CHARLES UNIVERSITY IN PRAGUE

FACULTY OF SOCIAL SCIENCES

Institute for Economic Studies

Doctoral thesis

Measuring Financial Market Perception of Economic and Monetary Union Enlargement

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Academic Year: **2010/2011**

UNIVERZITA KARLOVA V PRAZE

FAKULTA SOCIÁLNÍCH VĚD

Institut ekonomických studií

Disertační práce

Jak vnímají finanční trhy rozšíření Hospodářské a měnové unie?

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Akademický rok: **2010/2011**

Declaration of Authorship

I hereby declare that I compiled this thesis independently, using only the listed resources and literature.

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ACKNOWLEDGEMENTS

First and foremost, I am very grateful to my advisor, Doc. Tomáš Holub. Without his enthusiasm, guidance and support, I could not have kept going with my research for all these years while working intensively at the Czech National Bank, European Central Bank, and the European Commission. I also want to thank my other dissertation committee members, Doc. Oldřich Dědek, Prof. Kateřina Šmídková and Dr. Jarko Fidrmuc, for their interest in my work and their insightful comments.

During my years at the Czech National Bank and European Central Bank, I encountered friends and colleagues who have generously shared their time and knowledge with me: many thanks to all of you! In particular, I am indebted to Viktor Kotlán for the initial impetus in getting this study started and to Martin Cincibuch for his contribution with respect to one of the methods developed and applied in this thesis, whose underlying model is published together with him.

I highly appreciate the efforts of Prof. Pavel Šandera, Jana Procházková, Dana Hájková for getting this thesis structured and printed. Finally, I want to thank my parents and Dominic von Terzi from the bottom of my heart: my parents, because without their continuous love and support none of this would have ever happened, and Dominic not only for his crucial questions and thoughtful comments that made this a better thesis, but most of all for having been a tremendous source of moral support in difficult times.

ABSTRACT

This thesis deals with assessing how financial markets perceive prospects of future euro area enlargement. Market views on such an enlargement are measured using two different approaches. The first approach, the static probability calculators method (SPC), is based on an existing method that was previously used for the old EU Member States. In order to overcome inherent shortcomings of this method, a second, completely new methodology with an indicator that is based on short-term dynamics of forward spreads was developed, further referred to as dynamic probability calculators (DPC). Both the SPC and DPC are applied to data from four Central Eastern European countries: the Czech Republic, Hungary, Poland, and Slovakia. In addition, data of other European countries were used to assess the robustness of the two approaches.

The new methodology is conceptually based on the notion of ambiguity-averse agents. Specifically, it attempts to apply the framework of incomplete preferences, developing a general equilibrium framework, which allows for multiple equilibria supported by one set of fundamentals. This equilibrium indeterminacy offers a way to reconcile short-term fluctuations of market prices with a relatively stable underlying economic environment and expectations.

The thesis concludes with a comparison of the results of the two methods with financial market opinion surveys. Their similarity with national euro adoption strategies as well as compatibility with the obtained estimations provides an understanding of a degree of transparency and communication effectiveness by national authorities with the public.

Keywords: euro adoption, monetary unions, EMU enlargement, financial market surveys, financial market assessment, forward interest rates, interest rate swaps, ambiguity aversion, euro-strategies, credibility, uncertainty.

JEL Classification: G13, G14, E42, E43.

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ABSTRAKT

Tato disertační práce se zabývá tématem jak finanční trhy vnímají budoucnost rozvoje eurozóny. Názor trhu v oblasti rozšíření eurozóny je hodnocen s využitím dvou různých metod. První přístup, metoda Statických pravděpodobnostních kalkulátorů (SPC), je založena na existující metodologii, která byla dříve použita pro staré členské státy eurozóny. Tato statická metoda má však pár nedostatků, kterým se druhá, zcela nově vytvořená, metodologie snaží předejít. Druhá metoda, tzv. Dynamický pravděpodobnostní kalkulátor (DPC), je založena na indikátoru odvozeném z krátkodobé dynamiky budoucí úrokových diferenciálů. Jak SPC tak DPC jsou aplikovány na finanční deriváty (budoucí úrokové swapy) obchodované ve čtyřech středoevropských zemích: České republice, Maďarsku, Polsku a Slovensku. Deriváty obchodovaná v některých dalších Evropských zemí byly použity pro ověření robustnosti zkoumaných dvou metod.

Nová DPC metodologie je konceptuálně založena na předpokladu reprezentativního jedince averzního vůči nejistotě. Tato metoda je založena na modelu všeobecné rovnováhy za předpokladu nedokonalých preferencí. Předpoklad nedokonalých preferencí dovoluje výskyt mnohočetných rovnovážných stavů na základě pouze jedné množiny ekonomických fundamentů. Nemožnost určení jednoznačného rovnovážného stavu vysvětluje krátkodobé fluktuace tržních cen (tržních úrokových sazeb) i přes relativně stálý ekonomický vývoj.

Na závěr disertační práce porovnává výsledky těchto dvou metod ohledně tržních představ, tj. kdy a s jakou pravděpodobností by jednotlivé země mohly přistoupit k eurozóně, s výsledky průzkumu veřejného mínění. Následovné porovnání do jaké míry jsou tyto ve shodě s národními eurostrategiemi poté částečně vypovídá o úrovni transparentní a efektivní komunikace národních autorit s veřejností.

Klíčová slova: přijetí eura, měnové unie, rozšíření hospodářské a měnové unie, průzkum veřejného mínění, hodnocení finančního trhu, budoucí úrokové sazby, úrokové swapy, averse k nejistotě, Eurostrategie, kredibilita, nejistota.

JEL klasifikace: G13, G14, E42, E43.

TO MY PARENTS

Jana a Pavel Horníkovi

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NON-TECHNICAL SUMMARY

The thesis proposes a new approach to measuring how markets perceive the prospects of future euro area enlargement. This is a relevant aspect for domestic monetary authority because financial market participants are forward looking. Their reactions to changes in official short-term rates depend on their beliefs about the future development of interest rates. Among other factors, future interest rates depend on entry into the monetary union (EMU). Thus, to have a good signal on how the markets will react to current monetary policy, what they think about the EMU prospects of the national economy needs to be measured and suitable measures of the credibility of the whole euro-adoption process need to be developed.

Even before the EMU was launched in 1999 considerable interest was focused on methods of extracting market views of the project. Various methods were designed to infer the probability of a particular country becoming a member of the EMU. There is a large amount of literature analysing how financial markets assess the outlook of EU member countries of adopting the common currency in the future.

A review of literature on extracting market views from forward-looking financial market data is presented in Bates (1999). Bates surveys various methods and categorises them between those based on currency option contracts, as in Butler and Hördahl (1998) and methods utilising the European forward interest rates, as in J.P. Morgan (1997), Favero et al (1997), Angeloni (1997), and Lund (1999).

A lack of data in the countries under review hinders use of the option based approaches. At the time of the analysis the earliest new EMU entrants could have been expected in several years' time but the maturity of the interbank currency option contracts for the analysed countries did not extend much over one year. It is also too early to apply the time series exchange rate models. Indeed, Hördahl (1998) show that GARCH volatility estimates fell to very low levels only around two years before the EMU was launched.

In the EMU calculators, which are typically based on the term structure of interest rates, the EMU entry of a given country is treated as a random event and observed or implied interest rate forwards are used to estimate its probability. In particular, forward spreads

are viewed as a weighted average of zero, stemming from the union scenario being realised, and some non-zero value of the non-EMU scenario.

I also attempt to recover additional information by analysing the short-term dynamics of forward spreads. To justify this I appeal to the robust equilibrium indeterminacy arising in the ambiguity aversion model of Rigotti and Shannon (2005). I argue that this approach might be particularly useful when forward spreads are narrow.

In general, there are two main ways to assess market perceptions. Understanding of market participants on timing of the euro adoption can be either inferred from prices of market instruments or, alternatively, from survey evidence. It is important to cross-check these two information sources, because the beliefs expressed in the surveys are not necessarily incentive compatible and may differ from the beliefs or assumptions that investors act on. Therefore, in the second part of the thesis, I compare results based on my calculations with official strategies of the euro adoption published by national authorities available at the time of my estimations, to see to what extent are the markets in accord with communication by national authorities.

For comparison with public opinion, I analyse results of semi-annual market polls that are conducted and published by Reuters. This survey helps us to see the link between public, market and official opinion on the issue of timing of the euro adoption. These comparisons should help the readers to understand both whether the methods of EMU calculators from 1990s can be implemented as well nowadays and whether the financial market is, according to the methods used, in agreement with the official strategies.

In the end I compare both results of a method of static probability calculators (SPC) and dynamic probability calculators (DPC) with the current and past outcomes from Reuters opinion surveys with national euro adoption strategies that are presented by national authorities. Understanding and congruity of financial markets with the official strategies regarding the EMU integration is important to be in concordance with the decisions by the national monetary authorities. Moreover, when the date of the euro area accession suggested by a national authority is credible enough to private economic agents on the market, then monetary policy decisions by national central banks tend to be more effective.

Based on data until 2006 for which both methods can be performed the main findings are that the SPC method delivers euro adoption dates between 2016 and 2017, comparable for all CEE-4 countries. In contrast, the outcome from the DPC method are earlier dates, 2010 for Slovakia, 2013 in Poland, 2014 Hungary, and finally 2015 in the Czech Republic. Reuters polls conducted in May 2006 expected the latest entry date in case of Hungary (with the mean in 2013), followed by the Czech Republic (2011), Poland (2012), and Slovakia (2010). The market polls lead in the same direction as communicated EMU entry time-line published by the European Commission in Convergence Programmes at the end of 2006 or at the beginning of 2007, mentioning an entry schedule for the Czech Republic from 2010 onwards and for Slovakia (2009).

Based on more recent data until July 2009, the SPC method calculates the highest probabilities for years at the end of maturity horizon (i.e. the year 2019), even though these are still rather low (71%, 31% and 32% for the Czech Republic, Hungary and Poland, respectively). Reuters polls conducted in April 2009 reveal expectations of euro adoption date in 2014 for all CEE-4 countries still outside of the euro area in 2009, i.e. the Czech Republic, Hungary and Poland. Survey conducted in August 2009 presents mean responses being the entry year of 2014 for the Czech Republic but differs slightly for Hungary and Poland, expecting 2013 and 2014 adoption years, respectively.

INTRODUCTION

This paper as well as the rest of the thesis is based on my research work during my doctoral studies at the Charles University in Prague between 2003 and 2011. The thesis deals with the timing of the euro adoption, both as expected by the financial markets and as conceived by national authorities in their strategies and communication. I consider this topic one of the most interesting areas of research in monetary economics due to three main reasons.

First, euro adoption plans are subject to daily discussions at many levels of the public debate. Not only are these issues discussed at high-level national and international political meetings, and during academic conferences, but they are of great public concern. For this reason a suitable time plan and clear communication is of a great importance.

Second, decisions on the euro adoption stand at the cross-section of economics and politics. They are made and implemented by policy-makers, both at national and the European level. At the same time they relate to and stem from the economic readiness of a country to adopt a common currency and they have an impact on domestic economic developments after the decision is made. These decisions influence all sectors of the domestic economy and to a somewhat lesser extent also the international environment. Therefore, the decision-making bodies should respect needs of domestic financial and non-financial companies as well as households. Surveys, referenda and public discussion play a substantial role.

Third, the international financial market can be very influential during a country's preparations for euro adoption. Market activity can affect exchange rate stability, and speculative action on the foreign exchange market can jeopardize timely euro adoption by moving exchange rates out of the exchange-rate mechanism (ERM) II fluctuation margins, or within the ERM II margin but conflicting with exchange-rate stability. Financial markets can influence the assessment of durability of convergence towards the euro area via long-term interest rate levels through expected long-term interest rates that

are different from the ones based on economic fundamentals. Hence, openness and clear communication with financial markets is essential.

Last but not least, expectations on the euro adoption are very relevant for the design and implementation of national monetary policy which is yet another important aspect to be closely analysed and monitored.

The thesis adds an important new insight into the existing work. As a first publication of its kind, it presents a simple framework which quantifies a size of the reaction of monetary conditions for changing expected entry dates for countries in Central Eastern Europe. Proving its robustness and credibility on a country which had already adopted the euro, with minor changes the used methodology can be expanded further to other countries that are standing at cross roads of the euro adoption.

The thesis is organized as follows. The first chapter shortly explains my motivation for choosing this subject. Keeping in mind that euro adoption timing relies strongly on historical and regional background, chapter 2 and 3 cover these areas. After presenting a literature overview in chapter 4, important stylised facts are presented for selected Central Eastern European countries, showing to what extent convergence has been already achieved and what are the key steps to be made in near future. Chapter 6 presents official national strategies for euro adoption – both in the current and historical perspective – and interprets market surveys on euro area enlargement, showing the degree of consistency of communication and understanding among financial market participants.

After considering the strategies and timing of euro adoption from the policy point of view, chapters 7 and 8 look into future financial market data, to calculate via two different approaches the expected timing of adopting the common currency.[1] Chapter 9 compares and discusses results of both methods and presenting policy implications of the euro adoption before a final chapter concludes the thesis.

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[1] Chapter 8 of the thesis is based on a methodology introduced in the CNB working paper (CNB WP No. 13/2007), published together with Martin Cincibuch in 2007 and later published as an article in Finance and Credit. Cincibuch, M., Horníkova, M. (2008): "Measuring the Financial Markets' Perception of EMU Enlargement: The Role of Ambiguity Aversion", Finance and Credit, September 2008, Prague.

"My brother, if you mint coins, I want you to adopt the same divisions of value as in French money... I've already done the same thing for my own Kingdom of Italy. The confederated Princes have done the same thing. That way there will be uniformity of currency throughout Europe, which will make trading much easier."

Napoleon Bonaparte, 6 May 1807,

in a letter to his brother Louis, King of Naples.

1 MOTIVATION

Since the introduction of the euro in eleven EU Member States in January 1999, five more European countries have joined the euro area, the most recent one being Slovakia in January 2009. This means that eleven EU Member States are at present not full participants in Economic and Monetary Union (EMU) and have not yet adopted the euro. None of them have committed in the Treaty of Lisbon to adopt the euro, after they fulfil the convergence criteria.[2] However, when exactly national authorities will apply for EMU membership is not entirely clear in any of the new Member States (except Estonia, where the euro will become legal tender on 1 January 2011). The impact of uncertainty surrounding the timing of the euro adoption is visible in financial market data and in the real economy.

At the same time, due to forward-looking behaviour of financial markets, reactions of financial market's agents to changes in short-term interest rates depend also on the market's beliefs about the future time path of interest rate yield curves. While market

[2] Denmark and the United Kingdom have opted out of the obligation to join EMU. For them, EMU participation is entirely voluntary. Sweden relies on a *de facto* opt out by violating one convergence criterion (a two year participation in the exchange rate mechanism, until a future referendum approves euro introduction. ; see Chapter 2.

short-term interest rates are closely following monetary policy rates set by a national monetary authority, future interest rates depend strongly on the expected entry date into the monetary union. Therefore, to obtain a sound forecast of how market agents will react to current monetary policy decisions, one needs to measure what they think about the EMU prospects of the national economy.

For this reason, the proposed analysis gives monetary authorities a very meaningful signal on both, the implementation of their decisions and their communication with fiscal authorities and the financial market. At the same time, it provides an interesting comparison on euro adoption strategies between various countries of the Central Eastern European region.

Market participants pay significant attention to methods of extracting financial market views on long-term interest rates. Because accession to the euro area implies a common monetary policy, and particularly common interest rates, the long-term interest rates should already provide us with financial market expectations of timing of the euro area accession. Therefore market participants pay significant attention to methods of extracting financial market views on long-term interest rates.

Even before the EMU was launched in 1999 considerable interest was focused on methods of extracting market views of the project, and various methods were designed to infer the probability of a particular country becoming a member of the EMU. This thesis compares the implied future interest rates on zero-coupon interest rate swaps in selected new EU Member States and in the euro area for both possible cases - when the country is a member of the euro area at a given date and when the country is not, in order to answer the question what the market views as the most probable date on which countries of my sample would chose to access the euro area.

The methodology I follow is based on the concept that when a country adopts the euro, its nominal interest rates should not differ from the euro area average interest rates by more than just a default risk premium and liquidity premium. The implied forward interest rates already contain market expectations of future short-term interest rates. The observed differential of one-year implied forward rates then depends, at a particular point in time, on the probability the market attaches at that point in time to a country

being already a member of the euro area one year later, apart from default risk and liquidity premia.

When financial markets react in concordance with monetary policy actions, then unexpected shocks should be more limited. Understanding and congruity of financial markets with the official strategies regarding EMU integration should be in concordance with the decisions by the national monetary authorities. Moreover, when the date of euro area accession suggested by a national authority is credible enough to private economic agents on the market, monetary policy decisions by national central banks tend to be more effective. Clear communication and transparency of actions taken by national authorities is very important for smooth preparation and adoption of the euro area monetary policy and the euro as a future domestic currency.

Therefore, the thesis concludes with a comparison of results obtained from the calculations with the official euro adoption strategies, which is important for the evaluation of the communication and transparency of national central banks to the domestic financial market. On the back of past experience in several countries, credibility of national euro adoption strategies with respect to their consistency and fulfilment is also taken into account.

2 HISTORICAL BACKGROUND

European economic and monetary union (EMU) has become a normal feature of the daily lives of citizens in 16 EU member states. Yet it has taken decades to implement. Plans to introduce monetary union within the framework of the European Communities date back to the early 1960s.[3] Following the establishment of the European Monetary System in 1979, the first stage of EMU began on 1 July 1990 with the abolishment of exchange rate controls between the twelve member states of the European Economic Community. In 1992, the Treaty of Maastricht defined the convergence criteria[4] and in 1998, the European Central Bank in Frankfurt am Main was established. On 1 January 1999, the euro became the single European currency.

Euro coins and banknotes entered circulation on 1 January 2002 and fully replaced the national currencies with the cash changeover in the twelve Member States that participated in EMU.[5]

In principle, the EU Treaty requires every EU member state to join EMU. Eleven member states were part of the first group of countries that introduced the euro: Belgium, Germany, Spain, France, Ireland, Italy, Luxembourg, the Netherlands, Austria, Portugal and Finland. Three countries opted out of EMU membership: Denmark and the United Kingdom *de jure* in the Treaty of Maastricht;[6] Sweden *de facto* by violating one convergence criterion (a two year participation in the exchange rate mechanism), until a future referendum approves euro introduction. Greece was also supposed to join but was unable to complete all the stages of the economic integration

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[3] The first proposal for such a monetary union were submitted by the Comission of the European Economic Community under Walter Hallstein in 1962. In 1964, the Governors' Committee of the Presidents of the Central Banks of all EU member states was established.

[4] Today, the legal basis of EMU is Article 3 (4) of the Treaty on the European Union and Art. 119 et seq. of the Treaty of the Functioning of the Union, both as last revised by the Lisbon Treaty.

[5] Belgium, Germany, Greece, Spain, France, Ireland, Italy, Luxembourg, the Netherlands, Austria, Portugal and Finland.

[6] Political discussion on euro introduction in Denmark restarted in late 2008.

by 1999. The EU Council decided in 2000 that Greece was able to meet the Maastricht Criteria, thus become a part of the EMU and adopt the euro as of the beginning of the year 2001.

Since May 2004, twelve new member states – ten Central Eastern European countries as well as Malta and Cyprus - have joined the European Union. None of them obtained an opt-out clause. Hence an integral element of their accession is an obligation to fulfil the convergence criteria, join the euro area and adopt the euro as their national currency.

When exactly new member states are supposed to take these steps towards EMU is not defined in EU law. The Treaty does define, however, the convergence criteria that member states must fulfil before they are allowed to join EMU.[7]

There are four official convergence criteria also known as the "Maastricht criteria". They relate to inflation rates, government finances, exchange rates and long term interest rates: (i) Inflation rates: the average inflation rate over the year before assessment must not exceed by more than 1.5 percentage points (p.p.) the average of the three best performing member states in terms of price stability; (ii) Government finance: (a) Annual government deficit: the ratio of general government deficit to GDP must not exceed 3 per cent; (b) Government debt: the ratio of gross general government debt to GDP must not exceed 60 per cent; (iii) the country should not have faced severe tensions and devaluation of the exchange rate parity while in ERM II for at least two years before the assessment. (iv) the long-term nominal interest rate must not exceed by more than 2 percentage points the average of the three best performing member states in terms of price stability.[8] When countries participate in the ERM-II exchange rate mechanism for at least two years[9], the countries can apply for euro adoption. On the

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[7] The convergence criteria are defined in Article 140(1) of the Treaty on the Functioning of the Union.

[8] Chapter 5 elaborates in more details on Maastricht criteria fulfilment in CEE-4 economies, in particular on the long-term interest rate criterion.

[9] Four member states participate in ERM II: Denmark and the Baltic countries (Estonia until 1 January 2010, Latvia since June 2004, and Lithuania since May 2005). Latvia published their official euro

back of fulfilled Maastricht criteria, the European Council decide upon their admission to the euro area based on a recommendation from the European Commission and the Council of Finance Ministers.

So far four new member states joined the euro area: Slovenia in 2007, Cyprus and Malta in 2008 and Slovakia on 1 January 2009. Estonia will adopt the euro on 1 January 2011.

In summary, at the beginning of 2011 seventeen EU member states used the euro as their national currency;[10] three have opted out of the euro, and the remaining seven are obliged to join at some point in the future. None of these countries have an official target euro adoption dates. The Czech Republic, Hungary, Poland and Romania are, for different reasons, not ready or willing to enter ERM II at the moment. Official strategies for each of them were agreed upon in close cooperation of national governments and national central banks and, with different levels of clarity and specific limitations, published by national authorities to provide guidance to markets and public.

Their individual time plans for euro adoption differ, but all four countries want to stay in ERM II the shortest necessary period of two years. But the date when these two years will start is rather unclear, which makes them an interesting subject for this investigation.

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adoption target date for 2014. Due to prolonged recession, Bulgaria will continue their discussions on plans to apply for ERM II entry during 2011.

[10] Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Malta, the Netherlands, Portugal, Slovakia, Slovenia, and Spain.

3 FOCUS OF INVESTIGATION

The thesis focuses on four countries in Central Eastern Europe – the Czech Republic, Hungary, Slovakia and Poland. Throughout this thesis, I will use the abbreviation "CEE-4" to name this group of countries, which is often referred to as the Visegrád Group.[11] The term "CEE-3 countries" is used to designate the three CEE-4 countries that have not yet introduced the euro, namely the Czech Republic, Hungary and Poland.

Being situated in the same region, with similar trade partners, investment opportunities and economic structure, the CEE-4 countries developed close cooperation after 1989 with the aim to speed up their convergence and integration into the European economic environment. They are very similar with regards to the regional perspective and convergence of their economies towards the euro area, and share comparable levels of real economic variables (like GDP per capita, for example), Yet they have very different regarding the time frame for euro adoption.

In terms of exchange rates, the CEE-4 countries are under normal circumstances facing similar country risk premiums[12]. All operate (Slovakia until 2009) under a managed floating exchange rate regime. In such a situation, the assessment of financial markets' anticipations is very important. Changes in economic conditions might persuade financial markets that the Maastricht criteria might not be fulfilled on time, which could result in a shift of the expected entry date. Because of the forward-looking nature of financial markets, such a revision of expectations may affect current monetary conditions such as spot exchange rates and long-term yields.

