (1992) "Opening up International Trade with Eastern Europe" *Economic Policy* 14, 77-116.

Hansen, B.E. (1992a) "Testing for Parameter Instability in Linear Models" *Journal of Policy Modeling* 14, 517-533.

Hansen, B.E. (1992b) "Testing for Parameter Instability in Regressions with I(1) Processes" *Journal of Business and Economic Statistics* 10, 321-335.

Hassan, M.K and D. R. Tufté (1998) "Exchange Rate Volatility and Aggregate Export Growth in Bangladesh" *Applied Economics* 30, 189-201

Haug, Alfred A & Lucas, Robert F (1996). "Long-Run Money Demand in Canada: In Search of Stability," *The Review of Economics and Statistics*, 78(2), 345-48.

Helpman, E. and P. Krugman (1985) *Market Structure and Foreign Trade* Cambridge: MIT Press.

Hendry, D.F. (1995) *Dynamic Econometrics*, Oxford University Press

Hooper, P and S. Kohlhagen (1978) "The Effect of Exchange Rate Uncertainty on the Prices and Volume of International Trade" *Journal of International Economics* 8, 483-511

Im, K.S., M.H. Pesaran, and Y. Shin (1997) "Testing for Unit Roots in Heterogeneous Panels" *Discussion paper*, University of Cambridge, December

Ingram, J. (1973) "The Case for European Monetary Integration" *Essays in International Finance* No. 98, Princeton University

Johansen, S. (1988) "Statistical Analysis of Cointegration Vectors" *Journal of Economic Dynamics and Control* 12, 231-254

Johansen, S. (1991) "Estimation and Hypothesis Testing of Cointegrating Vectors in Gaussian Vector Autoregressive Models" *Econometrica* 59, 1551-1580

Johansen, S. (1992) "Determination of Cointegrated Rank in the Presence of a Linear Trend" *Oxford Bulletin of Economics and Statistics* 54, 383-397.

Johansen, S. and K. Juselius (1990) "Maximum Likelihood Estimation and Inference on Cointegration-with Applications to Demand for Demand" *Oxford Bulletin of Economics and Statistics* 52, 169-210.

Juselius, K. (1992) "Domestic and Foreign Effects on Prices in an Open



Economy: The Case of Denmark" *Journal of Policy Modelling*, 14 401-428

Kenen, P. (1969): "The Optimum Currency Area: An Eclectic View", in Mundell, R. and A. Swoboda eds., *Monetary Problems of the International Economy*, Chicago.

Kenen, P.T. and D. Rodrik (1986) "Measuring and Analyzing the Effects of Short-term Volatility in Real Exchange Rates" *Review of Economics and Statistics* 68, 311-315.

King, R., C. Plosser, J. Stock, and M. Watson (1991) "Stochastic Trends and Economic Fluctuations" *American Economic Review* 81, 819-840

Klaassen, F. (2002) "Improving GARCH Volatility Forecasts with Regime-Switching GARCH," *Empirical Economics* 27, 363-394

Koray, F. and W.D. Lastrapes (1989) "Real Exchange Rate Volatility and U.S. Bilateral Trade: A VAR Approach" *Review of Economics and Statistics* 71, 708-712.

Korhonen I. (2003) "Some Empirical Tests on the Integration of Economic Activity between the Euro Area and the Accession Countries," *The Economics of Transition* 11(1), 177-196

Kortum S. and J. Eaton (1997) "Technology and Bilateral Trade" *NBER Working Paper No. 6253* Cambridge, MA

Kröger, J. and D. Redonnet (2002): "Exchange Rate Regimes and Economic Integration: The Case of the Accession Countries", *CESifo Forum* 1, 6-13.

Krugman, P. (1993): "Lessons of Massachusetts for EMU", in Torres, F. and F. Giavazzi (eds): *Adjustment and Growth in the European Monetary Union*, 241-69.