The potential size of this short-term reaction is of primary interest for national central banks. Changes in market expectations can result in sharp reversals in capital flows and

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[11] The Group, also called the Visegrád Four (V4) originated in a summit meeting of the heads of state or government of Czechoslovakia, Hungary and Poland held in the Hungarian town of Visegrád on 15 February 1991.

[12] During the financial crisis, diversity in country risk premia among CEE-4 countries increased, mainly in the case of Hungary (see Figure 6) , which was the most severely affected by the crisis and which had to undergo financial assistance programme by the IMF and the European Community to support its economic stability. This of course had a negative effect on country's rating, however, only of a temporary nature.

expose the exchange rate to large swings. This was the case in the Baltic region where the euro adoption intentions needed to be postponed based on the 2006 Convergence Report published by the European Commission.

Hungary presents an especially interesting example in this respect. Financial markets' expectations about the country's euro area prospects have shown remarkable dynamics in recent years, as confirmed by market polls. Starting from quite high probabilities of expectations of an early-entry in 2001, further increasing until mid-2002, euro adoption prospects deteriorated significantly by the end of 2004 and remained rather gloomy afterwards.

A comparative look at Slovakia which has already adopted the euro, and at historical data from German and Italian financial markets in the 1990s, helps to evaluate the robustness and correctness of the methodology and the reliability of its results.

The time horizon of the analysis starts in January 1999 and uses data until July 2009 for the first methodology and until mid-2006 for the second, stochastic, method. The different time spans are due to two reasons. The dynamic stochastic equilibrium model that is the basis for the second method is based on a paper published in the Czech Journal of Economics and Finance in August 2008, which is estimated on data until the middle of 2006. Secondly, applying the second method to post-2006 data would reduce the precision of the investigation, because the data is affected by the recent financial crisis. The method is very useful when estimated on data until the start-up of the crisis and is expected to function well again based on financial time series that is long enough when the crisis is fully over. It is also in accord with studies on financial market integration, showing that the degree of integration declined during the crisis and has started slowly increasing only recently (see Babecky et al (2010) and CNB's regular publication of Convergence Criteria and a Degree of Economic Alignment in the Czech Republic). A comparison of results of these two models on 2006 data gives us similar results, as shown in chapter 9. For a time span from late-2006 onwards, I continue only with the first methodology, which is not so much disrupted by recent financial market turmoil and the following crisis.

4 LITERATURE OVERVIEW

Literature analyzing financial markets' perception of future interest rates is rich. Bates (1999) has summarised and categorized the most important methods. The two most prevalent approaches are those based on currency option contracts, developed in a seminal paper by Butler and Cooper (1997), Aguilar and Hördahl (1998), and methods utilizing the European forward interest rates, as in J.P. Morgan (1997), Favero et al. (1997), Angeloni and Violi (1997) and especially in Lund (1999).

Some of the methods are based on financial data only, as for example in Castren (2005), while some other authors use also economic data – such as Favero (1999); Angeloni and Violi (1997).

With regard to the CEE-4 countries, the option-based approach cannot be used for a number of reasons. Foremost, the history of option trading in the CEE-4 countries is limited. At the same time, the earliest new CEE-4 euro area entrants are expected to enter the euro area only in several years' time,[13] while the maturity of the interbank currency option contracts for the analysed countries did not extend much over one year. All these factors would significantly undermine the robustness of an estimation based on option data.

The same lack of data prevents using Aguilar and Hördahl's approach that relies on exchange rate correlations between old EU Member States' currencies and the Deutsche Mark (used a proxy for the euro) vis-à-vis the US dollar. Babetskaia-Kukharchuk et al. (2007) follow the same method to calculate correlations of CEE-4 currencies vis-à-vis the euro. However, GARCH volatility estimates fall to very low levels only around two years before the entry to the monetary union. This greatly limits the significance of the data for the CEE-4 countries, because they all want to stay in ERM II only for the necessary minimum period of two years.

[13] Including Slovakia for the time of the Slovak data estimation sample.

The second prevalent approach to determine financial market's perception of future interest rates relies on the analysis of forward interest rates. The most comprehensive study using this method is J.P. Morgan (1997). They develop a framework based on several exogenous variables, completely excluding macroeconomic fundamentals (such as price level and exchange rate developments, economic growth and fiscal factors). Focusing on six European countries - France, Belgium, Denmark, Sweden, Italy, Spain, and the UK - over the time range from 1988 to 1992, J.P. Morgan looks at a period when expectations of EMU were known to be quite low and performs a statistical regression of swap spreads, focusing on the difference between actual, estimated and EMU levels.

J.P. Morgan claim that it is possible to find good estimates of interest-rate swap spreads for countries outside the euro area from euro area interest-rate swap rates, using only real-time financial market data. It should then be possible to derive EMU-entry expectations also at real time. Their methodology is purely based on market participants' degree of risk-aversion. It should overcome the distortions created by convergence pressures, driven by the future euro adoption that affect current and expected developments in domestic macroeconomic conditions.

The success of the "J.P. Morgan Calculators", an index that measures the statistical likelihood of EMU based on market probabilities, was due to their originality at the time when they were introduced. The probabilities are based on the assumption that long-term interest rate spreads between the European countries involved are influenced by the market's expectations of EMU, which are pegged at a probability between 0 and 100%. At any given time, the markets will trade between these two probabilities, and the closeness with which the market approaches either of these extremes indicates the relative probability of EMU.

J.P. Morgan's model uses Germany as a benchmark, assuming that the probability of Germany and one other country joining EMU on 1 January 1999 was 100%. For the other old EU Member States the probability is then calculated based on comparison of three spreads: (i) post-1999 forward swap spread between swaps denominated in national currency (e.g. French francs) and swaps denominated in the German marks: (ii) spreads for the time when the EMU entry is 100% expected by the market and

(iii) spreads at the time when the expectancy of EMU entry is close to zero. Since spreads are determined only by the expected changes in exchange rates, if the market is 100% certain today that EMU will happen by 1999, today's post-1999 forward swap spread between a national-currency-denominated swaps and marks-denominated ones would be zero. The non-EMU swap spread is a bit more complicated.

The fundamental idea behind the proxy for the interest rate when a country is out of the euro area is a general risk aversion of investors, no matter where the investment is targeted. More specifically, there is a benchmark risk level above which investors do not want to trade. Such a benchmark can be estimated based on non-European indicators, which helps to keep exogeneity of variables in used regressions. J.P. Morgan argues that even if at the end of the 1990s a monetary union among old-EU Members States would not be formed, financial market participants still might have assumed a change in monetary and economic policy, which would change macroeconomic fundamentals. That was one of the reasons why the macroeconomic fundamentals were considered to be a poor guide to how markets would trade if EMU was no longer a factor. This problem resembles today's stage when macroeconomic fundamentals and interest rates converge even without euro area entry, simply because of openness of economies, trade relations and global factors. To escape this problem, J.P. Morgan suggest to consider a proxy for the out-of-euro area spread and the average of the difference between the US and the Canadian 10 year bond spreads and between the Canadian and Australian; Japanese and Australian ten-year bond spreads and the difference between the US and Japanese ten-year minus two-year yield spreads.

The main criticism of J.P. Morgan's model focuses on the significance attributed to forward swap spreads, and on the time horizon used in the study. First, forward swap spreads indicate a great deal more than simply the probability that a country will join EMU. Global currency trends, such as a strong dollar or yen, will make spreads converge as well, and the J.P. Morgan model would automatically attribute smaller spreads to an increase in the probability of joining EMU. Second, the J.P. Morgan model uses historical spreads from the 1980s which are difficult to be adapted to current market conditions. This was also the why it was not applied in this thesis. At the same time, macroeconomic fundamentals and convergence processes play a dominant role in

the CEE-4 countries and should be taken into account when calculating the probabilities of euro adoption.

A second study using forward swap spreads, BNP Paribas looks at forward swap spreads, but assumes that countries could join in 2000 or in any year after that. The model looks at one-year rates, since the countries that will be joining in 1999 will have identical one-year forward rates, and these will be lower than those of the countries not joining in 1999. The spread of one-year rates between each country and Germany can be used to determine the market's belief in a country joining the EMU in 1999. The key to the model is that it assumes that the spread is normally distributed around its mean or average spread. The probability is calculated based on the size of the area on the distribution curve beneath J.P. Morgan's EMU Calculator spread.

Bates (1999) further notes that the EMU calculators are most robust when national and foreign (euro area) interest rates would differ substantially in the case of the country not joining. In other words, if the expected future spread is large enough in absolute terms. Otherwise, forecast errors and other potential biases would make the EMU and non-EMU cases hard to distinguish and the probability of EMU entry would not be identifiable. Therefore, early research focused mainly on Italy and other countries with a history of substantial interest rate differentials that could be extrapolated into the future as non-EMU interest rate paths.[14]

However, the situation is quite different in CEE-4 countries. Low inflation has prevailed and they have independent central banks that pursue inflation targets identical or very close to the ECB's target of "below, but close to 2%". The countries have been converging fast to the euro area level, capital and financial markets are well integrated, the banking sector is largely foreign owned and trade linkages are well developed. All these factors imply that low inflation environment will likely be sustained and that interest rate spreads will remain low regardless of whether these countries join the euro area or not. For example, the Czech Republic is a very good case study, for which the EMU and non-EMU scenarios for interest rates seem to be too close for making reliable assessments about the EMU probabilities using forward rate levels only. The CEE-4

[14] For instance, at the beginning of 1996, three years before the EMU was launched, the long horizon spreads for Italy were close to four percentage points.

countries may converge to the euro area with correspondingly similar monetary policy also without a euro adoption. However, while macroeconomic fundamentals might converge fast, Fidrmuc and Korhonen (2006) show a relatively slow convergence of business cycles.

5 STYLISED FACTS

The following chapter analyses convergence in macroeconomic developments in the CEE-4 countries, inspired by the criteria assessed by the European institutions (European Commission and European Central Bank) in the Convergence Reports[15].

Convergence in macroeconomic fundamentals of national economies towards the euro area average has a great influence on current and future interest rate levels and on the euro adoption prospects. It is important to investigate past, current and future macroeconomic developments in order to analyse the level of convergence towards the euro area that the CEE-4 countries have achieved so far, and to elaborate on the future catching up process. It will show whether a high degree of sustainable economic convergence has been achieved for the countries to become an integral part of the euro area.

Examination of the level of legal convergence in these countries is beyond the scope of stylised facts relevant for this thesis. Moreover, past experience shows that all the countries that decided for the euro adoption manage in the end to overcome legislative constraints. The main binding constraints were the macroeconomic ones.

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[15] The Convergence Reports are prepared by the ECB at least once every two years – or at the request of a Member State with a derogation (i.e. Denmark and United Kingdom). They serve to fulfil the ECB's obligation to report to the Council of the European Union on the progress which Member States made in the fulfilment of their duties regarding the achievement of economic and monetary union. Even stronger mandate has been given to the European Commission, which based on the Convergence Reports (both by the ECB and by the European Commission) submits a proposal to the ECOFIN Council. The first Convergence Report was prepared in March 1998 for the old EU Member States (Belgium, Denmark, Germany, Greece, Spain, France, Ireland, Italy, Luxembourg, Netherlands, Austria, Portugal, Finland, Sweden, and United Kingdom). In May 2000, Greece and Sweden were examined leading to Greek entry to EMU and hence in 2002 only Sweden was assessed. Since October 2004 aspects of convergence in the new EU Member States have been analysed (Czech Republic, Estonia, Cyprus, Latvia, Lithuania, Hungary, Malta, Poland, Slovenia, Slovakia) together with Sweden. The assessment lead to euro adoption in Slovenia (and rejection of Lithuania) and EMU entry of Cyprus and Malta, based on reports from May 2006 and May 2007 respectively. Estonian euro adoption has recently been approved based on the 2010 Convergence Report, published in May 2010.

Analysis of macroeconomic fundamentals which are assessed in Convergence Reports serves as a good background to better understand results obtained in latter calculations. In particular, one can see to what extent the convergence process itself explains the decline in interest rate differentials from euro area levels over time. Moreover, macroeconomic fundamentals (such as price and exchange rate developments, real economic activity, fiscal indicators) and the way they differ from their expected developments have an effect on risk premiums of individual countries and as such determine interest rates both at short and long-term horizons, which are directly linked to the calculations in chapter 7. More detailed horizontal analysis of short and long-term interest rates developments follows in chapter 5.2.

Public understanding of Maastricht criteria assessment has changed over time. Believing in purely numerical margins, more political factors stand behind country's assessment of readiness for the euro adoption. In particular, after the assessment of Lithuania in May 2006, when the country tried to succeed in the euro adoption process, the stance by European authorities proved to be negative.[16]

5.1 Macroeconomic convergence

This chapter examines current monetary policy objectives in their historical perspective and discusses policy challenges in the light of recent macroeconomic and financial developments and projections (the projections are based on the Spring 2010 Convergence Programme). After providing some insights into monetary policy making, it analyses three key macroeconomic developments – (i) price stability and economic growth, (ii) government budgetary position, and (iii) exchange rates.[17]

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[16] The ECB Convergence Report published in May 2006, places – rather unexpectedly – more importance to expected future inflation developments, writing "… Over the reference period from April 2005 to March 2006, the 12-month average rate of HICP inflation in Lithuania was 2.7%, i.e. just above the reference value of 2.6 % for the criterion on price stability. However, on the basis of the most recent information, the 12-month average rate of HICP inflation is **expected to rise gradually in the coming months.**"

[17] See Tables 1 (i)-(iv) and 2 at the end of chapter 5.1 for more detailed data description.

5.1.1 Indicators of Economic Convergence

Czech Republic

(i) Price stability and economic growth

Among the CEE-4 countries the Czech Republic was one of the best economic performers over the last years. It benefited from large inflows of foreign direct investments attracted by low inflation, a cost-competitive and well-educated labour force, the country's central location in Europe, and strong macroeconomic fundamentals.

After somewhat sluggish growth before the entry into the European Union, real GDP growth increased significantly soon afterwards. Since joining the European Union in 2004, the Czech Republic has performed relatively well, with real GDP growth averaging 5.2% between 2004 and 2008 (compared to 2.6% real growth between 1999 and 2003), which helped to take GDP per capita to around 80% of the EU average. Trade integration was fostered by large inflows of foreign direct investment, which were underpinning an export-led expansion. Benefiting also from a higher initial standard of living than most other countries in the region, consumption convergence pressures were contained, while investment activity was sharply increasing.

Credible inflation targeting helped to maintain low inflation, with average HICP inflation at around 2.3% between 1999 and 2004 and at around 3.1% afterwards. This increase in consumer prices was mainly due to temporary one-off tax increases, global commodity price shocks and capacity constraints emerging in 2008. With domestic interest rates until recently lower than in the euro area, private sector borrowing in foreign currency has been very modest. A liquid and conservative banking sector limited the build-up of balance sheet vulnerabilities. The Czech Republic's strong fundamentals, healthy banking system and minimal external imbalances and have helped to weather the global financial crisis, although a large loss of output (-4.1 % in 2009) could not be avoided.

In 2008-2009, the Czech Republic's highly open economy, with important trade and investment linkages to the euro area and other developed economies (with exports

representing more than 75% of GDP), was impacted by spill-over effects from the global crisis mainly through a decline in foreign demand. This led to a significant drop in exports and industrial production, like in other export-oriented economies. The economy's integration in international supply chains and its specialization in capital goods were aggravating factors.

Despite the large shock to the real economy, unprecedented turbulences in international capital and financial markets, and a decline in real estate prices, the financial sector has remained relatively stable, mainly due to prudent regulation, a strong domestic deposit base and low exposure to toxic assets and foreign exchange loans. Recent developments were in line with a healthy convergence process. Inflation remained positive in 2009, although well below target.

(ii) Government budgetary position

The Czech Republic is, like Hungary and Poland, subject to a Council decision on the existence of an excessive deficit. The deadline for correcting the excessive deficit situation was set to 2013. Fiscal convergence criteria – especially the criterion on the government budgetary position – must remain below 3% (unless either the ratio has declined substantially and continuously and reached a level that comes close to the reference value, or, alternatively, the excess over the reference value is only exceptional and temporary and the ratio remains close to the reference value). Reducing general government deficits and improving the structural parameters of public finances will be the priorities of fiscal policy for the coming period.

The fiscal position has deteriorated sharply with the economic slowdown. The overall deficit increased by 4 percentage points to 6% of GDP in 2009. Currently, the main objective of fiscal policy is maintenance of the government deficit in 2010 at 5.3% of GDP and gradual consolidation in subsequent years such that the Czech Republic eliminates the excessive deficit by 2013. The main challenge for fiscal policy in the coming years will be to reverse the widening of budget deficits in a sustainable manner. While the overall fiscal position improved during the boom years, the opportunity for more fundamental fiscal consolidation was missed and the structural deficit barely changed. The recent economic downturn has compounded these problems and led to a

sharp increase in the overall deficit, fast accumulation of debt, and a widening of interest rate spreads vis-à-vis euro area.

(iii) Exchange rates

The initial exchange rate peg was abandoned after an exchange rate crisis in May 1997 in favour of a floating exchange rate, and the CNB introduced an inflation targeting regime from January 1998. Over the years, the Czech authorities have occasionally intervened in the foreign exchange market to smooth out excessive exchange rate fluctuations (the last direct intervention took place in the autumn of 2002).

Hungary

(i) Price stability and economic growth

The entry to the European Union brought Hungary an increase in real GDP growth of around 5% annually in absolute terms at the end of 2004. It declined slightly afterwards but still recorded a sound level of 4% year-on-year in 2006. Labour productivity and potential output started to decelerate, while lax fiscal policy and growing private sector indebtedness supported further growth of already elevated domestic demand. Moreover, from 2004 onwards, the share of foreign-exchange-denominated debt increased quickly.[18] Against this background, Hungary was in a fragile economic condition when the financial crisis broke out in autumn 2008. Among the CEE-4 economies, Hungary was the most severely hit by the global financial turmoil and real GDP growth contracted sharply.

With regard to price developments, in autumn 2008, financial market conditions in Hungary rapidly deteriorated to the extent that the external financing needs of the

[18] In Hungary, the share of FX loans in total loans to households and non-financial corporations reached 63% at the end of 2009, mainly due to high spread between local inter-bank rates and the EURIBOR. In October 2009, the Hungarian Central Bank proposed measures on new regulations to discourage Hungarian households from taking on foreign currency loans, which was implemented in early-2010. These measures included a limit in loan-to-value in mortgage lending to 70% for loans denominated in the Hungarian forint, 54% for euro-denominated loans and 35% for loans in other foreign currencies (according to the BIS data source).

government could no longer be sourced via financial market channels. With a simultaneous sudden decline in external demand and high uncertainty regarding the severity and duration of the crisis, both exports and industrial production dropped significantly at the end of 2008. In November 2008, acknowledging the government's commitment to maintain the fiscal consolidation process and to prevent a more severe financial market crash, the EU, the IMF and the World Bank provided a joint financial assistance of up to 20 billion euro linked to specific policy conditionality. Introduction of this financial assistance package provided a negative signal to financial markets about the country's readiness to adopt the euro any time soon.

(ii) Government budgetary position

As in the other CEE-4 countries, also in Hungary the fiscal discipline – rather, a lack of it - has been blamed for a delayed euro adoption. In the past Hungary's deficit-to-GDP ratio exhibited a quite volatile pattern, hitting very high levels. Starting from 8.0% of GDP in 1998, the deficit ratio consolidated to less than 3% in 2000, but proved unsustainable and rose to 8.9% of GDP in 2002 and worsened even further (by 2006 it reached 9.2% of GDP). In 2007, the deficit ratio improved markedly to 5.5% of GDP in the context of a significant slowdown in economic activity. Hungary has been subject to an EU Council decision on the existence of an excessive deficit since 2004. The deadline for correction of its excessive deficit is 2011 at the latest.

(iii) Exchange rate

From mid-1990s, the Hungarian forint followed a crawling peg regime initially in a narrow band. In May 2001, the width of the band was first extended to +/- 15%. In June 2001, all controls on capital account transactions were lifted and in October 2001 a new exchange rate corridor was established. The fluctuation band of the Hungarian forint was adjusted in the context of a devaluation of the central rate in June 2003. The fluctuation band was abolished in 2008.

Poland

(i) Price stability and economic growth

Starting from rather high level (averaging at 13.4% between 1996 and 1998) consumer price inflation followed a sharp downward trend from 2000 to 2003 (with an average annual increase of 5.1%). After a period of low inflation, price pressures started to pick up again at the end of 2006 and elevated in 2008 and 2009 (at around 4%), mainly due to higher food and energy prices, increases in administered prices and indirect taxes.

Taking into account some lag, inflation developments have largely followed the output performance of the Polish economy. After a strong growth between 1996 and 1998 (at the average around 6%) and slower growth (still above 3% annually) between 1999 and 2005 – except for 5.3% growth during the EU entry year 2004 - output expanded at an annual rate of over 6% in 2006 and 2007, with overheating pressures emerging gradually. This resulted in sizeable labour shortages and a notable rise in unit labour cost growth.

Poland is the only EU economy to have escaped a recession in 2009, when real GDP increased by 1.7%. Such exceptional performance during the crisis reflected several favourable factors of Polish economy. These include sound economic fundamentals and a well-capitalised financial sector with sound financial stability. The relatively low degree of openness of the economy also helped to decrease the pass-through of the crisis. At the same time a sizeable depreciation of the Polish złoty at an early stage of the crisis, the cushioning effect of real-wage adjustment on employment, and timely reactions from monetary and fiscal policies had a positive effect on macroeconomic developments over the past months. Nevertheless, the key challenges for the years ahead will be to secure steady competitiveness gains, continue the catching-up process and maintain macroeconomic stability.

(ii) Government budgetary position

The general government deficit increased from under 2% of GDP in 2007 to over 7% of GDP in 2009, mainly because of discretionary fiscal relaxation together with a fall in revenues due to the global economic slowdown. Poland is at present subject to an EU Council decision on the existence of an excessive deficit, with a general government

budget deficit that reached 7.1% of GDP in 2009 (significantly above the 3% reference value) and, according to the Spring 2010 Commission Forecast, is expected to increase further to 7.3% of GDP in 2010. Starting from low levels, the general government debt was increasing to above 50% of GDP (still below the 60% reference value) and is projected by the Commission to increase to 53.9%. Public finances are, according to the European Commission's 2009 Sustainability Report, at medium risk.

(iii) Exchange rate

The Polish authorities devised a crawling peg regime for the złoty in October 1991 with initially a narrow fluctuation band. By the time of the launch of the euro in January 1999 the fluctuation band had been gradually widened, and in April 2000 Poland switched to a floating exchange rate regime with no formal restrictions for currency movements. Since 1999, Poland has pursued a direct inflation targeting approach and the authorities have generally refrained from exchange rate intervention until 2010, when they had to react fast to a sudden spill-over of global financial crisis.

Slovakia

(i) Price stability and economic growth

Following Slovakia's accession to the euro area, the main goals of the Slovak government in the area of macroeconomic policies have narrowed down to the area of fiscal policy, which represents the main tool for influencing the development of real economy should internal or external shocks occur. The recent global economic crisis, the consequences of which required flexible and targeted reaction in the form of anti crisis measures, underscored the importance of fiscal policy.

Like in the other CEE-4 economies, an important part of the convergence process was played by large inflows of foreign direct investment, which were stimulated by the prospect of joining the euro area. These inflows contributed to strong productivity growth by allowing faster build-up of the capital stock and transfer of technology and knowledge. At the same time, sound macroeconomic and structural policies allowed large macroeconomic imbalances to be avoided and strong external competitiveness to

be maintained. The buoyant economic growth also led to a continuous fall of the unemployment rate, from 18.7% in 2002 to 9.5% in 2008.

Similarly to the Czech Republic, given its large degree of trade-openness, Slovakia was strongly exposed to the slump in global trade during the current financial and economic crisis. After several years of sustainable growth and fast real convergence, in 2009 the Slovak economy contracted for the first time since its formation in 1993. Real GDP fell by 4.7%, mainly driven by a collapse of industrial production by over 15%. Despite this large shock to the real economy and severe stress in global financial markets, the Slovak banking sector has remained strong.

Consumer prices, as measured by the Harmonised Index of Consumer Prices, declined significantly from their elevated levels until 2004. From 2005 onwards the inflation was rather volatile but except for 2006 levels always below 4% year-on-year. The European Commission expects the inflation level at 1.3% year-on-year at the end of 2010 while it is forecasted to increase to 2.8% the year after.

(ii) Government budgetary position

Slovakia experienced several years of pro-cyclical fiscal policies during its boom, which brought a deterioration of the structural deficit to 4.8% of GDP in 2008 (from 1.8% of GDP in 2005), while the GDP growth averaged 8% per year during 2005-2008. The headline deficit soared further from 2.3% in 2008 to 6.8% of GDP in 2009. The fiscal policy strategy assumes the resumption of fiscal consolidation already in 2010, and the government is committed to continue consolidation also in the years to come until a balance budget is reached. On such grounds, the approved general government budget for 2010–2012 envisages gradual reductions in the general government deficit, starting from 2010 and reaching the value of 3% of GDP in 2012.

(iii) Exchange rate

From January 1998 until January 2009, the Slovak koruna was following a managed floating exchange rate regime. On 28 November 2005, the koruna joined the ERM II regime at a central rate of 38.4550 SKK vis-à-vis the euro and with a +/- 15% band. On 17 March 2007, this rate was revalued by 8.5% to 35.4424 SKK against the euro with

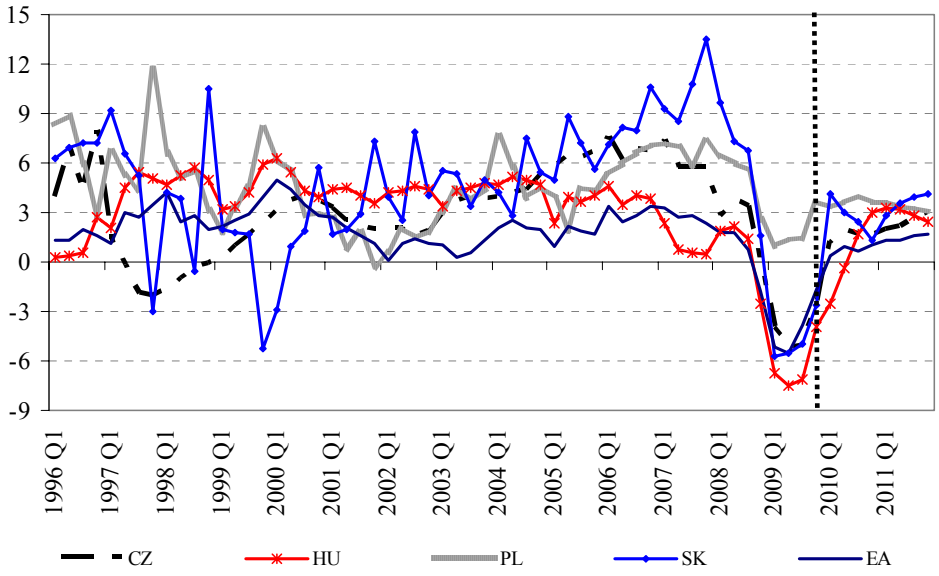
the same band. The central rate was then revalued once more on 28 May 2008 to 30.1260 SKK/EUR with no change in the +/-15% band.

Table 1: Main economic indicators

(i) Real GDP developments

- Real GDP growth *(annual growth, non-seasonally adjusted data, chain-linked)*

	1996-1998	1999-2003	2004	2005	2006	2007	2008	2009	2010 (p)	2011 (p)
Czech Rep.	1.4	2.6	4.5	6.3	6.8	6.1	2.5	-4.2	1.6	2.5
Hungary	3.5	4.4	4.9	3.5	4.0	1.0	0.6	-6.3	0.5	2.9
Poland	6.1	3.1	5.3	3.6	6.2	6.8	5.0	1.8	3.6	3.3
Slovakia	5.2	2.9	5.0	6.7	8.5	10.6	6.2	-4.7	2.7	3.6
Euro area	2.3	2.1	2.2	1.7	3.0	2.8	0.6	-4.1	0.8	1.5



Source: ECB, European Commission forecasts, autumn 2009 (for data 2010-2011).

- Output gap *(deviation of actual output from potential output as % of potential GDP)*

	1997-2001	2002-2006	2005	2006	2007	2008	2009	2010 (p)	2011 (p)
Czech Rep.	-2.5	-0.3	1.0	3.9	6.0	4.8	-2.2	-2.7	-2.5
Hungary	-1.0	1.4	1.8	3.6	3.1	2.9	-4.0	-4.7	-2.0
Poland	0.5	-0.3	-0.2	1.1	2.6	2.6	-0.4	-2.2	-2.3
Slovakia	-1.8	-0.8	-0.4	2.4	7.5	9.2	-0.8	-2.1	-3.0
Euro area	0.2	0.2	-0.1	1.3	2.5	1.9	-2.9	-3.0	-2.5

Source: ECB, European Commission forecasts, autumn 2009 (for data 2010-2011).

(ii) Fiscal developments

- Gross debt, general government *(as a % of GDP)*

	2003	2004	2005	2006	2007	2008	2009	2010 (p)	2011 (p)
Czech Rep.	29.8	30.1	29.7	29.4	29.0	30.0	35.4	39.8	43.5
Hungary	58.4	59.1	61.8	65.6	65.9	72.9	78.3	78.9	77.8
Poland	47.1	45.7	47.1	47.7	45.0	47.2	51.0	53.9	59.3
Slovakia	42.4	41.4	34.2	30.5	29.3	27.7	35.7	40.8	44.0
Euro area	69.1	69.5	70.1	68.3	66.0	69.3	78.2	84.0	88.2

Source: ECB, European Commission forecasts, autumn 2009 (for data 2010-2011).

- Primary balance, general government *(as a % of GDP)*

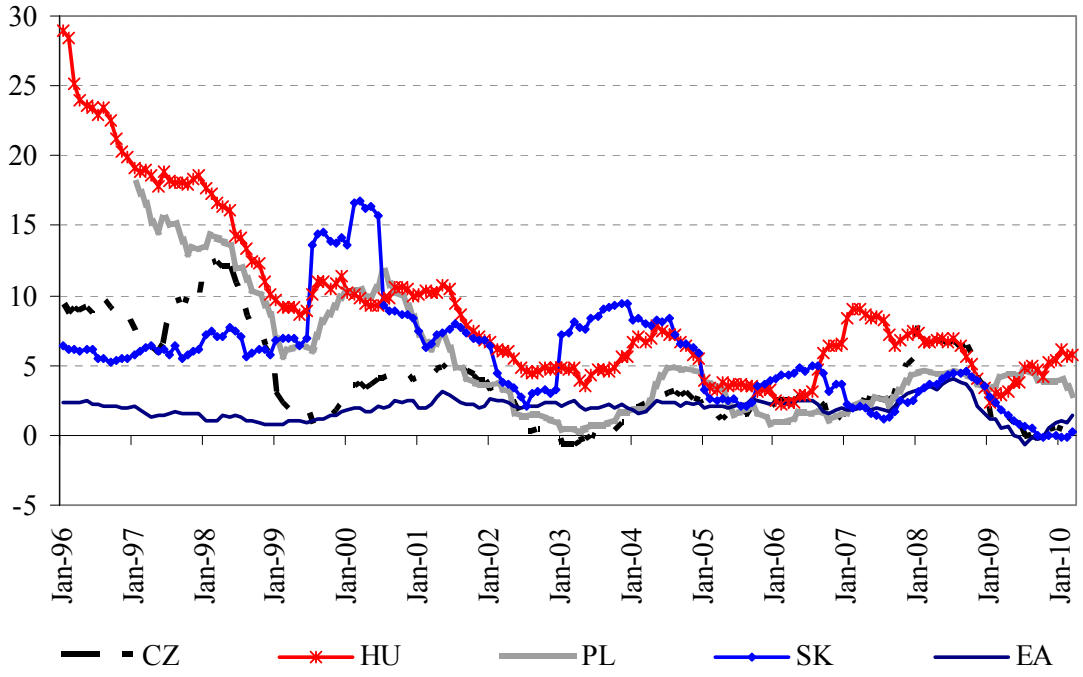
	1997-2001	2002-2006	2005	2006	2007	2008	2009	2010 (p)	2011 (p)
Czech Rep.	-3.3	-3.3	-2.4	-1.5	0.5	-1.6	-4.6	-3.9	-3.6
Hungary	1.3	-3.9	-3.8	-5.4	-0.9	0.4	0.7	0.5	0.1
Poland	-0.4	-2.0	-1.3	-1.0	0.4	-1.5	-4.5	-4.5	-4.0
Slovakia	-4.3	-1.6	-1.1	-2.0	-0.5	-1.1	-5.3	-4.5	-3.9
Euro area	2.6	0.7	0.4	1.6	2.3	1.0	-3.5	-3.6	-2.9

Source: ECB, European Commission forecasts, autumn 2009 (for data 2010-2011).

(iii): Price developments:

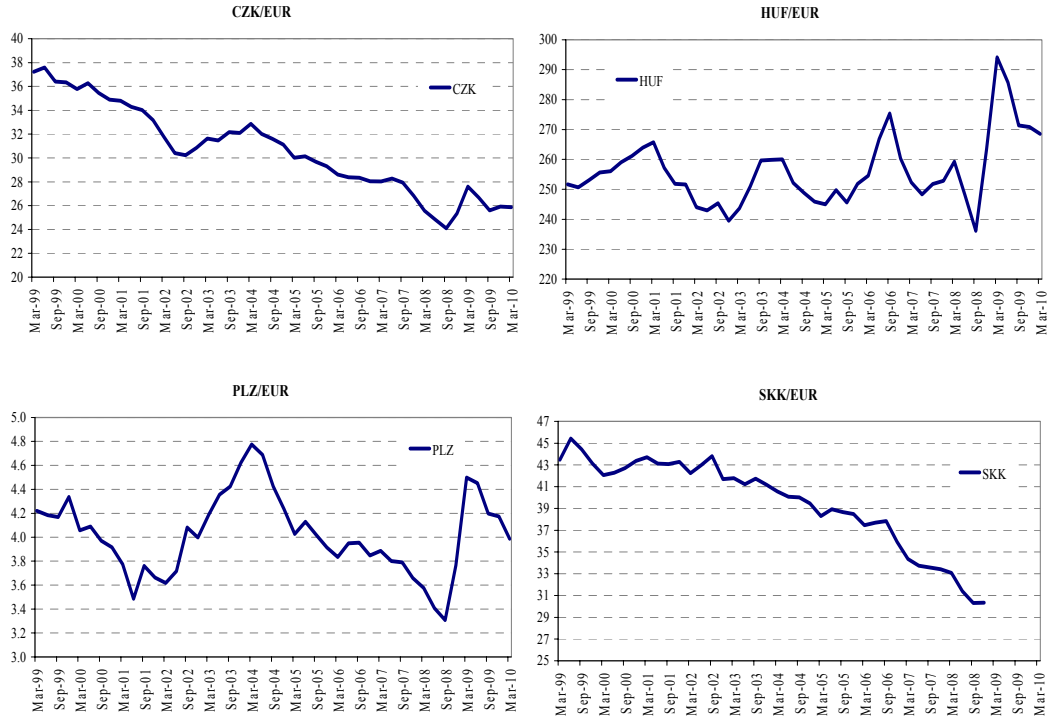
- Harmonised index of consumer prices *(% change on preceding year)*

	1996-1998	1999-2003	2004	2005	2006	2007	2008	2009	2010 (p)	2011 (p)
Czech Rep.	8.9	2.3	2.6	1.6	2.1	3.0	6.3	0.6	0.9	1.3
Hungary	18.8	7.8	6.8	3.5	4.0	7.9	6.0	4.0	4.5	2.8
Poland	13.4	5.1	3.6	2.2	1.3	2.6	4.2	4.0	2.5	2.6
Slovakia	6.2	8.4	7.5	2.8	4.3	1.9	3.9	0.9	1.3	2.8
Euro area	1.6	2.0	2.1	2.2	2.2	2.1	3.3	0.3	1.5	1.6



Source: ECB, European Commission forecasts, autumn 2009 (for data 2010-2011).

(iv) Foreign exchange developments *(nominal bilateral exchange rates, vis-à-vis the euro, end of quarter data)*



Source: ECB.

Table 2: Overview table Economic Indicators of Convergence

		Price stability	Exchange rate vis-à-vis the euro		Long-term interest rates
		HICP inflation [1]	*Participating in ERM II*	*[2] [3]*	*[1]*
Czech Republic	***2007***	3.0	no	2.0	4.3
	2008	6.3	no	10.2	4.6
	2009	0.8	no	-6.0	4.9
Hungary	***2007***	7.9	no	4.9	6.7
	2008	6	no	-0.1	8.2
	2009	3.9	no	-11.5	9.2
Poland	***2007***	2.6	no	2.9	5.5
	2008	4.2	no	7.2	6.1
	2009	3.9	no	-23.2	6.1
Reference value [7]		0.7% - 1.7%			6.5%

[1] Average annual percentage change. 2009 data refer to the period December 2008 to November 2009.

[2] Average annual percentage change. Data for 2009 are calculated as a [ercentage change of the average over the period 1 January 2009 to 4 January 2010 compared with the average of 2008.

[3] A positive number denotes an appreceation vis-à-vis the euro, and a negative number a depreciation vis-à-vis the euro.

Source: European Commission (Convergence Programme), ECB (Convergence Report).

5.2 Interest-rate developments

The following section looks into developments in short-term and long-term interest rates. They are the basis for market-based approaches to measure expected euro adoption date (Chapters 7 and 8). It begins with a short analysis of movements and past trends of short-term interest rates, bearing in mind that developments in long-term interest rates are influenced by an average of current and expected future short-term rates (plus possibly by a term premium) .

5.2.1 Short-term interest rates

Short-term interest rates in the CEE-4 countries converged noticeably to the euro area level over the past years. Starting from very high levels – in Poland, three-month money market rates stood around 30% in early 1995, as an effective way to fight high inflation at that time - short-term interest rates decreased below 10% in all CEE-4 countries in mid-2002 and stayed below this level further on (with the exception of Hungary from November 2003 till November 2004).

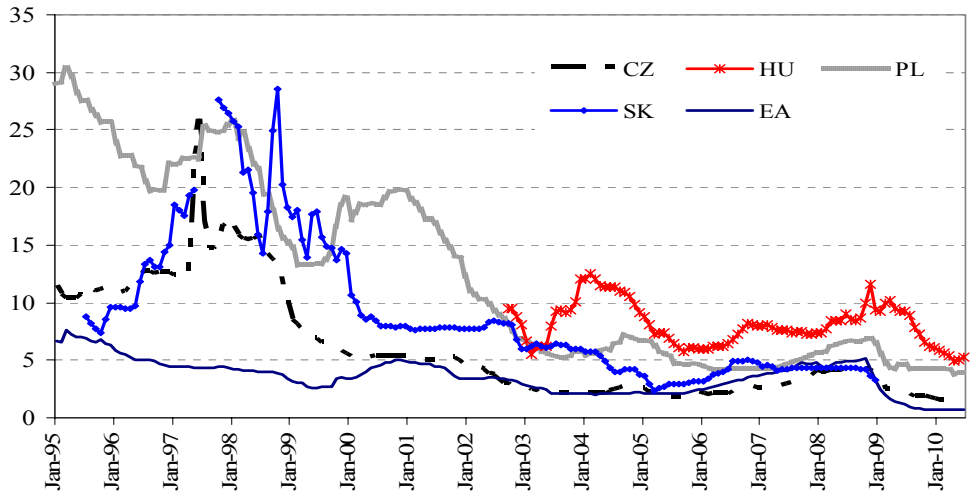
The interest rate spreads vis-à-vis the euro area level followed the same pattern. They were below 5% since mid-2002 (Hungary again being the exception between June 2003 and June 2005, and since October 2008 as a reaction to the global financial crisis). Between mid-2002 and mid-2003 and especially from March 2005 until November 2008, three-month money market rates in the Czech Republic stood below the comparable rates in the euro area. A trough was reached in April 2007 at -1.38 percentage point spread. Slovakia also recorded a negative spread vis-à-vis the euro area short-term rates from August 2007 until it adopted the euro in January 2009. The minimum spread, which was recorded, stood at -0.9 percentage points in October 2008 (see figure 1).

Such small spreads in short-term interest rates, and even negative ones in a few cases, are obviously due to a successful convergence process. They complicate the market-based calculations of expected euro adoption date, especially those using the EMU calculators. The method of the EMU calculators, which is developed within this thesis,

is based on methodology performed for the old EU member states at the end of 1990s, when the differences among countries were much higher, as demonstrated in figure 2. German rates are used as a benchmark, instead of euro area rates, which did not exist at that time.

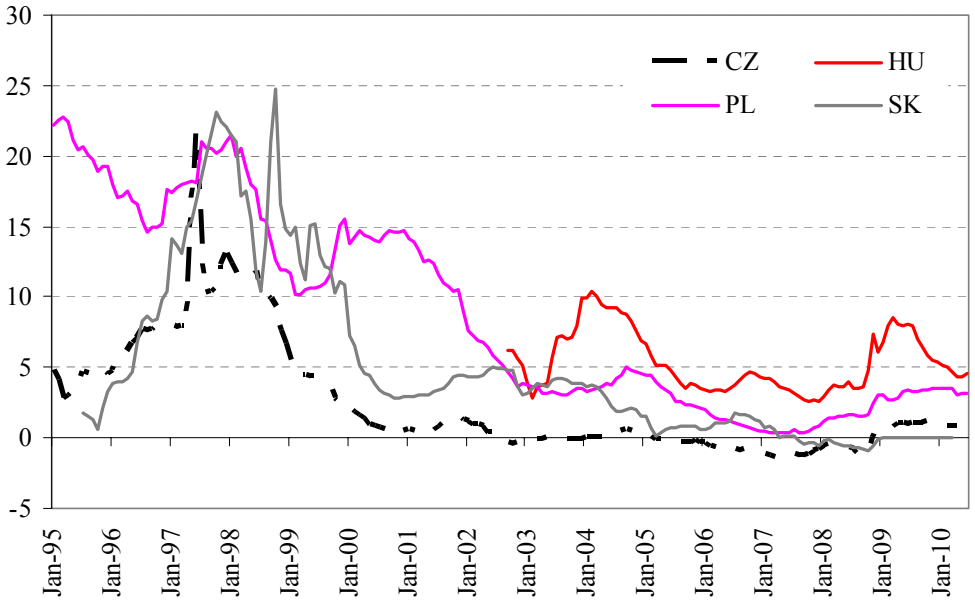
Figure 1: Short-term interest rates, 3-month money market rates (monthly data)

(i) Levels



Source: Eurostat.

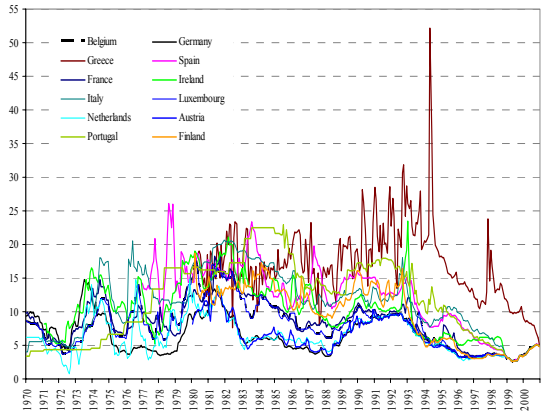
(ii) Spreads vis-à-vis the euro area



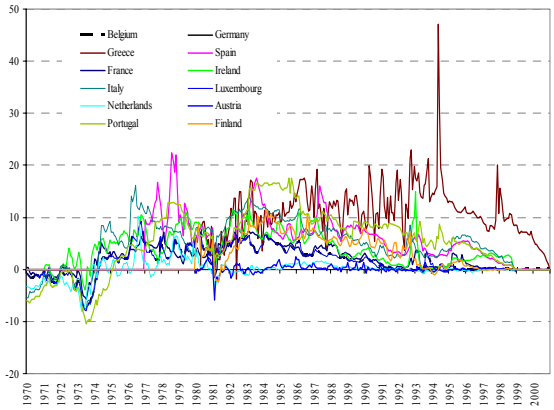
Source: Eurostat.

Figure 2: Comparison with the old EU Member States - Money market interest rates, 3 months (80-100 days) maturity short-term interest rates, monthly data.

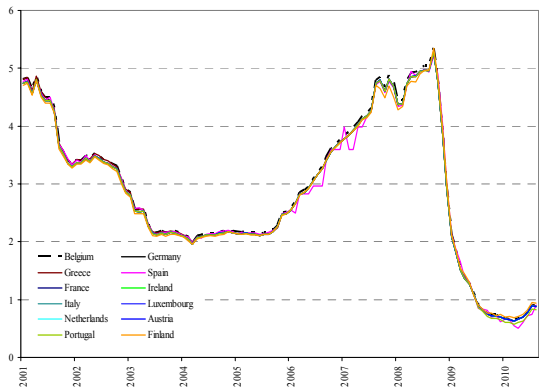
Levels (1970 – 2001)



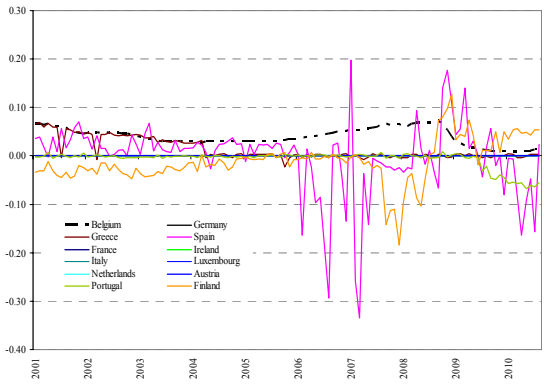
Spreads (1970 – 2001)



Levels (2001 – 2010)



Spreads (2001 – 2010)



Source: Eurostat.

Note: Spreads are calculated as differences vis-à-vis German short-term interest rates.

5.2.2 Long-term interest rates

Long-term interest rates are one of the four Maastricht criteria that are used to measure convergence of EMU candidates towards the euro area. Article 140 (1) of the Treaty of the Functioning of the Union states that harmonised statistics on interest rates for long-term government bonds denominated in national currencies are used to assess convergence. More specifically, it requires "the durability of convergence achieved by the Member State with a derogation and of its participation in the exchange-rate mechanism being reflected in the long-term interest-rate levels".