Kutan, A., and S. Dibooglu (2001) "Sources of Real Exchange Rate Fluctuations in Transition Economies: Evidence from Hungary and Poland" *Journal of Comparative Economics* 29(2), 257-275

Lastrapes, W.D., (1992) "Sources of Fluctuations in Real and Nominal Exchange Rates" *Review of Economics and Statistics*, 530-539

Leamer, E. (1974) "The Commodity Composition of International Trade in Manufactures: An Empirical Analysis" *Oxford Economic Papers* 26, 350-374

Leamer, E. and J. Levinsohn (1995) "International Trade Theory: The Evidence" in Gene M. Grossman and Kenneth Rogoff, eds., *Handbook of international economics*, Vol. 3. Amsterdam: Elsevier Science

## Publishers.

Levin, A. and C.F. Lin (1992) "Unit Root Tests in Panel Data: Asymptotic and Finite Sample Properties" *Discussion paper* No. 92-93, Department of Economics, University of California at San Diego

Levin, A. and C.F. Lin (1993) "Unit Root Tests in Panel Data: New Results" *Discussion paper* No. 93-56, Department of Economics, University of California at San Diego

Levin, A., C. F. Lin and C-S J. Chu (2002) "Unit Root Tests in Panel Data: Asymptotic and Finite-Sample Properties" *Journal of Econometrics* 108, 1-24

Linnemann, H. (1966) *An Econometric Study of International Trade Flows*, Amsterdam: North-Holland

Lippi, M. and L. Reichlin (1993): "The Dynamic Effects of Aggregate Demand and Supply Disturbances: Comment", *American Economic Review*, 83, 644-652.

Lippi, M. and L. Reichlin (1994): "VAR Analysis, Nonfundamental Representations, Blaschke Matrices", *Journal of Econometrics* 63, 307-325

MacDonald, R. (1998) "What Do We Really Know about Real Exchange Rates" *Oesterreichische Nationalbank Working paper* 28

Mark, N. and D. Sul (1999) "A Computationally Simple Cointegration Vector Estimator for Panel Data", *manuscript*, Ohio State University.

Maurel, M. (2002): "On the Way to EMU Enlargement towards CEECs: What Is the Appropriate Exchange Rate Regime?" *CEPR Discussion Paper* No. 3409.

McKenzie, M.D. (1999) "The Impact of Exchange Rate Volatility of International Trade Flows" *Journal of Economic Survey* 13, 71-106.

McKinnon, R. (1963): "Optimum Currency Areas", *American Economic Review* 52, 717-25.

Medhora, R. (1990) "The Effect of Exchange Rate Variability on Trade: The Case of the West African Monetary Union's Imports" *World Development* 18, 313-324.

Melitz, J. (2001): "Geography, Trade and Currency Union", *CEPR Discussion Paper* No. 2987.

Mongelli, F. (2002): "New Views on the Optimum Currency Area Theory: What Is EMU Telling Us?" *ECB Working Paper* No. 138.



Mundell, R. (1961): "A Theory of Optimum Currency Areas", *American Economic Review* 51, 657-65.

Mundell, R.A., (1973a) "A Plan for a European Currency" in H.G. Johnson and A.K. Swoboda eds., *The Economics of Common Currencies*, London: Allen and Unwin, 143-172.

Mundell, R.A., (1973b) "Uncommon Arguments for common Currencies" in H.G. Johnson and A.K. Swoboda eds., *The Economics of Common Currencies*, London: Allen and Unwin, pp. 114-132.

Mundell, R. (2002): "Exchange Rate Arrangements in Central and Eastern Europe", in Austrian Ministry of Economic Affairs: *Eastern Enlargement: The Sooner, the Better?* Vienna.

Nguyen, D. T. (1989) "The Demand for LDC Exports of Manufactures: Estimates from Hong Kong: A Comment" *Economic Journal* 99, 461-466

Obstfeld, M. (1985), "Optimum Currency Areas and the Misalignment Problem", *Brookings Papers on Economic Activity*

Obstfeld, M. and K. Rogo (1996). *Foundations of International Macroeconomics*. Cambridge MA: MIT Press.

OECD (2003): "Labour Market and Social Policies in the Baltic Countries", April.

Oksuzler, O. (2003). "Exchange Rate Volatility and Trade Volume: The Turkish Case" *Doctoral dissertation*, George Mason University

Osterward-Lenum, M. (1992) "A Note with Quantiles of the Asymptotic Distributions of the Maximum Likelihood Cointegration Ranks Test Statistic: Four Cases" *Oxford Bulletin of Economics and Statistics* 54, 461-472.

Pedroni, P. (1999) "Critical Values for Cointegration Tests in Heterogeneous Panels with Multiple Regressors" *Oxford Bulletin of Economics and Statistics* 61, 653-670.