According to Article 4 of the Protocol on the convergence criteria, this means that over a period of one year before the examination, the member state must have had an average nominal long-term interest rate that does not exceed by more than 2 percentage points that of, at most, the three best performing Member States in terms of price stability.[19] Interest rates shall be measured on the basis of long-term government bonds or comparable securities, taking into account differences in national definitions.

Long-term interest rates developments in the CEE-4 countries before the current financial and economic crises signalled an intensification of the convergence process in domestic financial markets compared to previous years.[20]

The speed of convergence differed among CEE-4 countries. The Czech Republic and Slovakia were closest to the euro area average, Poland lagged slightly behind and Hungary was furthest away but still keeping a good speed of convergence (at least before the financial crisis). This fast convergence process in the CEE-4 region spoke in favour of sooner euro adoption. With the beginning of the turmoil in 2008, however, long-term interest rates in the CEE-4 region overall increased in an environment of high

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[19] In 2006 when Lithuania applied for the assessment with regard to the possibility of the euro adoption, there was a big discussion whether the term "the three best performing Member States" meant "the three best performing EU Member States" or "the three best performing euro area member states". In the end the first interpretation was pushed through.

[20] As discussed in Babecky et al. (2010), in line with findings published in Analyses of the Czech Republic's Current Economic Alignment with the Euro Area by the Czech National Bank.

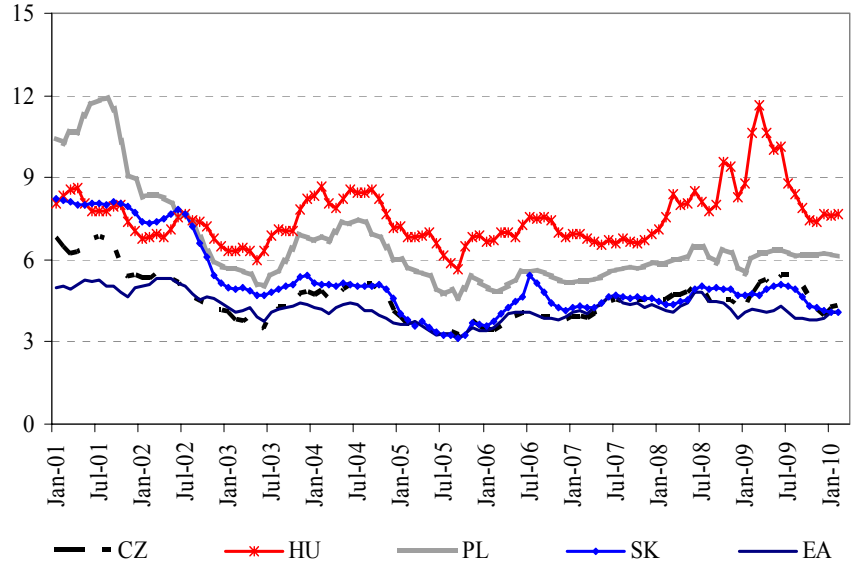
levels of risk aversion among investors and uncertainties regarding the economic outlook.

According to the Convergence Report published in May 2010, long-term interest rates in the CEE-4 countries averaged 6.1% over the reference period from April 2009 to March 2010, and thus just above the reference value for the interest rate convergence criterion. The long-term interest rates differed among individual countries, with the Czech Republic being even below the reference value.

This widening of the long-term interest rates spread was connected with the international financial crisis that brought along a general change in risk pricing and a decline in global risk appetite, but also to a general deterioration of macroeconomic conditions. Markets' assessment of external and internal vulnerabilities, the deterioration of the governments' budgetary performance, as well as prospects for sustainable convergence of some countries within the region all had an adverse impact on long-term bond market developments. While the Czech Republic and Slovakia recorded higher interest rate differences only between summer 2008 and the end of 2008, Hungary and Poland deviated to a much greater extent and for a longer period of time (see figure 3).

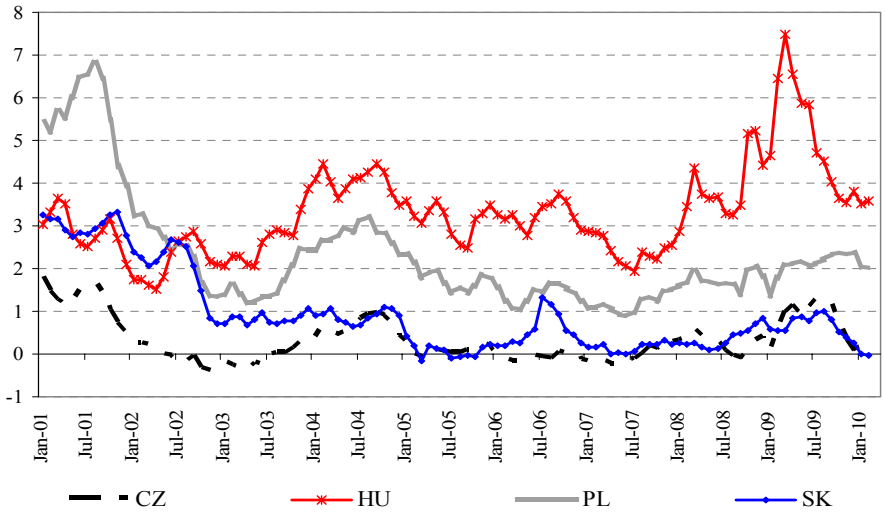
Figure 3: CEE-4 countries: Long-term interest rates, 10-year government bonds, monthly data

(i): Levels



Source: Eurostat.

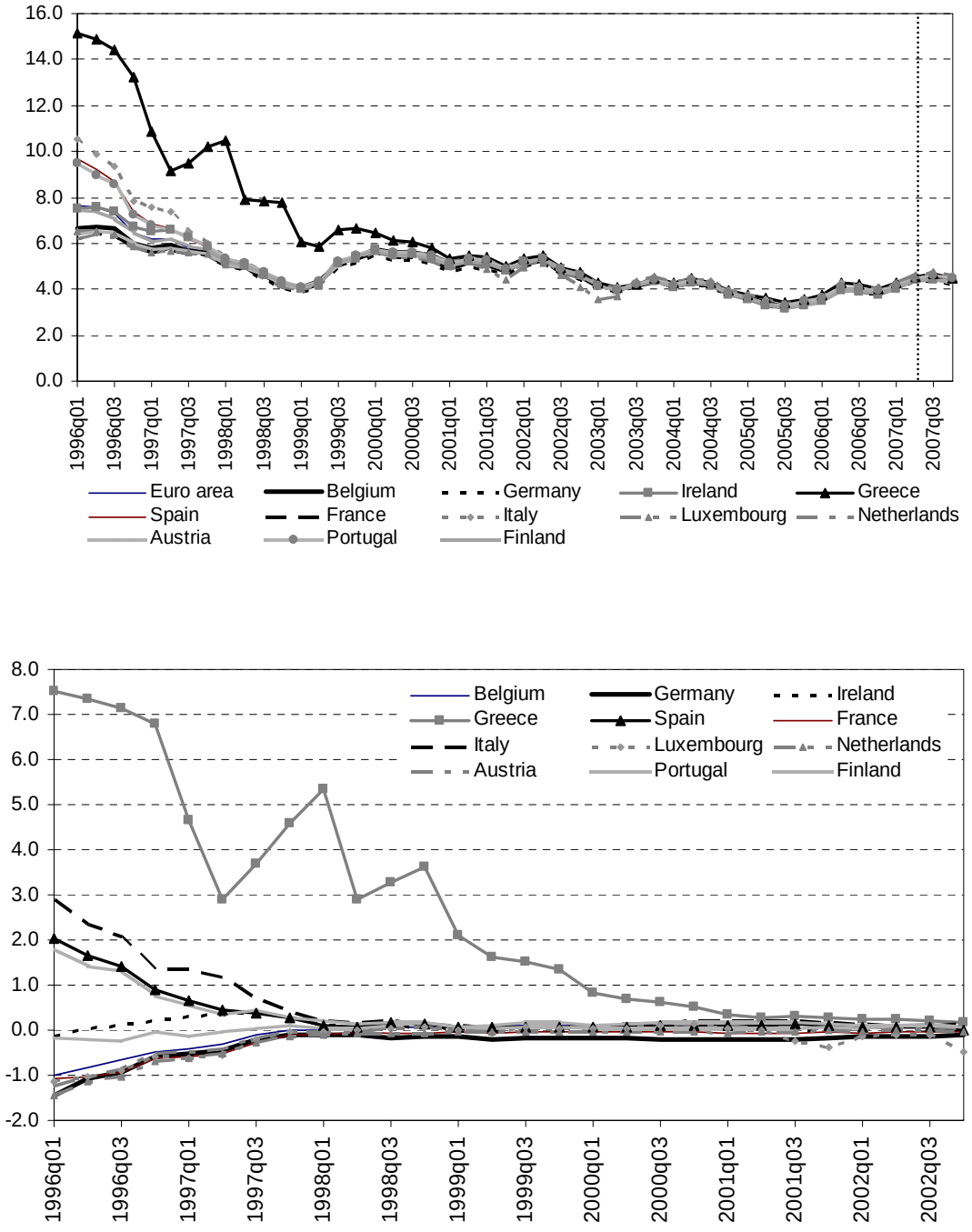
(ii) Spreads vis-à-vis the euro area



Source: Eurostat.

At the end of the nineties, when the EMU calculators were on top of their popularity, the environment was much different from nowadays. At that time, the spreads were much higher in comparison with Germany, (used as a proxy for the euro area level at that time). Quite to the contrary, the current spreads for the Czech Republic and Slovakia for most of the estimation period were not significantly different from zero and sometimes even negative, which would then cause problems in the calculations of the model developed in Chapter 7.5.

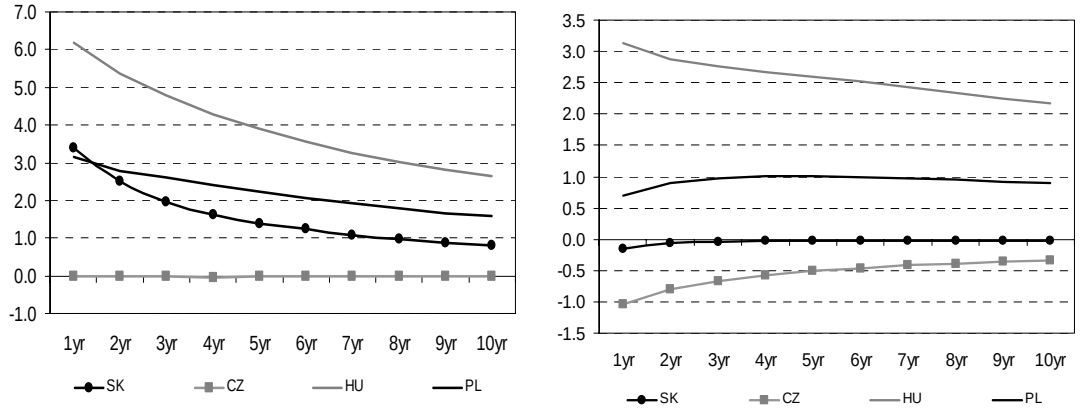
Figure 4: Old-EU Member States: Long-term interest rates, 10-year government bonds, quarterly data. Levels, in per cent (above); Spreads from the euro area, in percentage points, (below).



Source: Eurostat, own calculations.

The figures 5 below show the spreads of zero-coupon interest rate swaps of various maturities. These spreads are changing significantly over years, reflecting moves in short-term interest rates at different points of time, interest rate expectations and in particular liquidity on the swap market. Depending on the date of issuance, there are some differences in maturity yield paths but generally, they converge towards the euro area yield path. For the purpose of the thesis I preferred always to choose the most recent zero-coupon rates, based on which instantaneous rates would provide the necessary financial markets' information.

Figure 5: Zero-coupon interest rate swaps, in percent, average spread in 2003 (left) and 2005 (right), maturity 1 year to 10 years



Source: Bloomberg, own calculations.

Risk-premium factor

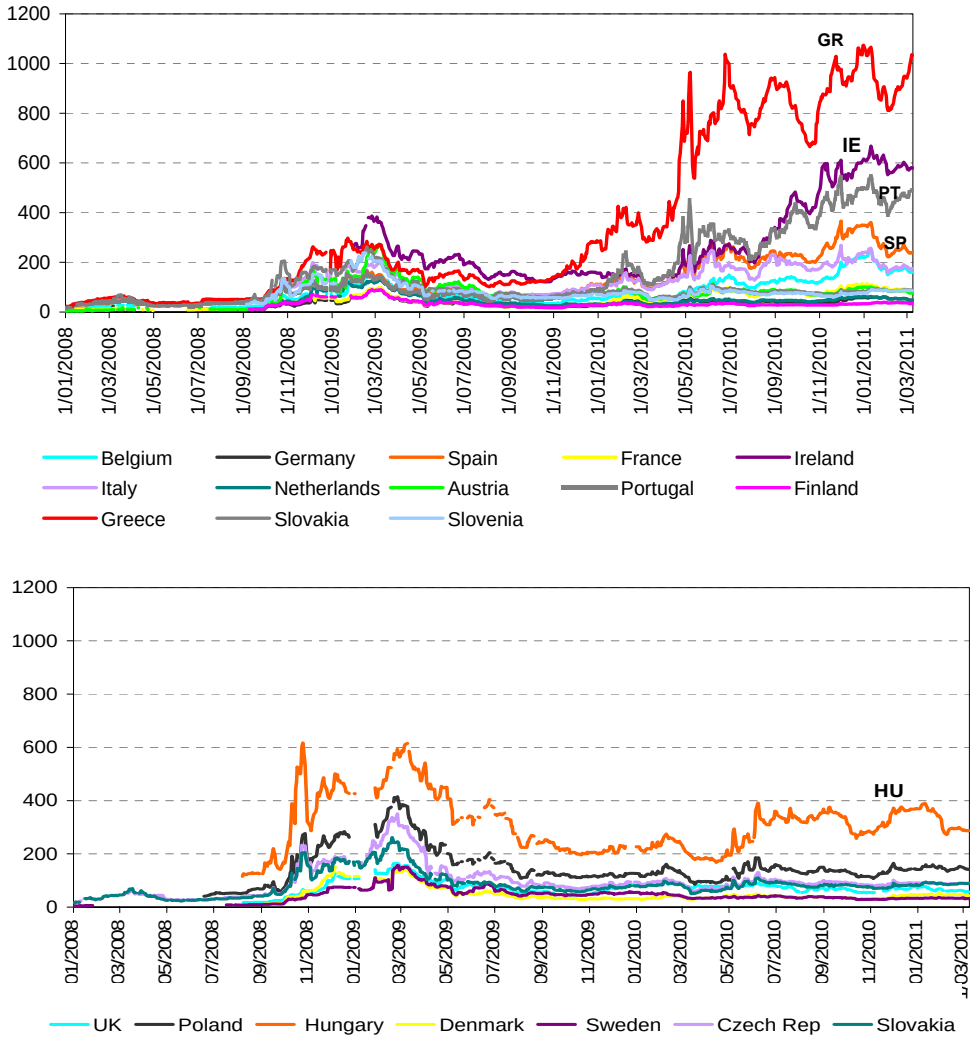
A credit default swap (CDS) are often used to manage the risk of default which arises from holding debt. CDS on sovereign bonds serve as a form of insurance of buying government bonds issued by national countries and as such the CDS can be used as an approximation for a country-risk.

The figure 6 below shows how country-risk has been changing over time. Before the end of 2008, the risk values were very low within euro area as well as for the non-euro area countries (CDS swap-market did not really exist in CEE-4 countries before mid-2008). From January 2010 onwards one can see a significant increase in risk-factor for some European countries. The risk-premium has increased especially in the case of Greece, Ireland and Portugal. Elevated levels were also reached in Spain, Italy and

Belgium. Among CEE-4 countries Hungary encountered the most increases in price of CDS on sovereign bonds, in particular during the months when EU/IMF financial assistance was negotiated.

Even though, the CDS swaps on sovereign bonds do signal varied country-risk among the EU countries, the instantaneous interest rate swaps are of a very short (instantaneous) maturity, when the influence of the country-risk factor is of a limited importance.

Figure 6: Credit default swaps on sovereign bonds – euro area compared to non-euro area countries (in basis points)



Source: Bloomberg.

6 NATIONAL STRATEGIES AND SURVEY INTERPRETATIONS OF EMU ENLARGEMENT

Let me start this chapter with a quote of my favourite Irish playwright, George Bernard Shaw: *"The problem with communication ... is the illusion that it has been accomplished."*

Communication with the public is very important for monetary authorities. To make their policy decisions understood by the public and by financial market participants, they need to give strategic priority to effective communication and proper interaction with the public. A high degree of transparency helps to make the monetary policy more credible and effective. On the one hand, it makes it easier for the public to hold the national authorities accountable for their policy decisions. On the other hand, national authorities (especially the central banks) can develop a proper interaction and understanding with financial markets on policy-related issues. This helps to limit surprise factors and shocks disrupting a smooth policy-implementation process. Changing over to a new currency affects many aspects of the daily life of every citizen. Timely and effective communication is an essential task for any Member State planning to introduce the euro, and experience shows that it is also crucial for a successful adoption of a new currency.

This chapter elaborates on national monetary policy objectives and strategies concerning euro adoption in CEE-4 countries, as communicated in official publications by National Central Banks and governments. In a second part, it shows to what extent their communication was in line with market understanding of expected entry to the euro area. The latter is analysed using market surveys performed by Reuters on a regular basis.

6.1 Monetary integration plans in a historical perspective

All Member States that joined the European Union in 2004 or later have to enter the euro area sooner or later. This process started on 1 January 2007 when Slovenia became the first EU Member State from the 2004 enlargement to adopt the euro. It was followed by Cyprus and Malta as of 1 January 2008. Slovakia adopted the euro in January 2009 as the first country from the CEE-4 group.

In all CEE-4 countries, official strategies for adopting the euro are published in cooperation between the national central bank and the Ministry of Finance. While these strategies include a certain political element, they focus mainly on the assessment of meeting the Maastricht convergence criteria. The strategy papers also define the individual stages of the accession process and requirements for individual types of policies, as well as technical and organisational measures necessary to prepare the introduction of the euro. These communication measures contribute to economic and financial stability in the period prior to the entry into the monetary union, and in the period following the entry.

Over the past years, official strategies communicated by national authorities have changed several times. The changes reflected new developments in national macroeconomic developments like delays in public finance reforms, and in the global economic climate. The recent financial crisis had also a significant impact on euro adoption plans. However, despite all the recent pressure on the euro caused by the crisis, and debt problems of member states in the past year, joining the common currency may still be attractive to those CEE-4 countries that have not yet adopted the euro.

Before looking at each country in more detail, I start with a general overview of facts common for all the countries of the CEE-4 region. As was the case for all new EU Member States, when these four countries entered the EU in 2004, foreign direct investment inflows grew rapidly on the back of good investment opportunities and expected increasing profits in these new markets. This stimulated economic growth in these economies and brought along structural reforms and improvements in national

legal frameworks, facilitating the economic and legal convergence process. During the first years after the EU entry, the situation regarding a possibility to fulfil all necessary Maastricht criteria rather fast looked very optimistic for all of these countries.

Since mid-2006, however, unsuccessful implementation of structural reforms as well as loose fiscal policy and worsening fiscal stance has led to a postponement of national euro adoption plans in all CEE-4 countries but Slovakia. Throughout the relevant reporting period, the Slovak Ministry of Finance reported that Slovakia's preparations for entering the euro area were proceeding according to the government's plan to adopt the single currency in 2009. It was, in the end, the only CEE-4 country that followed its original plans.

Yet another adjustment of national euro adoption plans in the other three sample countries came with the financial crisis. For all the non-euro area new EU Member States the global crisis has set back their path into the euro area. On one side, the crisis brought a decline in inflation for the CEE region. On the other side, price levels also declined in global terms, shifting the reference value for a price criterion downwards. At same time, fiscal balances seriously deteriorated in CEE-4 countries as well as globally. This was, however, not reflected in the fiscal criterion benchmark. The political climate is usually not much in favour of tightening fiscal stance and therefore only the coming years will reveal how much political capital the governments of the CEE region are willing to give up in order to bring their fiscal balances back in line with the Maastricht criterion set at government deficits below 3% of GDP. Unstable political environments with frequent elections and a rather short legislative cycle also play a weighty role within the convergence process. Volatility in exchange rates of domestic currencies vis-à-vis the euro increased, bringing even more instability to economic developments in these countries.

Below I look in more details on country-by-country experience with euro adoption plans. Comparing changes of national strategies in individual countries and their communication towards the public, and placing these in connection with market polls, provides a good signal of their credibility and understanding by general public. Following subchapters are also based at convergence programmes published by the

European Commission and European Central Bank, as these might be seen as less politically (but more data) driven sources of information on euro adoption, which are read by a broad public.[21]

6.1.1 Czech Republic

The most specific declaration of the monetary integration plans of the Czech Republic, regarding the intentions and timetable for participation in the ERM II and the third stage of the economic and monetary union, was published in "The Czech Republic's Euro-area Accession Strategy", a joint document of the Czech Government and the Czech National Bank (CNB). The first version was approved by the Government on 13 October 2003. The three key elements are the following:

1. The Czech Republic should enter the exchange-rate mechanism only when such conditions are established that would make the euro introduction feasible and smooth, and which would make it possible to introduce the euro at the time of the assessment of the exchange rate criterion (two years after joining the ERM II) and then to benefit from its introduction without experiencing any problems.

2. The readiness of the Czech Republic for ERM II participation and euro-area accession shall be assessed each year not only with respect to fulfilment of the formal entry criteria but also by means of detailed economic analyses.

   While the strategy shall remain stable over time, the Czech National Bank prepares an evaluation of the convergence process in its annual "Assessment of the Fulfilment of the Maastricht Convergence Criteria and the Degree of Economic Alignment of the Czech Republic with the Eurozone".

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[21] Convergence Programmes are published regularly by the European Commission, after being submitted by the European countries. Convergence Reports are written and published by the European Central Bank, after being commented by national central banks. Convergence Reports, however, do not elaborate on euro strategy, therefore Convergence Programmes provide a useful source of information on this matter.

Specifically, every autumn the Government should receive from the CNB and the Czech Ministry of Finance an assessment of the Czech economy's current situation with respect to convergence towards the euro area and expected fulfilment of the Maastricht convergence criteria, and an assessment of the Czech economy's alignment with the euro area. On the basis of this assessment, the CNB and the Ministry of Finance propose to the Government a decision on whether to initiate the procedure that would lead the Czech koruna into the ERM II.

Given the intention to participate in the ERM II for only the minimum two-year period, the decision to join the ERM II immediately implies an approximate date when the Czech koruna is supposed to be converted for the euro. The euro adoption date was conditionally expected to be 2009-2010.

3. Until the monetary integration process is completed, independent Czech monetary policy will continue to be implemented by means of the inflation targeting strategy. Within this system, the inflation targets will be directed at fulfilling the Maastricht convergence criteria on price stability and long-term interest rates.

The Strategy was updated in 2007. A target date for euro adoption, previously 2009-2010, was not mentioned anymore due to unforeseeable developments in the area of fiscal policies.

The Convergence Programmes apply several criteria which include a successful consolidation of public finances, a sufficient level of achieved real convergence and adequate progress with structural reforms guaranteeing sufficient economic alignment. Later publications of the Convergence Programme up to the most recent one from February 2010, provide a good overview of how euro adoption plans in the Czech Republic developed over time (summarized in table 3). Therefore I will look into these Programmes in more details.

Starting with the first Convergence Programme submitted by the Czech authorities and published by the European Commission in May 2004, soon after the Czech Republic's EU accession, the line of communication on a strategy for euro adoption was based on the joint document from October 2003, "The Czech Republic's Euro-area Accession

Strategy", which announced the aimed date for the euro adoption being set around the years 2009 and 2010. The strategy document also made it clear that the CNB perceives the participation in ERM II only as a prerequisite for joining the euro-area and as such a longer-than-necessary stay in ERM II is not considered desirable. Hence, the Czech Republic should enter ERM II only after conditions have been established for successful fulfilment of convergence criteria. This requires that the Maastricht criteria are fulfilled, including the most difficult one – a successful consolidation of public finances –, and that a sufficient level of real convergence is achieved alongside with an adequate progress in the necessary structural reforms, in order to ensure sufficient economic alignment with the other euro area Member States. Since the Czech Republic was expected to join the euro-area around 2009–2010, ERM II participation was to be requested in time to start in around mid-2007.

The 2004-2005 Convergence Report published in December 2004 continued along the same lines, in accordance with the joint document of the CNB and the Government. This strategic document, analytical background papers for an annual assessment of the Czech economy's current and expected fulfilment of the Maastricht convergence criteria, and an assessment of the degree of the Czech economy's alignment with the euro area, led the Ministry of Finance and the CNB to recommend the Czech government to postpone participation in ERM II. The expected date for the Czech Republic to join the euro area stayed however the same as mentioned in the 2004 spring Convergence Programme (i.e. around 2009–2010), implying the start of the ERM II regime around 2007.

The 2005-2006 Convergence Programme published in November 2005 communicated that the Czech Republic was preparing to join the euro area in 2010. A major shift came with the next Programme published in March 2007. It indicated that the long-term stabilisation of the general government sector had not been maintained at a level significantly below the 3% reference value, and that there remained a traditional weak spot in the labour market's flexibility. On one hand, analyses of the Czech economy's alignment with the euro area confirmed that real economic convergence progressed well; on the other hand, there were persisting substantial differences in cyclical development of GDP between the Czech Republic and the euro area and in price levels.

Against this background, a decision was made not to join the ERM II system the year after and as such to the euro adoption year was postponed after 2010, without a concrete specification of any date.

The Assessment of the Fulfilment of the Maastricht Convergence Criteria and the Degree of Economic Alignment of the Czech Republic with the Eurozone, which was published in 2007, stated that insufficient progress had been made towards creating the conditions necessary for adopting the euro in order to be able to assign a target date for accession to the euro area. It also recommended that the Czech Republic, for the time being, should not set a target date for accession to the euro area. This also implied that it was not recommended to aim at entry to the ERM II mechanism in 2008; yet no concrete date for aiming at the euro adoption was communicated.

When the 2008-2009 Convergence Programme was published in November 2008, it was obvious that the Czech Republic's original Strategy for Eurozone Accession was not fulfilled and that the originally envisaged date for euro adoption in the Czech Republic of 2009/2010 was no longer realistic, as already signalled in previous Reports. The Czech Republic's Updated Strategy for Eurozone Accession, approved by the Czech government in August 2007, stated that the main obstacle to meet the Maastricht criteria was still the unconsolidated state of public finances. This, along with the low flexibility of the Czech economy, and especially of the labour market, was also a risk to Czech economic performance in the euro area and would have prevented it from reaping the benefits associated with adopting the euro. The euro adoption date was therefore linked to resolving these problematic areas with a fundamental public finance reform and strengthening the flexibility of the Czech economy. The amount of time spent in ERM II continued to be desired to be kept at a minimum.

The most recent Convergence Programme, published in January 2010, draws similar conclusions, still following the Czech Republic's Updated Strategy for Euro Area Accession. It does not set a new target date for accession to the euro area, as this date will depend on the resolution of problematic areas as part of a fundamental public finance reform and strengthening the flexibility of the Czech economy. The latest "Assessment of the Fulfilment of the Maastricht Convergence Criteria and the Degree

of Economic Alignment of the Czech Republic with the Euro Area", approved by the government on 21 December 2009, states that it is very improbable under current conditions that the Czech Republic will be able to meet all Maastricht convergence criteria in the medium-term horizon. The major barrier for entry into the monetary union will be that the general government deficit is higher than 3%. Equally uncertain is the sustainability and necessary further increase in the achieved degree of alignment of the Czech economy with the euro area in coming years. Given this situation, it is therefore impossible to establish a new target date for accession to the euro area. The document confirms that the Czech Republic will not strive for entry to the ERM II mechanism during 2010.

National euro adoption strategy

The Czech Republic's Updated Strategy for Euro Area Accession, as approved by the Czech government in August 2007, did not set a specific new target date for accession to the euro area – insisting on the resolution of problematic areas, such as a fundamental public finance reform and strengthening the flexibility of the Czech economy. The periodic document "Assessment of the Fulfilment of the Maastricht Convergence Criteria and the Degree of Economic Alignment of the Czech Republic with the Euro Area", jointly prepared by the Ministry of Finance of the Czech Republic and the CNB and approved by the government on 21 December 2009, states that it is very improbable under current conditions that the Czech Republic will be able to meet all Maastricht convergence criteria in the medium-term horizon. The major barrier for entry into the monetary union will be the general government deficit, which is higher than 3% of GDP.

Equally uncertain is an economic policy consideration whether the Czech economy can achieve an increased and sustainable alignment with the euro area in coming years. In particular, the recent financial and economic crisis has had adverse consequences for the future euro adoption. Given the situation, it is considered impossible to establish a new target date for accession to the euro area.

Market surveys and public polls results among domestic analysts show that the majority believe 2015 is the earliest realistic target date for euro adoption.

Euro-area accession will remain a highly political issue, in which the Ministry of Finance will have a significant role, trying to cut the budget deficit of the country from over 5% of GDP to under necessary 3% by 2013 or 2014 to be ready to adopt the currency by 2015-16. The current Czech government has refrained from setting a firm date, but has said it wants the country to be ready for membership by 2015. The CNB also continuously updates the material "Future Steps in the Process of Preparation for the Introduction of the Single Currency in the Czech Republic". It is aimed at defining specific measures to be taken by the central bank in institutional, technical-organizational and legislative areas, when the euro is introduced.

6.1.2 Hungary

The first Hungarian Convergence Programme, submitted by Hungary and published by the European Commission in May 2004, mentioned two scenarios on timing of the euro adoption. According to the baseline scenario, both the fiscal criteria and the inflation criterion for joining the euro area could be fulfilled by 2008. Hence, based on macroeconomic conditions, Hungary could adopt the euro relatively safely in 2010. The Programme also considered an alternative (more positive) scenario as a counterbalance to a relatively cautious baseline, according to which the criteria for joining the euro area could be fulfilled already in 2007, and the adoption of the euro could take place in 2009. The same message was provided by a macroeconomic scenario of the Updated Convergence Programme for Hungary (2004-2008), published in December 2004. The criteria for joining the euro area could be satisfied by 2008 and, the introduction of the euro would be then possible in 2010.

However, neither an Update of the Convergence Programme published in December 2005 nor the one published a year afterwards specify any concrete desired date for the euro adoption. Following a change in the Hungarian Government and also in the communication strategy on euro adoption issues, the Programme published in November 2007 communicated that the Government treats the adoption of the euro as a priority. To facilitate the introduction of the common European currency as soon as economic factors would allow, the Government started a preparation for practical changeover, setting up the National Euro Coordination Committee. The Committee

should be responsible for creating the organisational framework for the introduction of the euro and the preparation of the national changeover plan.

The 2008-2009 Convergence Programme, published in November 2008, continues along the same lines. The most recent Update of the Convergence Programme of Hungary (published in January 2010) provided information that at its meetings in 2009 the National Euro Coordination Committee reviewed the required measures and prepared the first update of the National Changeover Plan, approved by the Government in December 2009. Nevertheless, no concrete date was yet specified and communicated, while market analysts expect Hungary to adopt the euro around 2014.

National euro adoption strategy

Hungary always wanted to join the euro "as soon as possible" but it faces difficulties of meeting Maastricht criteria due to years of lax fiscal policies between 2002 and 2006 and a lack of sufficient reforms. Before the financial crisis, markets expected Hungary to adopt the euro in 2013-2014 at the earliest. Now the entry date is mostly seen in 2015.

As the MNB's governor stated, the euro has a future and adoption of the euro should be of high priority for Hungarian policy makers. One of the reasons is that the global financial crisis and the so-called European sovereign debt crisis demonstrated some weakness in the euro area but, in his words, the currency has held up better than the 16 individual member-state currencies would have done. Therefore the crisis has only strengthened the Hungarian view of the euro. While he urged Hungarian politicians to focus on working towards the euro, he also cautioned that a premature adoption of the currency would be counterproductive.

Hungary has no official target date for euro adoption, but the government plans to set a target date by the end of 2011. The consensus of analysts for Hungary's euro area entry is 2014, while some believe that Hungary adopting the euro will not come before the second half of 2015.

6.1.3 Poland

Poland's official euro adoption strategy was first laid down in two documents published in 2004. The Communiqué of the "Interdepartmental Working Group on Poland's Integration with the Economic and Monetary Union" (January 2004) discussed details of the specified objective of the Government and the National Bank of Poland (NBP) about Poland becoming a member of euro area. In March 2004, NBP published a "Report on the Costs and Benefits of Poland's Adoption of the Euro", where they mentioned two scenarios of timing of the euro area entry, stating 2007 or 2010 as the years with the highest probability.

The first Convergence Programme of Poland, published by the European Commission in May 2004, emphasized that accession to the euro area should take into consideration the macroeconomic conditions, including the possibility to fulfil the Maastricht convergence criteria. It was also agreed that the strategy for the euro adoption should provide for the shortest possible participation in the ERM II and for setting the central exchange rate at a level that would provide for a sustainable economic growth, avoiding tensions on the exchange rate market and taking into consideration the market exchange rate of the Polish złoty against the euro for a determined reference period. During the first years after Poland's accession to the European Union, the Monetary Policy Committee was convinced that Poland would profit the most from an adoption strategy that fosters optimum conditions for the introduction of the euro at the earliest possible date.

The following Convergence Programmes, starting with the one published in December 2004, repeated the main objective of monetary policy in Poland, to achieve fast real convergence with the euro area countries. This aim was supposed to be achieved through high long-term economic growth, while maintaining macroeconomic stability (i.e. price stability and sustainable current accounts), which would then facilitate preserving a stable exchange rate and fulfilling the Maastricht criteria to make it possible to enter the euro area soon. On the fiscal side, a decrease in fiscal imbalances and public finance reform were relied upon as a base for long-term macroeconomic sustainability.

Even though the Convergence Programmes in Poland did not specify any clear date for the euro adoption, except for the 2008-2009 Programme (published in the midst of the financial crisis in January 2009), a national euro adoption strategy was communicated to the public in 2007, setting a target date for the euro adoption for the beginning of 2009. However, this target date was not realistic even under the most optimal economic developments. To be able to adopt the euro in 2009, Poland would need to enter the ERM II mechanism already during the year 2006. Therefore, the communication in 2007 was clearly overly-optimistic.

Seeing it as an unrealistic target date in the midst of worsening fiscal stance, slow implementation of structural reforms and emerging global financial turmoil, both the National Bank of Poland and the new government declared an intention to join the euro area as soon as possible, but only after the budget is close to balance but the officials had avoided to indicate any target date for euro adoption.

In October 2008, the Polish government approved "the Roadmap for Poland's adoption of the euro" in order to establish the sequence of actions necessary for the introduction of the euro in Poland, as well as to specify the institutions involved in this process. The document plans necessary actions for joining the euro area, including a schedule for execution of most important tasks (especially the ones of technical character) in subsequent stages of preparations. The Roadmap envisaged euro adoption on 1 January 2012. A change in communication strategy was a part of a series of moves designed to help calm concerned investors who had been retreating from the Polish złoty as emerging market currencies were buffeted by the global financial crisis. Under this scenario, entry into ERM II should occur in the first half of 2009 and the convergence criteria would be fulfilled in 2011. However, also this plan of setting the final exchange rate between the euro and the Polish złoty in the summer 2011 is now out of consideration.

Public opinion on euro adoption was quite favourable at that time. According to an opinion poll provided in January 2009 by GfK Polonia, 65% of Poles were currently in favour of adopting the euro, up by 11 percentage points from mid-2008. Around 70% of respondents believed that the matter should be decided in a national referendum. 59% of those questioned would agree that the introduction of the euro in Poland would have

positive effects for the country. In June 2008 this opinion was shared only by 36%. Such a shift of opinion might have been caused by a belief that Poland could avoid a financial crisis by being in the euro area

The Convergence Programme published on 15 January 2009 officially announced the aimed target date for euro adoption. It stated that if Poland would meet the nominal convergence criteria in 2011, obtaining the positive opinion of the European Commission and abrogation of the derogation by the ECOFIN Council, then it should be able to adopt the euro as of 1 January 2012.

However, turbulence on financial markets and a slowdown in economic growth in Poland, as well as in its main trading partners impeded the full realisation of the schedule adopted before the economic crisis intensified. For this reason, on 27 April 2009, a document entitled "Prerequisites for Implementation of the Next Stages of the Road Map for Euro Adoption in Poland" was published. It dropped the previously announced plan for the euro adoption as of 1 January 2012 only three months after it had been officially stated. This document sets out the conditions for safe membership in ERM II. This elaborated on the issue of a central parity of the exchange rate (that should be consistent with the macroeconomic situation in the country), was clear about the duration of ERM II membership (that should be as short as possible, which should increase the credibility of the central parity as a reference point for the final conversion rate of the Polish złoty against the euro), and on other formal requirements for the participation in the euro area at the time of the assessment of Poland's readiness to adopt the common currency, which should be ensured. The report did not mention any specific date of planned euro adoption anymore, bearing in mind that first the above mentioned conditions needs to be fulfilled to be ready to adopt the European common currency at a predetermined date.

Even though the Polish government postponed their official plans to swap the złoty for the common currency in 2012 and has no longer a specific goal, several Polish officials have expressed to the media that it should be possible in 2015.

National euro adoption strategy

While euro adoption remains one of the Polish government's priorities, the prospects have been postponed somewhat, although national authorities still aim at following the necessary steps to adopt the euro in Poland as soon as possible.

On 28 October 2008, the government adopted the Roadmap for Euro Adoption in Poland, which should be followed to prepare timely and accordingly for a full membership in the monetary union. However, the plan needed to be revised after the turbulence on financial markets and a slowdown in economic growth in Poland as well as in its main trading partners that impeded the full realization of the schedule adopted before the economic crisis intensified. For this reason, on 27 April 2009, the document "Prerequisites for Implementation of the Next Stages of the Road Map for Euro Adoption in Poland" was published. It sets out the main conditions for safe membership in ERM II.

First, the level of central parity should be consistent with the macroeconomic situation in the country. Second, duration of ERM II membership should be as short as possible, which - by drawing nearer to the moment of adopting the common currency – will increase the credibility of the central parity as a reference point for the final conversion rate of the złoty to the euro. Third, the fulfilment of all formal requirements for the participation in the euro area at the time of the assessment of Poland's readiness to adopt the common currency should be ensured. Only then it will be possible to adopt the common currency at a predetermined date. Fourth, a political consensus over the necessary formal adjustments to adopt the common currency will be necessary. The conditions set out have not been met so far, which makes it impossible to set a new credible target date for euro adoption in Poland.

The adoption of the euro continues to be a strategic goal for Poland, but the government continues to work towards that goal without setting a firm euro adoption target. The Polish government originally planned to join the euro zone in 2012, but failed to meet all adoption criteria amid the global financial crisis. According to the Polish Ministry of Finance, euro area entry in the years 2014-2016 was possible.

In March 2010, the managing director of the International Monetary Fund said in an interview to the Gazeta Wyborcza daily that Poland's government would be right in postponing the euro adoption now, from their original plan to swap the złoty for the common currency in 2012. Adopting the euro should still remain Poland's longer term goal, accompanied however with responsible fiscal policy and structural reforms aimed at enhancing labour productivity and competitiveness.

Market analysts say 2015 is now the earliest that Poland can hope for with regard to euro adoption. In January 2010, the Polish president said that euro adoption in 2015 could be considered, although this seemed to be “very soon”. Poland's government has indicated that euro adoption in 2015 was realistic.

In August 2009, the IMF urged Poland to delay euro adoption to have more time to adjust to the impact of the global financial crisis. The IMF said adopting the euro was a good move for Poland but waiting until the economy recovers properly from the global turmoil would ensure a smoother transition and would also allow the economy to adjust to possible changes in long-run financing prospects prompted by global deleveraging. In response, the Polish authorities acknowledged there may be a need for short delays in adopting the euro in 2012, but overall said there were benefits to moving ahead as planned, considering that an early adoption target would help galvanize support for fiscal consolidation and structural reforms.

6.1.4 Slovakia

In Slovakia, monetary policy strategy had been inflation targeting. Since November 2005, this meant inflation targeting under the conditions of ERM II, as the Slovak koruna now participated in the ERM II regime with a ±15% fluctuation band around the exchange rate of 38.4550 SKR vis-à-vis the euro. This parity was re-valued on 17 March 2007 to 35.4424 against the euro. On 28 May 2008, the exchange rate was re-set one more time, to 30.1260 per euro. The inflation target for the period 2006-2008 was set below 2.5% for end-2006 and below 2% at end-2007 and at the end of 2008.

On 16 July 2003 the Slovak Government approved the joint proposal of the Slovak Ministry of Finance and the National Bank of Slovakia (NBS) on the euro adoption

strategy. "The Strategy of the Slovak Republic for Adoption of the Euro" was a subject of public, academic and political discussions and presented a programme approach of the Government and the NBS on the issue of entering the euro area. After its approval by the Government it became a starting point for specifying and setting out further steps in the accession process. As a strategy it did not set a precise deadline, but rather spoke of a timetable of 2008 to 2009.

In September 2004 the government passed the "Specification of Strategy for the Adoption of Euro in the Slovak Republic ". The main objective of this document was to offer a detailed description of the accession process to the public and to specify the exact timetable based on the assessment of Maastricht criteria fulfilment on a sustainable basis. The main conclusion of the specified strategy was that Slovakia would be ready to join the euro area in 2009. The managed floating exchange-rate regime in Slovakia was then planned to be replaced with the ERM II exchange rate mechanism no later than in the first half of 2006.

The Convergence Programme for Slovakia, published at the end of 2005 and covering the period 2005-2010, presented three main targets in the fiscal, monetary and labour market areas. (i) The medium-term fiscal target is to reduce general government deficit together with the impact of the pension reform, to 3% of GDP in 2007, and to 0.9% by 2010, which is in line with the range recommended by the European Commission under the Stability and Growth Pact reform. Furthermore, long-term sustainability of public finance at the end of the decade was to be ensured. (ii) As regards the monetary area, the key intention was integration into the euro area, with full integration of Slovakia still expected to begin in 2009. (iii) The main medium-term target of the labour market was to increase the employment rate by 1 to 2% per annum.

In the end, the Slovak Republic was the first CEE-4 country to adopt the euro and entered the euro area on 1 January 2009. Slovakia is clearly the most relevant precedent for the rest of CEE-4 countries

It is an exemplar case for inflation targeting economies with managed floating exchange rates. Slovakia's monetary policy had been based on inflation targeting framework before it entered the exchange rate mechanism, inside which for two years the Slovak koruna could fluctuate only within a narrow band.

The Slovak experience with speculations against the Slovak koruna during this two years time and sustainability of the necessary interventions activities in by the National Bank of Slovakia financial markets are very useful for the rest of the CEE-4 countries. The euro was successfully adopted on 1 January 2009.

6.1.5 Summary

Tables 3 and 4 provide an overview and summary of information on euro adoption plans according to published convergence programmes and monetary integration plans of CEE-4 countries presented above within sections 6.1.1. to 6.1.4.

Table 3: Euro adoption plans according to Convergence Programmes published by the European Commission

Country	Round	Date	Euro adoption
Czech Republic	2003 - 2004	13.5.2004	2009-2010
	2004 - 2005	1.12.2004	around 2009-2010
	2005 - 2006	24.11.2005	2010
	2006 - 2007	15.3.2007	> 2010
	2007 - 2008	30.11.2007	> 2010
	2008 - 2009	20.11.2008	no date
	2009 - 2010	15.2.2010	no date
Hungary	2003 - 2004	14.5.2004	2010
	2004 - 2005	1.12.2004	no date
	2005 - 2006	1.12.2005*	no date
	2006 - 2007	1.12.2006	no date
	2007 - 2008	30.11.2007	no date
	2008 - 2009	19.12.2008	no date
	2009 - 2010	29.1.2010	no date
Poland	2003 - 2004	17.5.2004	no date
	2004 - 2005	1.12.2004	no date
	2005 - 2006	19.1.2006	no date
	2006 - 2007	30.11.2006	no date
	2007 - 2008	26.3.2008	no date
	2008 - 2009	15.1.2009	1 January 2012
	2009 - 2010	8.2.2010	no date
Slovakia	2003 - 2004	14.5.2004	2008 or 2009 at the latest
	2004 - 2005	30.11.2004	2009
	2005 - 2006	1.12.2005	2009
	2006 - 2007	1.12.2006	2009
	2007 - 2008	29.11.2007	1 January 2009
	2008 - 2009**	30.4.2009	1 January 2009
	2009 - 2010**	29.1.2010	1 January 2009

* Adjusted programme submitted 1.9.2006, following the Council's invitation of 14.2.2006
** Stability Programme.
NB: In accordance with Regulation (EC) No 1466/97, amended by Regulation 1055/2005, Member States are required to submit a stability programme (members of EMU) or a convergence programme (non-members).

Source: European Commission, Stability and convergence programmes.
http://ec.europa.eu/economy_finance/sgp/convergence/programmes/2009-10_en.htm

Table 4: Monetary integration plans of CEE Member States (excl. Slovakia)

Country	Intentions for ERM II	Intentions for euro adoption
Czech Republic	Currently no official target date.	No official target date.
	The Czech national authorities aim to stay in ERM II for the minimum two-year period.	According to the Czech euro accession strategy (08/2007), the main obstacles relate to the need for enhancing the flexibility of the economy and fiscal consolidation.
Hungary	No official strategy.	No official target date.
Poland	No official strategy.	No official target date.
	Once the conditions are more favourable in terms of exchange rate volatility and political support. Poland national authorities aim to stay in ERM II for the minimum two-year period.	At the earliest possible time after achieving the necessary political support. The government published a revised roadmap ("National Changeover Plan") in autumn 2009.

Source: ECB, ESCB.

6.2 Market survey results

Financial market participants' views on the date when a EU member state will join the euro area can differ from the official strategies. Survey results are a useful source to detect such differences. Since the late 1990s, Reuters news-wire services have been conducting market surveys concerning EU and EMU enlargement. Reuters surveys around 40 emerging market strategists for their views on when the newest members of the European Union are likely to adopt the euro and when the EU may admit more new members. In the survey, experts at banking institutions, research houses, think tanks, universities and employers' associations in Europe are asked about their opinion on various issues regarding the euro adoption and EMU entry.[22] During the 1990s, such market polls were conducted monthly for the old EU Member States, with the results being released and often compared to several published EMU calculators, such as J.P. Morgan EMU calculators (published in the Financial Times).