Pedroni, P. (2000) "Fully Modified OLS for Heterogeneous Cointegrated Panels" in Baltagi, B.H. ed., *Advances in Econometrics. Nonstationary Panels, Panel Cointegration, and Dynamic Panels* 15, New York: Elsevier Science, 93-130

Pedroni, P. (2001) "Purchasing Power Parity Tests in Cointegrated Panels" *Review of Economics and Statistics* 83, 727-731

Perre, E. and Steinherr, A. (1989) "Exchange Rate Uncertainty and Foreign Trade" *European Economic Review* 33, 1241-1264



Persson, T. (2001): "Currency Unions and Trade: How Large Is the Treatment Effect?" *Economic Policy* 33, 435-461

Poyhonen, P. (1963) "A Tentative Model for the Volume of Trade between Countries" *Weltwirtschaftliches Archive* 90, 93-99.

Pozo, S. (1992) "Conditional Exchange Rate Volatility and the Volume of International Trade: Evidence from the Early 1990s" *Review of Economics and Statistics* 74, 325-329

Ramos, R. and J. Suriñach (2004) "Shocking Aspects of European Enlargement" *Eastern European Economics* 42, 36-57.

Rose, A.K. (2000) "One Money, One Market: Estimating the Effect of Common Currencies on Trade", *Economic Policy* 30, 7-45

Rose, A. and E. van Wincoop (2001) "National Money as a Barrier to Trade: The Real Case for Currency Union", *American Economic Review* 91(2) 386-90

Sanso, M. Rogelio C. and F. Sanz (1993) "Bilateral Trade Flows, the Gravity Equation, and Functional Form" *Review of Economics and Statistics* 75, 266-275

Sapir, A. (1997) "Domino Effects in Western European Trade: 1960-92" *CEPR DP* No. 1576

Sauer, C. and A. K. Bohara (2001) "Exchange-Rate Volatility and Exports: Regional Differences between Developing and Industrialized Countries", *Review of International Economics* 9(1), 133-152.

Sercu, P. (1992) "Exchange Risk, Exposure, and the Option to Trade" *Journal of International Money and Finance* 1(8), 579-593.

Sercu, P. and Van Hulle, C. (1992) "Exchange Rate Volatility, International Trade, and the Value of Exporting Firms" *Journal of Banking and Finance* 16, 155-182.

Sercu, P. and R. Uppal, (1998) "Exchange Rate Volatility and International Trade : A Case for Agnosticism", in *Exchange Rate Volatility, Trade, Capital Flows, and Alternative Exchange Rate Regimes* Sanwa Foundation Monography in International Finance, Chp. 6.

Sercu, P., and Vanhulle, C. (1989) "Exchange Rate Volatility and International Trade: A Case for Agnosticism" Mimeo, University of British Columbia.

Sercu, P. and R. Uppal (2003) "Exchange Rate Volatility and International Trade in a General Equilibrium Economy" *European Economic Review* 47, 429-441.

Shapiro, M.D., and M.W. Watson (1988) "Sources of Business Cycle Fluctuations" in S. Fischer, ed., *NBER Macroeconomics Annua*, 111-156

Sims, C. (1980) "Macroeconomics and Reality" *Econometrica* 48, 1-47

Sims, C. (1986) "Are Forecasting Models Usable for Policy Analysis?" *Federal Reserve Bank of Minneapolis Quarterly Review* 10, 1-16

Sukkar, A. and Hassan, S. (2001). "US Exports and Time-varying Volatility of Real Exchange Rate" *Global Finance Journal* 12, 109-119

Suppel, R., (2003) "Economic Dynamics in EU Accession Countries: A Case for Exchange Rate Flexibility" *ECB mimeo*

Szapáry, G. (2002) "Is Maastricht Too Much for the Candidate Countries?" *Mimeo*.

Tavlas, G. (1994): "The Theory of Monetary Integration", *Open Economies Review* 5 (2), 211- 30.

UNECE (2002): *Economic Survey of Europe*, United Nations.

Thursby, M.C. and J.G. Thursby "Bilateral Trade Flows, Linder Hypothesis, and Exchange Risk" *Review of Economics and Statistics* 69, 488-495

Timbergen, J. (1962) "Shaping the World Economy" New York: Twentieth Century Fund.

Viaene, J.M. and C. G. de Vries (1992) "International Trade and Volatility" *European Economic Review* 36, 1311-1321.

Wang Z.K. and L.A. Winters (1992) "The Trading Potential of Eastern Europe" *Journal of Economic Integration* 7, 113-136

Weliwita A., E.M. Ekanayake, and H. Tsujii (1999) "Real Exchange Rate Volatility and Sri Lanka's Exports to the Developed Countries, 1978-96" *Journal of Economic Development* 24, pp. 147-165.

West, K.D., H. J. Edison and D. Cho (1993) "A Utility Based Comparison of Some Models of Exchange Rate Volatility" *Journal of International Economics* 35, 23-45.