Nowadays, these polls are conducted semi-annually for the non-euro area EU Member States that joined the EU in May 2004 (Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, and Slovakia) and in January 2007 (Bulgaria and Romania) as well as for several candidate countries (Croatia and Turkey). The respondents also provide their expectations about exchange rate parities of national currencies vis-à-vis the euro and about other euro-related topics. Such polls provide a genuine helpful insight into market perceptions about the timing of euro adoption, most of which are priced in financial markets data.

The results have to be interpreted with some degree of caution for several reasons. For example, some responses are rather unrealistic and not internally consistent. In particular, answers to questions about ERM II entry and euro adoption do not always reflect the Maastricht requirement that a country should remain in the exchange rate mechanism for at least two years before it is allowed to adopt the euro.

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[22] More information and a list of respondents is available at Reuters under a code <EMUPOLL34>. For additional survey details, see <EMUPOLL30> to <EMUPOLL37>.

Table 5: Reuters poll on EMU expansion – the latest available market survey, conducted in May 2010: "In what year do you expect the following countries to formally adopt the euro?"

	Mean	Latest	Earliest
Czech Rep.	***2016***	2020	2013
Hungary	***2015***	2019	2013
Poland	***2015***	2019	2014

Source: Reuters.

Table 5 presents a summary of the latest results on the question of the expected timing of EMU accession of the Czech Republic, Hungary, and Poland. The survey was conducted by Reuters in May 2010. Based on the outcome of the survey, all the CEE-3 countries (the Czech Republic, Hungary, and Poland) are expected to join the euro area at the earliest in 2013 and 2014 (the latter in the case of Poland). This would imply an entry to ERM II already early 2012, which is a seemingly unrealistic date. The most sceptical entry dates are 2019 and 2020 (the Czech Republic).

The most meaningful expected entry date is represented by a mean of provided responses. These tell us that a representative market analyst would expect Hungary and Poland to adopt the euro in 2015 and the Czech Republic in 2016. This implies an ERM II entry date in or around 2013, which seems to be a realistic scenario.

The expected date of ERM II entry is another question asked within the Reuters query. This question provides additional information on market feedback on the expected euro adoption process but also serves as a robustness check. Knowing - based on the Maastricht criteria - that the period when a countries' currency moves within the allowed ERM II interval cannot be shorter than two years, it can be checked how reasonable markets' responses are. Table 6 presents responses on ERM II entry dates.

Table 6: Reuters poll on EMU expansion, May 2010: "In what year do you expect the following countries, which are at various stages on the road to euro adoption, to enter the exchange rate mechanism ERM II?"

	Mean	Latest	Earliest
Czech Rep.	***2013***	2017	2011
Hungary	***2013***	2015	2011
Poland	***2012***	2015	2011

Source: Reuters.

In May 2010, financial market participants would on average expect the Czech Republic and Hungary to enter the exchange-rate mechanism in 2013F and Poland a year earlier. The interval within which their responses lie is smaller in case of Hungary and Poland – between 2011 and 2015 – and wider in the case of the Czech Republic – between 2011 and 2017.

Table 7: Robustness check – Reuters poll on euro area / EMU expansion, May 2010.

	Mean		Latest		Earliest	
	euro	**ERM II +2**	**euro**	**ERM II +2**	**euro**	**ERM II +2**
Czech Rep.	***2016***	***2015***	***2020***	***2019***	***2013***	***2013***
Hungary	***2015***	***2015***	***2019***	***2017***	***2013***	***2013***
Poland	***2015***	***2014***	***2019***	***2017***	***2014***	***2013***

Source: Reuters.

Table 7 provides a check of reliability of their answers on the euro adoption timing question. Columns ERM II+2 present a date that is obtained adding two years (i.e. the minimum necessary time that countries must spend within the ERM II mechanism) to answers presented in the same Reuters survey on question of expected date of entry to the exchange-rate mechanism (see table 6). Adding at least half a year for administrative purposes and transition process and a bit of leeway, these would imply that being fully consistent with responses on the ERM II timing responses; the euro adoption date should take place at the earliest in 2015-2016 in the Czech Republic and Hungary and in 2014-2015 in Poland, which is in full accordance with responses on the euro adoption

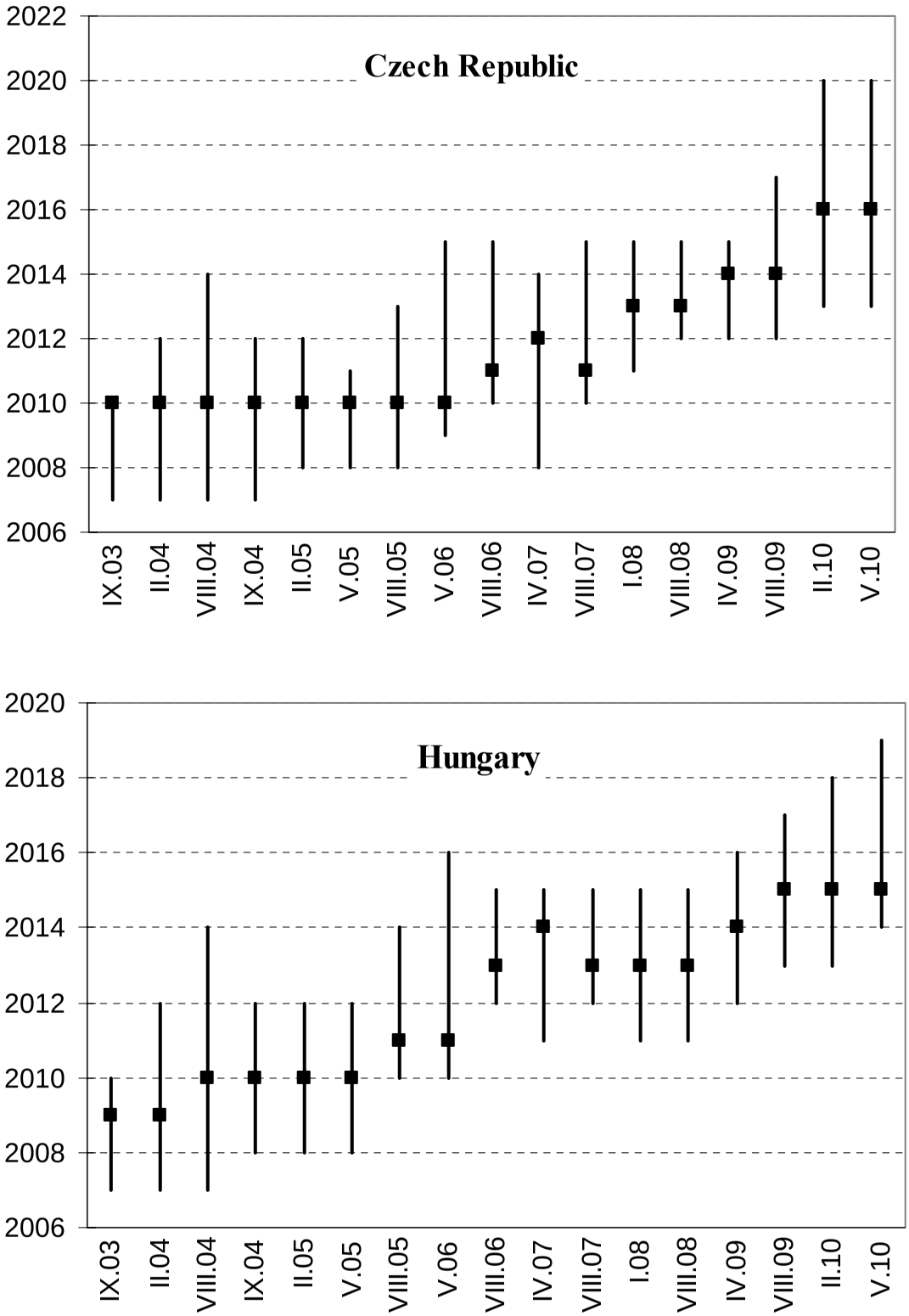
question. This shows that, at least from consistency perspective, the Reuters survey can be a valid instrument to find out about financial markets' expectations with regard to the ERM II / EMU entry dates.

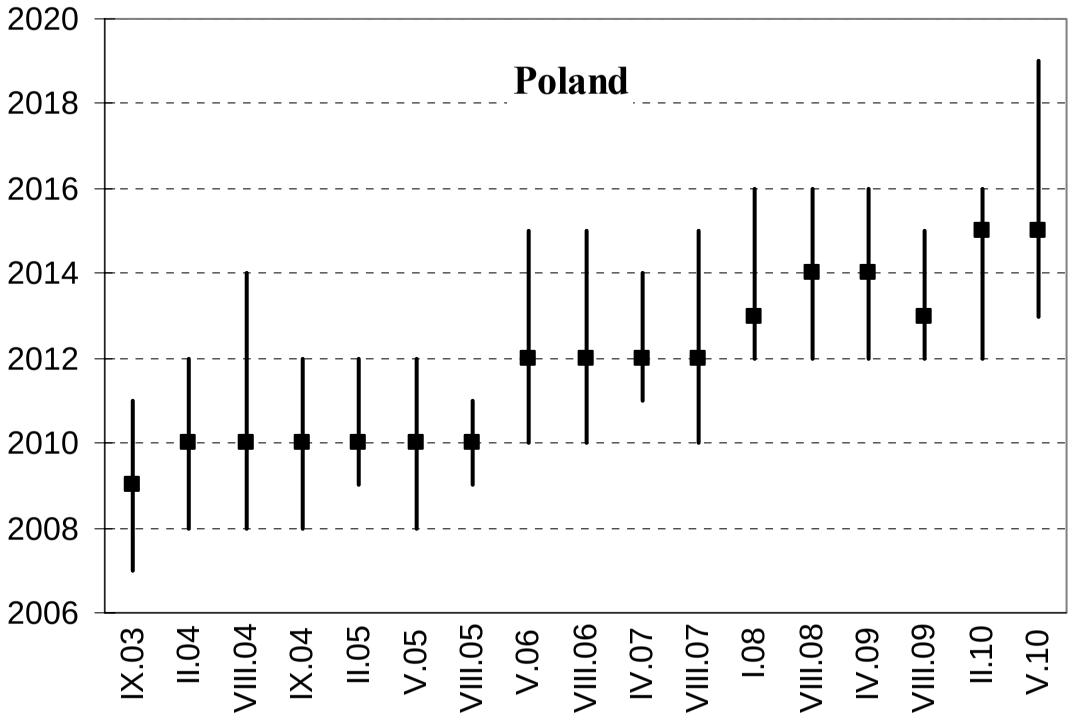
An interesting aspect provides also a look at a development of the Reuters polls results in time (see figure 7). In case of the Czech Republic and Hungary, we can see an increasing trend in the mean estimates of the polls, except for August 2007 when the mean declined compared to its previous value (as of April 2007). In case of Poland, one can see also a non-declining trend in timing of the euro area expected accession date (expect August 2009), measured as a mean value of all provided responses. In Slovakia, the market poll was very stable, expecting the country to adopt the euro in 2009, except for a less optimistic outcome in August 2007 and August 2008, when Slovakia was assumed to enter only in 2010, however, with a rather high dispersion interval (i.e. the difference between a minimum and a maximum expected date).

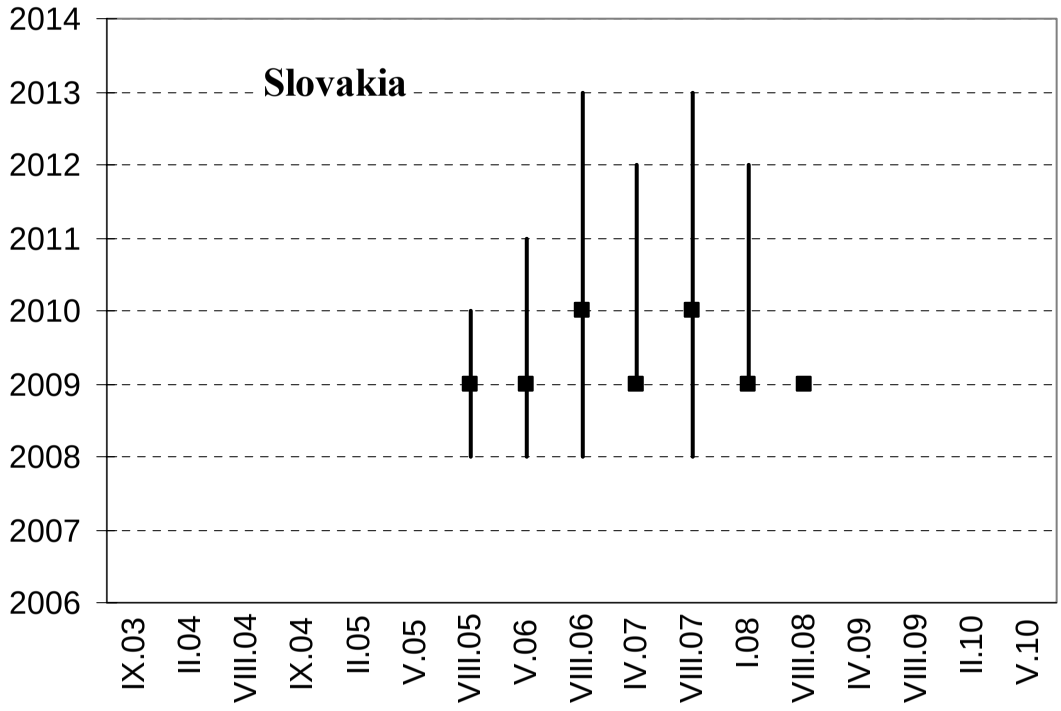
The outcome of Reuters surveys shows to what degree are market analysts in accords with officially communicated official strategies adopted by individual countries. Due to the fact that future financial market data should include expectations on euro adoption, these polls should be also in line with market-based data calculated probabilities, except for a risk premium that is stemming from other external factors not necessary connected with the convergence process (i.e. market liquidity, term-structure of traded instruments, country risk premium, and others).

In general, Reuters results are closely mirroring the outcomes of national official strategies communicated by national authorities, as demonstrated in Chapter 9.

Figure 7: Reuters market polls







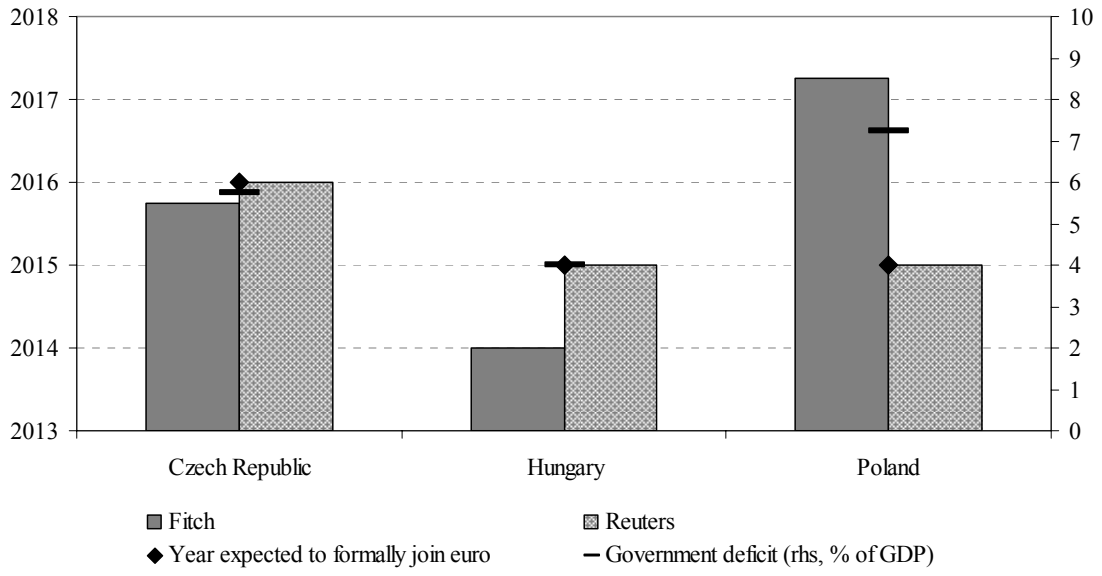
Source: Reuters.

In a Reuters poll conducted in May 2010 forecasters scaled back their median forecast for the Czech Republic's euro accession by a year to 2016, while Poland and Hungary were still seen adopting euro in 2015. Eight analysts out of 38 saw at least one country out of Bulgaria, Hungary, Poland, Lithuania, Latvia, Romania and the Czech Republic adopting the euro as late as 2018 onwards, compared to four out of 49 in February 2010.

An interesting source to extract market views on euro accession in the CEE-3 group is Fitch Ratings' Report on EMU Convergence, published in May 2010. The report outlines that the global financial crisis has caused a further delay in euro adoption timetables in most EU member states in the CEE region, owing to a marked widening of budget deficits and higher sovereign bond spreads.[23] Fitch's May 2010 forecast dates for euro adoption were 2015 for Hungary and Poland; and 2016 for the Czech Republic. However, the risks are said to be skewed towards longer delays, especially due to increased average budget deficits and increasing government debt ratio. The crisis has also made it more difficult for CEE countries to meet the Maastricht criterion on long-term interest rates, owing to a rise in global risk premiums and the heightened focus on sovereign risk. On contrast, the recession and correction of prior overheating have helped to reduce inflation. Overall, Fitch currently believes that euro membership would be a net benefit to CEE sovereign creditworthiness in the medium term.

[23] Fitch Ratings' Report entitled "EMU Convergence Report: 2010", available on the agency's website at www.fitchratings.com

Figure 8: EMU enlargement poll – by Reuters and Fitch



Source: European Commission, Reuters poll, Fitch Rating's Report.

Note: Year expected to formally join euro area is represented by a median forecast in the Reuters poll.

Figure 8 provides a comparison between Reuters poll and Fitch's EMU Report, both from May 2010. The expected year to formally join the euro area, represented by a median forecast in the Reuters poll, is also depicted in the figure. While for the Czech Republic both sources are nearly in accordance, Fitch is much more pessimistic in Poland's case, where they better account for recent negative developments in government accounts. For Hungary, Reuters mean estimate believes a more optimistic by one year than Fitch; however, the median forecast is in line with the latter one.

7 MEASURING FINANCIAL MARKETS' ASSESSMENT OF THE EURO ADOPTION: METHOD OF THE STATIC PROBABILITY CALCULATORS

Based on financial market data chapter 7 estimates a probability that financial market attaches to the event that a non-euro area EU country joins the euro area at a specific point of time. In other words, this method estimates consensus probability that a country becomes a future member of the euro area, based on the idea that under a common currency and common monetary policy regime money market interest rates of participating countries should almost coincide, except for some difference due to contry-risk and liquidity premia.

7.1 Introduction

Extracting market expectations from asset prices has been attracting a lot of attention already since the middle of 1990s. In late 1990s, new methods on the term structure of asset prices were introduced, among other reasons also with the aim to estimate the probability financial markets attach to the event that a country joins the monetary union.

Throughout the 1990s, Italy received a lot of attention because of discrepancies between conducted market surveys and results of published EMU calculators. Market surveys were at that time conducted and published monthly by Reuters, while the EMU calculators were among others presented daily by J.P. Morgan in the Financial Times and by Credito Italiano in the Italian Corriere della Sera newspapers.

Similarly to the situation in the mid-1990s, the entry date to the euro area is not obvious for most of the non-euro area EU member states. The assessment in Chapter 6 has shown how Reuters market surveys on euro adoption in these countries have varied, and national euro adoption strategies have changed significantly, over the years. At the moment, the exact timing of the euro adoption in these countries remains unclear. This fact is even multiplied lately by the recent financial crisis that has impacted the euro

area accession perspective of all four CEE-4 countries. Even though reasons for ambiguities regarding the euro adoption in these countries differ to some extent from the Italian case, a methodology based on financial market data and analysis of market surveys is well suited to be applied.

This part of the thesis follows an adjusted approach initially developed by Favero (1999), where the calculators treat the fact that a country becomes a member of the EMU as a random event and attempt to use observed market interest rates to calculate the probability.[24]

The SPC method is based on the same data market analysts would consider to examine. At the same time, for its simplicity and logic the methodology can be compared to a way financial market expectations are normally derived.

Chapters 7.2 and 7.3 elaborate on forward interest rates of several maturities and on the way how instantaneous forward rates were derived. Following a more detailed explanation given in Chapter 7.5 on how the EMU calculator was constructed, section 7.6 concludes this chapter by presenting empirical results.

[24] Such a technique could also be applied to extract information from asset prices on imminent changes in an exchange rate regime. In particular, how asset prices incorporate the expectation of a regime switch, as in Flood and Garber (1983). Nonetheless, the regime-switching expectation model is behind the scope of the thesis.

7.2 Data and Methodology

The model uses the current spot money market interest rates and the best available money market derivative instruments. For the CEE-4 countries, these are interest rate swaps, denominated in respective national currencies.[25]

The swaps markets had grown rapidly in CEE-4 countries over the past years and became one of the most liquid markets. Therefore, interest-rate swap time series are well suited for these calculations because of necessary length and frequency of the series for all CEE-4 countries. Interest rate swaps data are available on Bloomberg for all CEE-4 countries with maturities from one to 15 years at daily frequency and with maturities between 16 to 20 years, 25 and 30 years at a lower frequency and a lower regularity.

Forward swap interest rates are interest rates on investment made at a future date, the settlement date, which will expire at a date even further in the future, the maturity date. Instantaneous swap interest rates are the limit as the settlement date and the maturity date converge to each other. In case that the yield curve is positively sloped, the instantaneous forward rates lie above the curve of spot rates and the other way round.

Instantaneous interest rates play an important role when making a judgement on euro adoption timing. They should be very much in line with those of the other euro area countries. The only difference stems from a country-specific risk that has been diminishing significantly over the past years as economic fundamentals of the CEE-4 countries fast converging to the euro area level.

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[25] A swap is an agreement between two counterparties to exchange a sequence of cash flows in the same or different currencies. There are five basic kinds of swaps: interest rate swaps, foreign currency swaps, equity swaps, commodity swaps and credit swaps. For the purpose of the thesis, where probability is calculated based on convergence of interest rates towards the euro area rates, the interest rate swaps are well suited to be used. In an interest rate swap, one party might pay interest based on a floating rate, while the other party would pay at a fixed rate. Hence, interest rate swap is an exchange of a fixed rate of interest on a certain notional principal for a floating rate of interest on the same notional principal.

Historical data availability varies over the sample of CEE-4 countries. It is the longest for the Czech Republic (since January 1999), starting later for Poland and Slovakia (June and October 2000, respectively) and the latest for Hungary (since April 2002). The cut-off date for CEE-4 countries data is July 2009. In case of Italy and Germany, the data span is from January 1991 until July 2009. However, the interest rate swaps are equal for both countries from January 1999 onwards, when the monetary union started. Data after the start-up of the current financial crisis, in June 2007, might be somewhat misleading as the recent data has not been following the normal path but were deformed due to lacking liquidity in the market and increasing risk premia not only on country level, but also in general due to lack of creditworthiness of global financial system.

Calculations are then based on zero coupons data[26] calculated from the swap rates over the past ten years for CEE-4 countries and for the euro area (as well as Germany and Italy for comparative purposes). The proposed model then estimates market consensus forecast of future monetary policy developments and calculates a priced-in probability of interest rate changes for different future time horizons, throughout a time frame from 2003 to 2019. The same approach is used also for the German and the Italian data during the years 1998 to 2010, to show the robustness and reliability of the model.

A spot interest rate can be defined as an annual return of a zero-coupon with a remaining maturity equal to the investor's horizon (meaning the length of time between the start of the loan and the time of its reimbursement). Following the Nelson-Siegel-Svensson methodology, presented in the following subchapter, instantaneous forward rates were calculated based on the zero-coupons rates on interest rates swaps of several maturities.

For all of these data I calculate monthly and quarterly averages, which I use throughout my estimations – monthly data whenever only financial side of economy is considered, while quarterly data have to be applied in case of macroeconomic developments are taken into consideration.

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[26] A coupon rate is the yearly value of cash flows paid by the bond issuer divided by the amount borrowed (so called principal, par value). If no coupons are to be paid, the bond is called a zero-coupon bond and is said to be a pure-discount security.

7.3 Nelson-Siegel-Svensson Method

The Nelson-Siegel-Svensson method was developed in Svensson (1994) to derive instantaneous forward rates from interest rates financial derivatives of several maturities. The underlying idea is the following.

Let PZC_{mt} be a price of a zero-coupon bond issued at time *t*, with a face value *l*, maturity of *m* years, with a yield Y_{mt}. In these conditions, the relation between the price and the yield can be defined according to equation (1.2) below:

$$PZC_{mt} = \frac{1}{(1+Y_{mt})^m}, \tag{7.4.1}$$

The spot rate r_{mt} is then defined as a continuously compounded yield, $\log(1+Y_{mt})$, and the discount function D_{mt} as the price at time *t* of a zero-coupon that pays one unit at a time t+m**.** It then implies

$$PZC_{mt} = \exp(-mr_{mt}) = D_{mt}.$$

Let us consider a coupon bond with a paid-out coupon rate at *c* percent annually and its face value of *l* at its maturity. The price of the bond at its trading date is given by the following formula:

$$P_{mt} = \sum_{k=1}^{m} cD_{kt} + D_{mt}. \tag{7.4.2}$$

Given the prices of coupon bonds, spot rates on zero-coupon equivalents can be derived by fitting a discount function based on the specification for the spot rates as derived below:

$$r_{kt} = \beta_0 + \beta_1 \frac{1-\exp\left(-\frac{k}{\tau_1}\right)}{\frac{k}{\tau_1}} + \beta_2 \left(\frac{1-\exp\left(-\frac{k}{\tau_1}\right)}{\frac{k}{\tau_1}} - \exp\left(-\frac{k}{\tau_1}\right) \right) + \beta_3 \left(\frac{1-\exp\left(-\frac{k}{\tau_2}\right)}{\frac{k}{\tau_2}} - \exp\left(-\frac{k}{\tau_2}\right) \right) \tag{7.4.3}$$

The form above (7.4.1) was originally introduced by Svensson (1994) as an extension to an older parametrisation as in Nelson and Siegel (1987). The estimated spot rate then differs from the yield to maturity, y_{mt} quoted for coupon bonds, which is defined by:

$$P_{mt} = \sum_{k=1}^{m} c \exp(-k y_{kt}) + \exp(-m y_{mt}) .$$

Yield to maturities y_{mt} are averages of spot rates up to the date of maturity. While the spot rates P_{mt}, as in (7.4.2), vary with the maturity, the yield to maturity y_{mt} as defined by the formula above is constant. Hence the term structure of interest rates estimated on yields to maturity is only valid on a flat term structure of spot rates. Moreover, the yield to maturity for a bond with a given maturity depends on its coupon rate while the spot rates are not dependent on their coupon rates.

Implied forward swap rates can be computed from the spot swap interest rates in a rather straightforward way. A forward swap rate at time t with a trade date $t + t'$ and a settlement date $t + T$ can be computed as a return on an investment strategy based on buying zero-coupon bonds that are maturing at time $t + t'$.

The forward rate is related to the spot rate based on the following formula:

$$f_{T+t,t'+t,t} = \frac{T r_{T,t} - t' r_{t',t}}{T - t'} .$$

The instantaneous forward rate is the rate on a forward contract with an infinitesimal investment after the settlement date:

$$f_{mt} = \lim_{T \to m} f_{T+t,m+t,t} .$$

In normal practice, the instantaneous interest rates are identified as overnight forward rates, i.e. as forward rates with a maturity of one day after the settlement.

Such a definition then leads to the following relationship between the instantaneous forward rate and a spot rate:

$$r_{mt} = \frac{\int_{\tau=t}^{t+m} f_{\pi} d\tau}{m}$$

or equivalently

$$f_{mt} = r_{mt} + m\frac{\partial r_{m,t}}{\partial m}.$$

Given specification for the spot rates

$$\Delta d(T)_t = (1-\pi(T)_t)\Delta d^{OUT}(T)_t - \Delta d^{OUT}(T)_t \Delta\pi(T)_t.$$

The resulting forward function is

$$f_{kt} = \beta_0 + \beta_1 \exp\left(-\frac{k}{\tau_1}\right) + \beta_2 \frac{k}{\tau_1}\exp\left(-\frac{k}{\tau_1}\right) + \beta_3 \frac{k}{\tau_2}\exp\left(-\frac{k}{\tau_2}\right).$$

With $k \to 0$, the spot and the forward rates coincide at $\beta_0 + \beta_1$, and with $k \to \infty$, the spot and the forward interest rate coincide at β_0. The forward rate function features a constant, an exponential term decreasing when β_1 is positive.

In case of lack of data of various maturities, which is often the case in emerging economies, the presented Nelson-Siegel-Svensson interpolation can be simplified according to de La Grandville (2001). Following de La Grandville's approach, zero-coupon forward interest rate swaps are transferred into one-year-maturity swap rates based on a formula (7.4.4) below (as an approximation used for instantaneous interest rates, referred to further onwards).

$$\mathrm{f(t,T)} = \frac{(1+i(t+1))^{T/(T-t)}}{(1+i(t))^{t/(T-t)}} - 1 \tag{7.4.4}$$

which in our case when $\mathrm{T} = t+1$ can be simplified as follows:

$$\mathrm{f(t,t+1)} = \frac{(1+i(t+1))^{t+1}}{(1+i(t))^{t}} - 1 \tag{7.4.5}$$

where $\mathrm{f(t,t+1)}$ is a forward interest rate starting at a period t and reimbursed (terminating) in one year horizon in a year $\mathrm{t+1}$.

A spot rate (for a loan that starts at time 0 and is reimbursed at any time *x*) is a particular case of a forward rate, denoted $\mathrm{f(0,x)} \equiv \mathrm{i(x)}$ for a maturity *x*, or $\mathrm{f(0,t)} \equiv \mathrm{i(t)}$ representing an interest rate on swaps with maturity t.

Any interest rate plus one is usually called the "currency return" and is equal to the coefficient of one-euro (dollar) increase when invested at a yearly rate $\mathrm{i(t)}$. Since the spot interest rate $\mathrm{i(t)}$ can be considered as the forward rate $\mathrm{f(0,t)}$, the *T*-horizon spot currency return, $\mathrm{1+i(t)}$, is the weighted geometric average of the euro (dollar) forward returns, the weights being the shares of the various trading periods for he forward rates in the trading period *T*.

Hence the $\mathrm{t_n}$ horizon spot currency return is the geometric average of all currency forward rates

$$\mathrm{1+i(t_n)} = \prod_{\mathrm{j=1}}^{\mathrm{n}} [1+f(t_{j-1},t_j)]^{(t_j-t_{j-1})/t_n} \tag{7.4.6}$$

Following the above-explained Nelson-Siegel-Svensson methodology I estimate a term structure of spot interest rate swaps based on an observation of available rates of maturities up to 15 years. The resulting modified spot and forward zero-coupon rates (as in 7.4.5) are then used for further calculations of probabilities.

7.4 Construction of the Static Probability Calculator

The followed method is building on an equation (7.5.1), which is the common base for both static and dynamic probability calculator. Factors that stand behind different outcomes of these two methods will be explained later.

The Static Probability Calculator (SPC) is based on two assumptions as in Favero (1999) and J.P. Morgan (1997). The first one, of risk neutrality is relying upon derivatives being priced according to a risk-neutral martingale measure, which results when one assumes that the current value of all financial assets is equal to the expected value of the future payoff of the asset discounted at the risk-free rate. Under expectation of complete markets, the risk-neutral measure is unique.

The second assumption is based on a minor difference between a yield curve of a country which adopted the euro and the euro area yield curve. These two curves would differ only by a country-risk premium (in comparison with the euro area average risk-premium), which is very small in normal circumstances.

Implied future interest rates on zero-coupon interest rate swaps in CEE-4 countries are therefore compared to implied future interest rates on zero-coupon interest rate swaps in euro area. Market expectations of the euro area entry date are extracted as a sum of a weighted average of forward interest rates for two possible cases – first, when a country is inside the euro area at a considered time T and second, when a country is still out of the euro area at that particular date. The considered weight is based on a probability with which the country would belong to the euro area at that date.

I start with estimating a term structure of spot rates for the CEE-4 countries and for the euro area. The term structure of instantaneous forward interest rates can be extracted afterwards for each individual country, following the Nelson-Siegel-Svensson method, which was explained in the previous sub-chapter.

The fundamental idea behind construction of the static EMU calculator is that the observed forward interest rate for a country at time T can be represented as a sum of weighted average of forward interest rates when a country is a member of the euro area

at a considered time T and when such a country is outside the monetary union at this time *T*. The weight used for the purpose of the weighted average here is a probability of the country belonging to the euro area at a time *T*, denoted as $\pi(T)$ further on, which can be calculated based on formula (7.5.1).

$$f(T)_t = \pi(T)_t f^{EMU}(T)_t + (1-\pi(T)_t) f^{OUT}(T)_t \qquad (7.5.1)$$

where $f(T)_t$ is the instantaneous zero coupon interest rate swap of a non-euro area country at a future date T observed at date *t*, $f^{EMU}(T)_t$ is the instantaneous zero coupon interest rate swap the euro area for a date *T* observed at date t, $f^{OUT}(T)_t$ is the instantaneous zero coupon interest rate swap of a non-euro area country for a date T if at that time the country is still not a euro area member,[27] $\pi(T)_t$ is a probability that a non-euro area country would be a inside of the euro area at a time *T*. The probability is then calculated based on forward interest as in (7.5.2).

$$\pi(T)_t = \frac{f(T)_t - f^{OUT}(T)_t}{f^{EMU}(T)_t - f^{OUT}(T)_t} \qquad (7.5.2)$$

While all other variables are available based directly on financial market data, the forward interest rate $f^{OUT}(T)_t$ for the case that a country is not a member of the euro area at time *T* has to be estimated or approximated. Apart from the use of various financial market data, this is the main reason for the differences in output from the different methods and basically the only difference between SPC and DPC.

There are several ways to obtain such a proxy. In this thesis I chose to use the forward interest rate of one-year maturity. With such a short-term maturity and a minimal two-year time span inside the ERM II mechanism it is guaranteed that a country cannot enter the euro area within this one-year, unless it is already in the second stage of the euro

[27] For simplicity all instantaneous zero coupon interest rate swaps will be further referred to as forward interest rates.

adoption at least for one year.[28] The calculated probability then represents the four-quarter average over the last year.

Since I am only interested in the difference of forward interest rates of CEE-4 countries and the euro area ones, I calculate the spreads directly. A spread denoted as $d(T)_t$ is then a difference between the forward rate $f(T)_t$ of a non-euro area country at a future date T observed at date t and forward rate $f^{EMU}(T)_t$ of the euro area for a date T observed at date t. Analogically, $d^{OUT}(T)_t$ is a difference between a forward rate $f^{OUT}(T)_t$ of a non-euro area country at a future date T observed at date t if at that time the country is still not a euro area member and forward rate $f^{EMU}(T)_t$ of the euro area for a date T observed at date t as shown in an equation (7.5.3) and (7.5.4).

$$d(T)_t \equiv f(T)_t - f^{EMU}(T)_t \tag{7.5.3}$$

and

$$d^{OUT}(T)_t \equiv f^{OUT}(T)_t - f^{EMU}(T)_t \tag{7.5.4}$$

then

$$d(T)_t = (1-\pi(T)_t)d^{OUT}(T)_t \tag{7.5.5}$$

From equation (7.5.5) I can derive a probability of the EMU entry, i.e. the EMU probability as follows:

$$\pi(T)_t = 1 - \frac{d\ (T)_t}{d^{OUT}(T)_t} \tag{7.5.6}$$

The equation (7.5.6) is the main formula that evaluates the probability of a country being a member of the euro area at a time T, given the observed spread of forward rates for the country and for the euro area and approximating for $d^{OUT}(T)_t$.

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[28] Among CEE-4 countries this concerns only Slovakia, which entered the exchange-rate mechanism in December 2006, which needs to be taken into account.

In my approximations of $f^{OUT}(T)_t$ I decided not to follow Favero's approach based on regressions on monetary policy reaction function of each country of the sample. The rationale of Favero's approach is based on an assumption that when a country is not a member of the euro area at time *T*, its domestic monetary policy should follow the same pattern as at the time *t*. Such an assumption was well applicable for the case of Italy at the end of 1990s when it was economically rather diverged from Germany (i.e. my euro-adoption benchmark country) at that time. However, in CEE-4 countries it is biased by the fact that these countries are already integrated and converged with the euro area and therefore long-term forecasts of domestic macroeconomic fundamentals would be misleading.

The SPC is most robust when national and foreign (euro area) interest rates would differ substantially in a case if a country is not joining the monetary union. In other words, formula 7.5.6 can form a basis for estimating $\pi(T)_t$ only if the spread

$$d^{OUT}(T)_t \equiv f^{OUT}(T)_t - f^{EMU}(T)_t$$

is large enough in absolute terms. Otherwise, forecast errors and other potential biases would make the EMU and non-EMU cases hard to distinguish and $\pi(T)_t$ would not be identifiable. Therefore, the early research focused mainly on Italy and several other countries with a history of substantial interest rate differentials that could be extrapolated into the future as non-EMU interest rate paths.[29]

However, low inflation has prevailed in CEE countries and many of these potential euro area entrants have independent central banks pursuing inflation targets close to the ECB target. One can assume that the low inflation environment would be sustained and that interest rate spreads would remain low regardless of whether these countries join euro area. The Czech Republic is a good example of a country for which the EMU and non-EMU scenarios for interest rates could be too close for making reliable assessments about the EMU probabilities using forward rate levels only.

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[29] For instance, at the beginning of 1996, three years before the EMU was launched, the long horizon spreads for Italy were close to four percentage points.

All attempts to apply Favero's approach based on maximum likelihood estimation of general-to-specific selected model based on variables contained in Taylor reaction functions, were thus unsuccessful. The reasons behind the lack of success of my estimations based on reaction functions are the following. First, the short-term interest rates spreads from the euro area rates are very small and in some cases even negative. Therefore, any error in terms of calculating $d^{OUT}(T)_t$ is of a great importance when calculating the probability. Any $f^{OUT}(T)_t$ rate obtained as a forecast based on reaction functions introduces a significant level of uncertainty and robustness of the estimates is not fulfilled. The latter was not such a problem when the old EU Member States were joining the monetary union, also due to the fact that the interest rate differentials (mostly compared with Germany) were much higher (around 6% in mid-1990s). Second, at the time when Italy was considering joining the monetary union, the possibility of a convergence impact on the Italian interest rates was very limited. On the contrary, the CEE-4 countries, being small and open economies with major trade exposure towards the euro area, are facing a great influence from the euro area countries, which is reflected both in expected future interest rates as well as in fundamentals. Therefore, estimations based on domestic macroeconomic fundamentals can be biased due to already contained euro adoption expectations. Hence, under the current conditions Favero's approach is rather difficult to be applied. For this reason it does not make sense to forecast future interest rates based on macroeconomic fundamentals but concentrate on pure financial markets' data instead.

Therefore, I decided to use information available directly on the financial market data, in particular, considering an interest rate swap spread with a maturity of one year settled at the time for which the calculation is carried out. Due to the fact that none of the CEE-4 countries is in the ERM II mechanism at this point (only Slovakia was from 2007 to 2009), market interest rates one year ahead even from July 2009 cannot not be affected by the euro adoption. EU countries that have not adopted the euro need to participate for at least two years in the ERM II before joining the euro area. Therefore, one year forward interest rates can be taken as a suitable approximation of the case when the country is still out of the euro area at time *T*. To achieve consistency of the used methodology, the same definition on the non-EMU proxy has been used for all the countries, except for Slovakia, for which an earlier forward rate had to be used due to an

earlier euro adoption date. The biggest advantage of the used non-EMU proxy is that it is stationary and does not reflect future catching up convergence process of the countries.

Finally, a crucial issue remains how to interpret daily fluctuations in forward spreads. Explanatory factors of the current forward spread on the right-hand side of equation

$$d^{OUT}(T)_t \equiv f^{OUT}(T)_t - f^{EMU}(T)_t$$

characterise medium to long-term expectations, and the fundamental information that could affect them arrives at a relatively low frequency. In other words, it does not seem reasonable that either $\pi(T)_t$ or $d^{OUT}(T)_t$ can vary in such a way as to explain the short-term fluctuations of $f^{OUT}(T)_t - f^{EMU}(T)_t$. However, the short-term dynamics might contain useful information, especially when the conditional non-EMU interest rate spread is low and the probability of entry is high.

Due to the fact that forward instantaneous interest rates in CEE-4 countries do not significantly differ from the euro area forward instantaneous interest rates, calculations based on splitting the spreads into weighted part for the future entry of the euro area and to the residual part for the case of the country staying out of the EMU at some future time are difficult to obtain and are not very robust. Every small shift in forward interest rates nowadays results in a big move in the calculated probability. This is not a very realistic scenario, since such a probability should be rather stable over time.

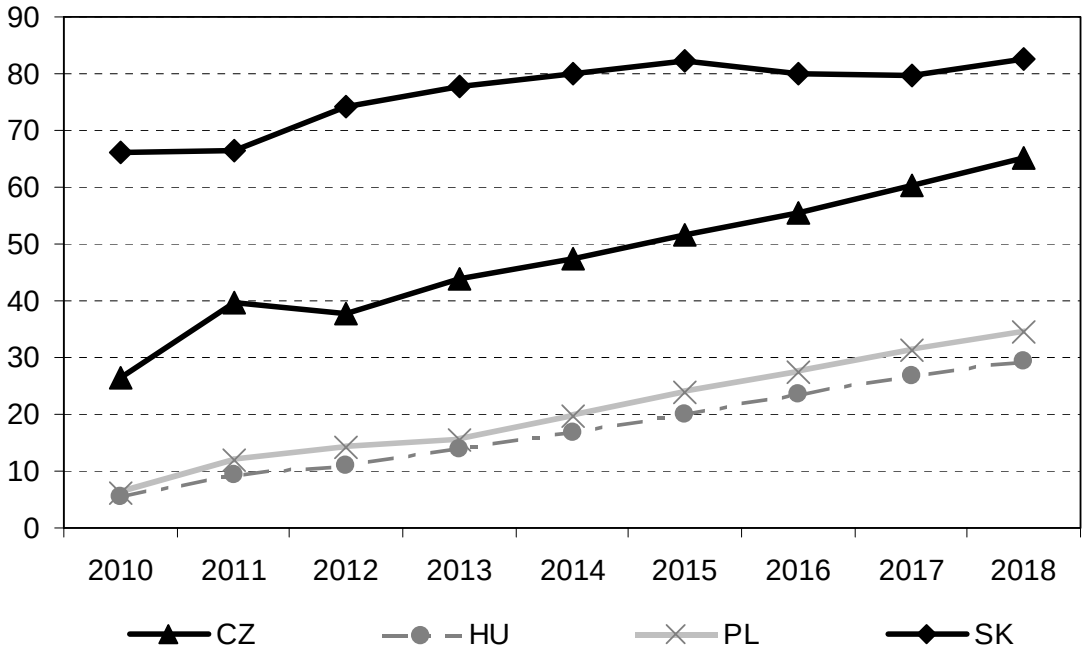
There are several complications regarding the main equation (7.5.1). In particular, both explanatory factors of the current forward spread on the right-hand side of the main equation characterise medium to long-term expectations, and the fundamental information that could affect them arrives at a relatively low frequency. Since such variations in results based on daily data are not reasonable, the calculations rely on monthly averages. This does not prevent fluctuations in results completely, however, such variations might contain useful background information about reasons for differences based on different times of estimations, especially when the conditional non-EMU interest rate spread is low and the probability of entry is high.

This above-mentioned problem, which cannot be addressed using the simplified methodology of this chapter, is however taken care of within the Chapter 8, which introduces a new methodology of calculating the EMU entry probability, which bypasses the drawbacks faced throughout the first method of estimation, developing a framework involving Bewley preferences and equilibrium indeterminacy.

7.5 Empirical Results

Figures 9 to 11 present probabilities of euro adoption (respectively, level of convergence towards the euro area) priced in financial market data in the CEE-4 countries. These figures defer with respect to chosen date of issuance of financial market data. For example, based on interest rate swaps data issued in 2008, figure 9 shows the following:

Figure 9: Probability of being in the euro area (base year = 2008)



Source: own calculations.

The axis *x* represents possible years for euro adoption in the CEE-4 countries. The axis *y* then shows what is the probability priced in market data of a country having entered

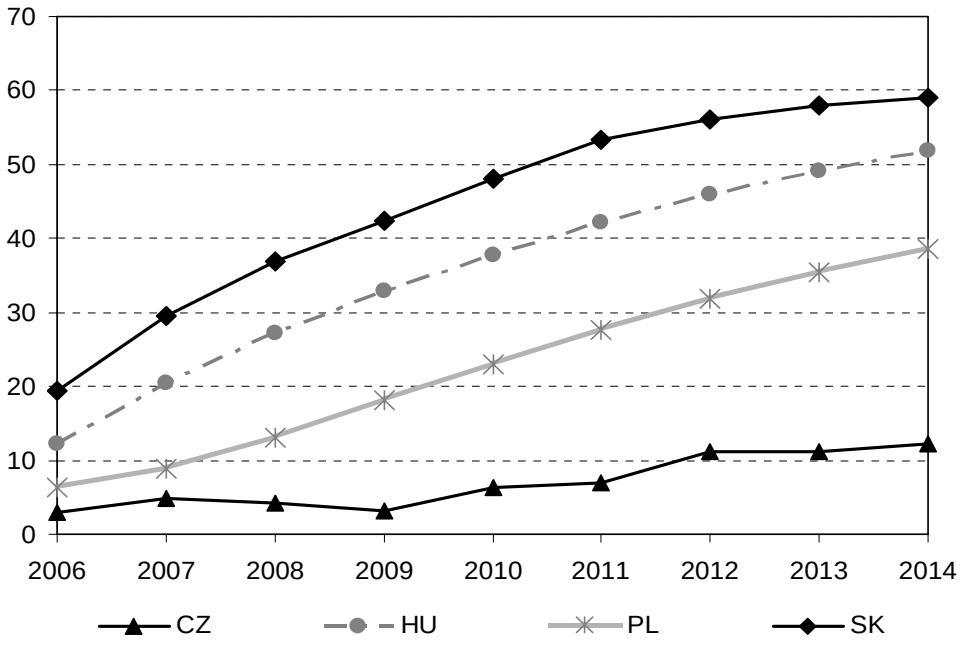
the euro area at date marked on the axis *x*. For example, the probability financial markets considered in the year 2008 for the Czech Republic entering the euro area in 2010 was 28%, while the probability of being inside the euro area increased to 65% for the year 2018 (these probabilities are cumulative, meaning that they consider all the years before the marked year as possible entry years).

Calculated results of probabilities of the euro area entry, presented in figures 9-11 below, show a remarkable difference between two groups of countries – low spread countries and high spread countries. Countries whose rates with lower interest rate spreads from the euro area levels (such as the Czech Republic and Slovakia) are expected to reach higher probabilities of euro adoption earlier on, while countries with higher spreads (Hungary and Poland) are more likely to reach lower probability results increasing only slowly.

Obviously, results obtained using the SPC vary depending on the year of interest rate swaps issuance. Therefore, as presented in figures 10, there is a variation in results based on data from 2008 and earlier on from the year 2004, signalling some degree of convergence towards an integrated European capital and financial market. The degree of financial integration varies, however, greatly depending on a country's general progress with economic integration towards the euro area. Figure 12 shows these chronological developments for all CEE-4 countries.

Figure 10 provides a combination of various base-year results, which were collected as the most recent instantaneous estimate from each baseline date, starting with 1999 and ending with 2009. The final outcome of combined results is then smoothed via using 12-month moving average. Using this combined outcome has the advantage that I can use all the information based on historical data. However, for the reason of comparing obtained results with Reuters polls and national strategies, figures 8 and 9 are very useful. A summary of such comparison is presented in table 8 and figure 10 below.

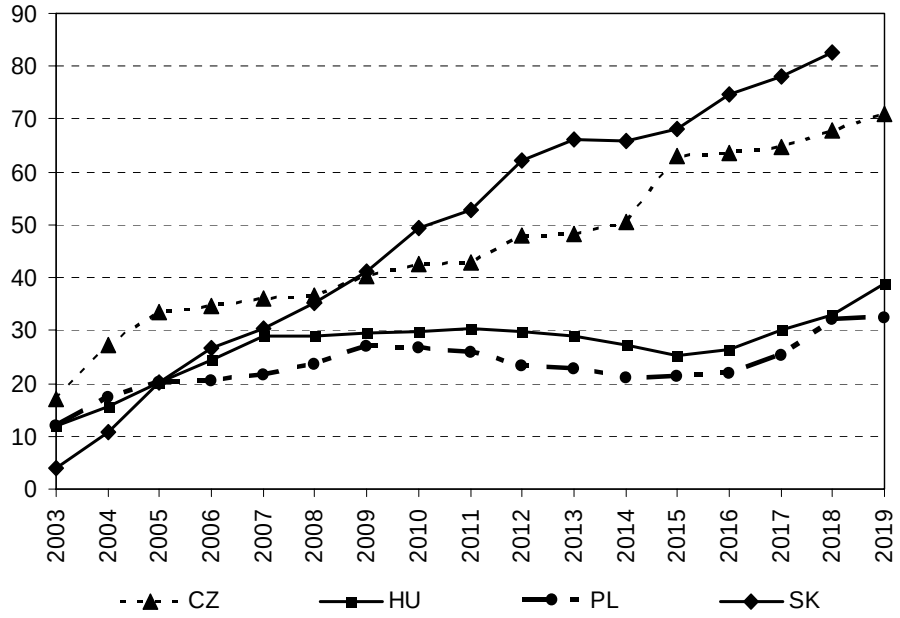
Figure 10: Probability of being in the euro area (base year = 2004)



Source: own calculations.

Figure 11: Probability of being in the euro area (combined base years)

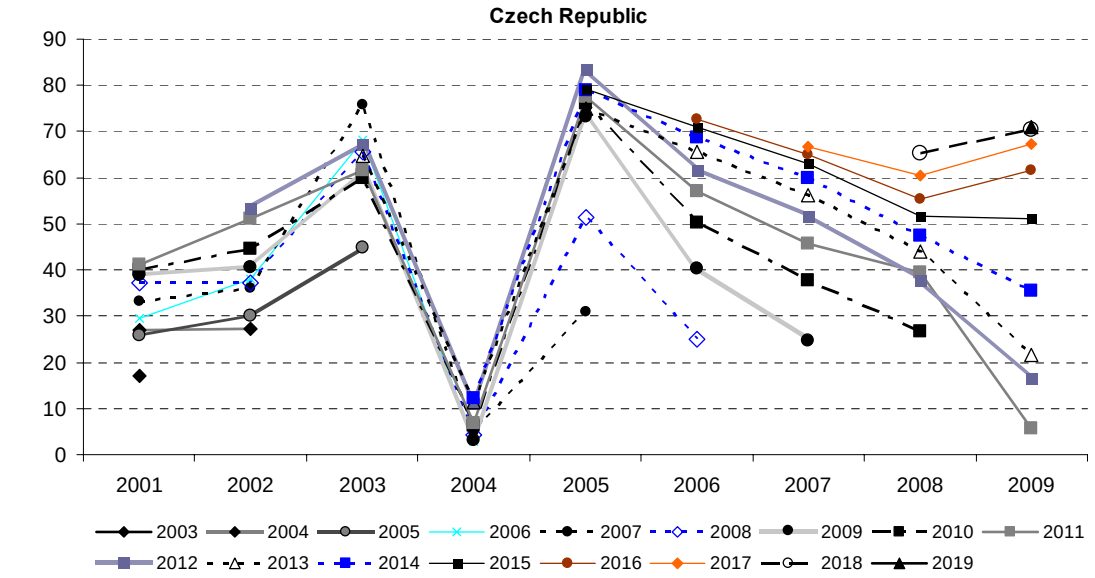
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	*Slope (linear trend)*
CZ	36	37	40	43	43	48	48	50	63	64	65	68	71	***3.0***
HU	29	29	30	30	30	30	29	27	25	26	30	33	39	***0.9***
PL	22	24	27	27	26	23	23	21	21	22	25	32	32	***0.7***
SK	30	35	41	50	53	62	66	66	68	75	78	83		***5.1***

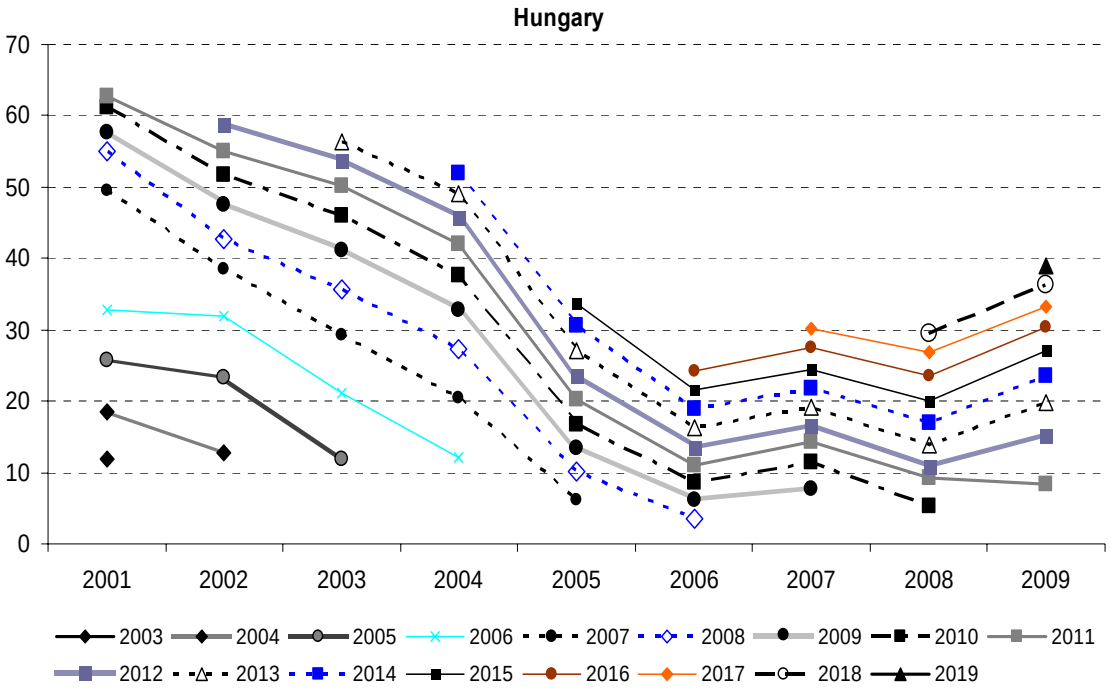


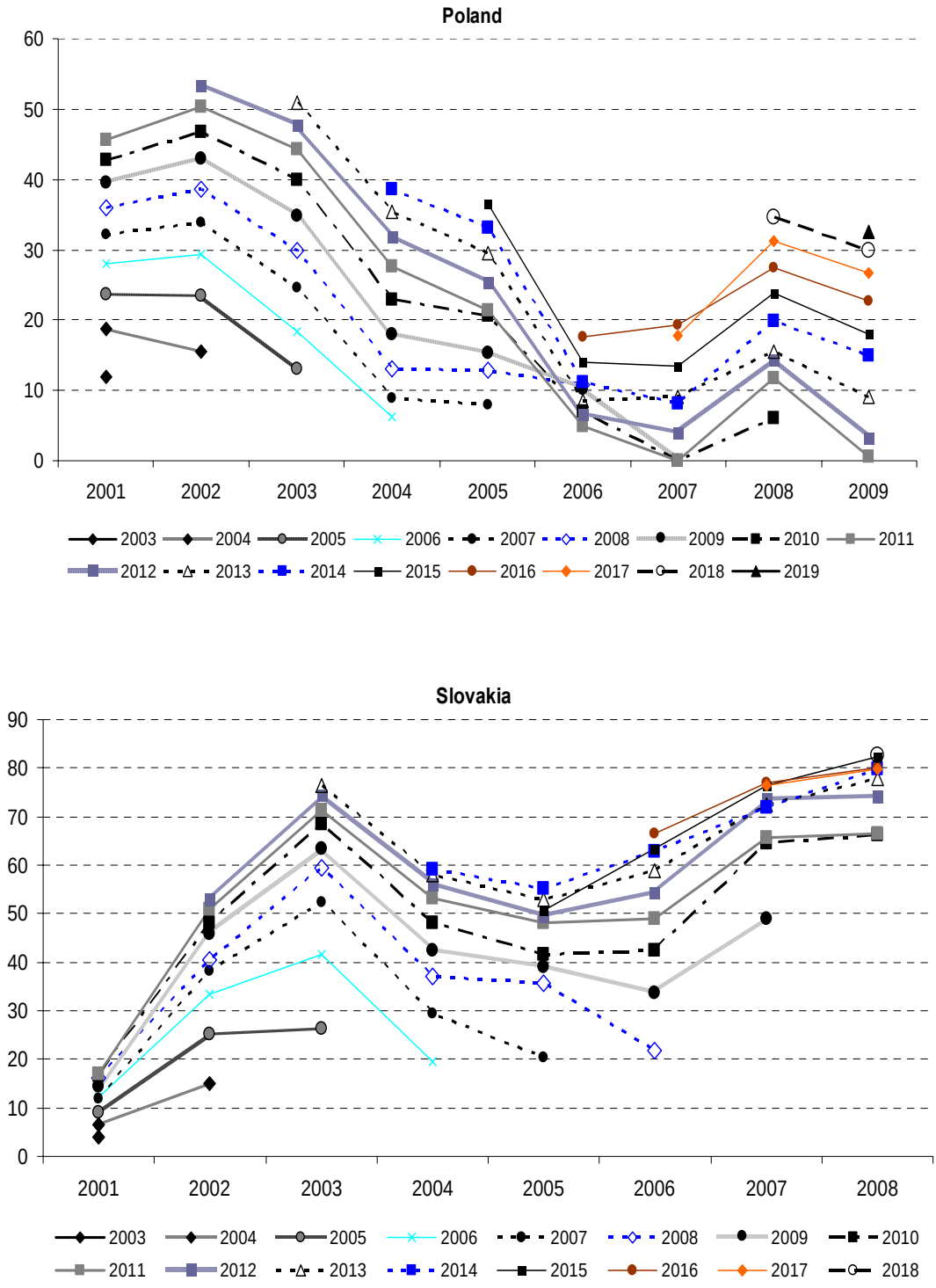
Source: own calculations.

The calculated probability of the euro area entry for the time span from 2008 until 2019 varies widely across the countries of the sample, as seen above in figure 10. The Czech Republic and Slovakia see a general steeper trend in the probability of euro adoption, from around 31% and 20% respectively in 2007 (as the earliest realistic possible euro adoption timing) to 70 and 83% in 2018. For Hungary and Poland the euro area entry probability is much less varying, fluctuating between 20% and 30% and increasing above this interval only from 2018 expected entry year onwards.

Figure 12: Probability of being in the euro area (chronological development)



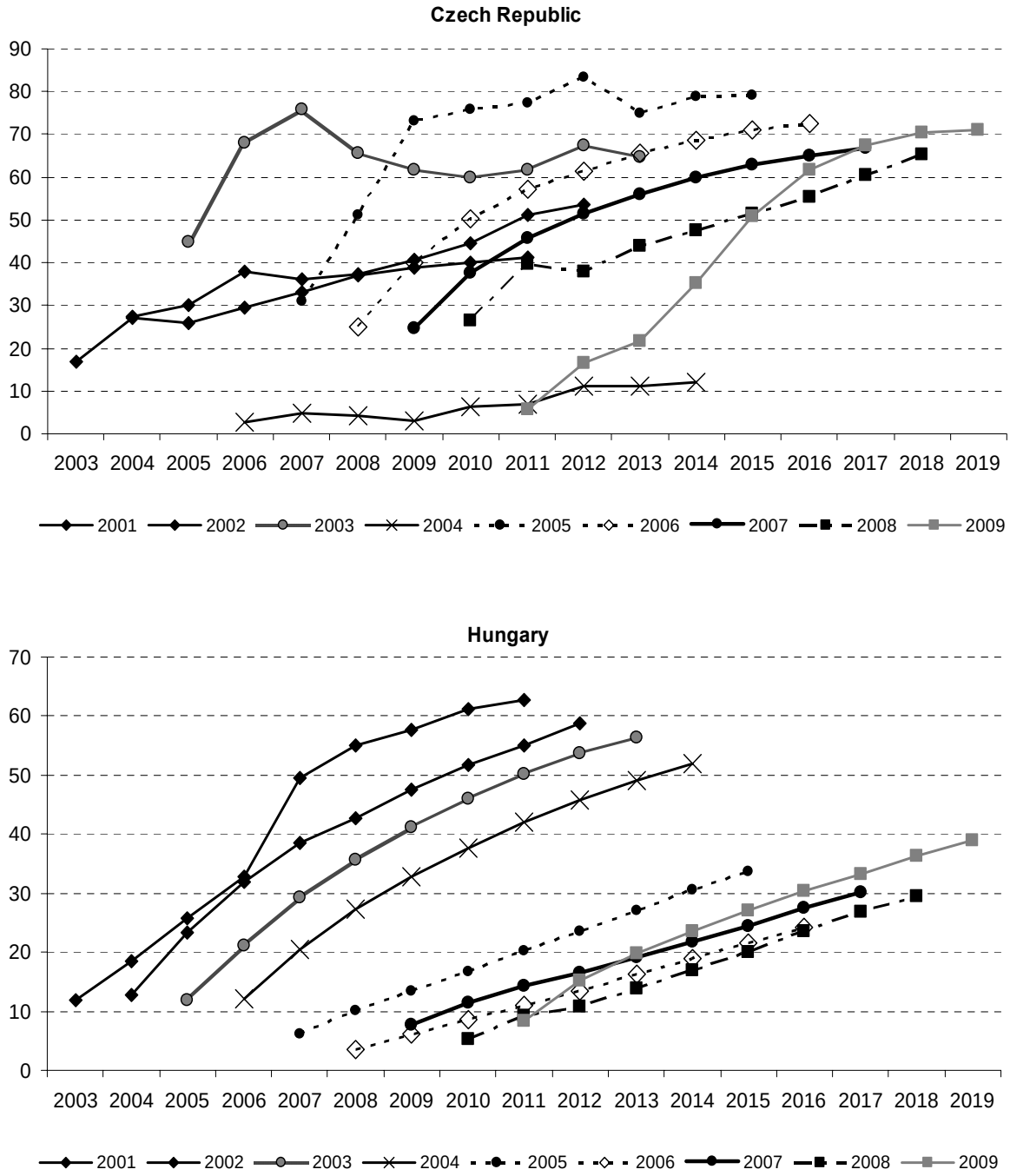


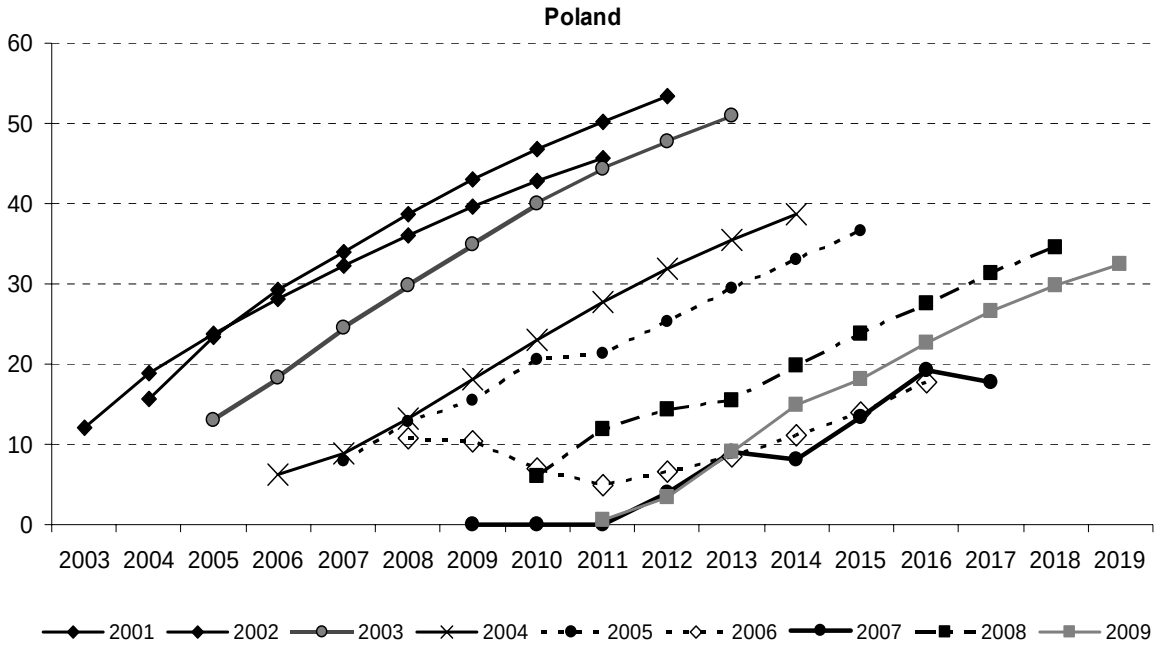


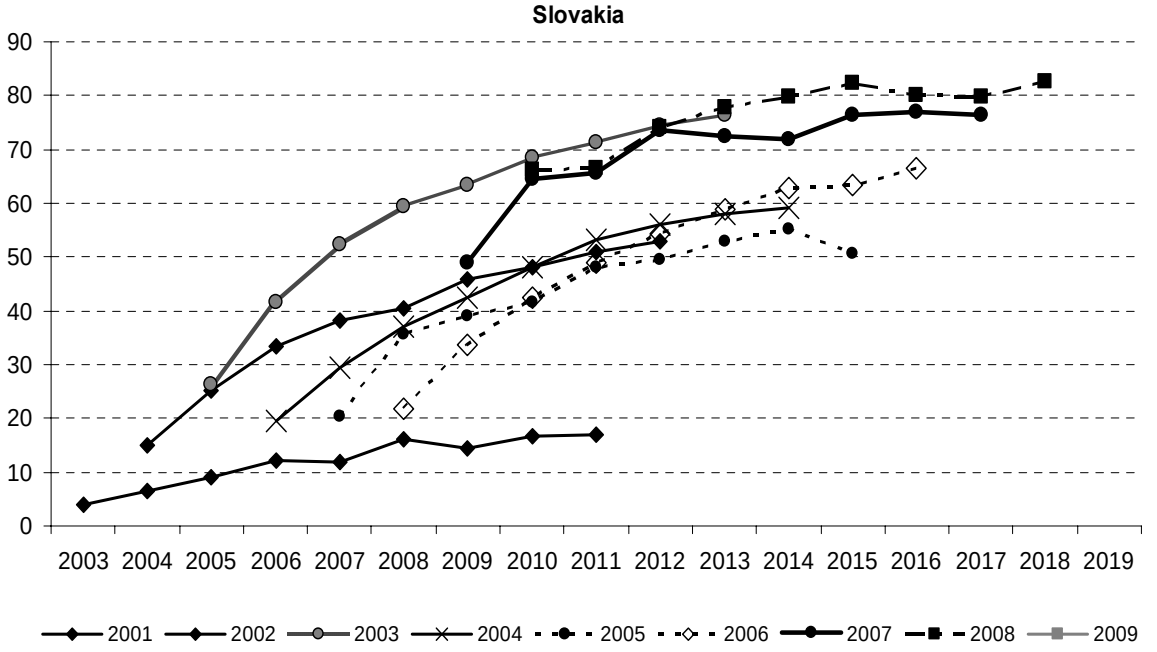
Source: Bloomberg, own calculations.

Note: x-axis denotes date of issuance of interest date swaps based on which the probability (depicted by axis y) is calculated. Probability of entry in years 2003 to 2019 is represented by individual curves.

Figure 13: Probability of being in the euro area (chronological development) – reverse.







Source: Bloomberg, own calculations.

Note: x-axis denotes date of entry (2003-2019) to the euro area for which a probability is calculated (axis y), based on interest rate swaps issued in 2001-2009 (represented by individual curves).

Figures 12 and 13 demonstrate how market perception has been changing over time for different countries, based on different years when interest rate swaps were issued. In case of the Czech Republic, the market was following an increasing trend until 2003, when the most probable was a euro introduction in 2007 with 75% probability. In 2004 the data signalled a huge deterioration, which cannot be well explained by economic and political developments at that time. Probability calculated based on the data as of 2004 stayed below 15% for any euro area accession dates, which is also not a realistic scenario. This situation might have been caused by the fact that the interest rates differential vis-à-vis the euro area was too minor and therefore huge standard error biases the obtained outcome. Especially, since the 2005 issuance the results are back in a range between 70 and 85%, with the maximum reached for 2011 entry date. From 2005 onwards the calculated dates were following a slightly negative trend, except for entry dates 2016-2019 which were on the optimistic side after 2008. To sum up, in 2009 the most optimistic outcome was 2018 and 2019, both reaching 70% probability.

For Hungary probabilities for all euro adoption dates were increasing from 2001 onwards and since 2006 they were very pessimistic. While in 2001 the most probable entry date was 2010 or 2011 at around 60% probability, in 2009 the best outcome was reached for 2018/2019 date at close to 40% probability. One has to bear in mind, however that in both cases these were dates with the furthest entry horizon (which was based on available data and maturities 2011 and 2019 for 2001 and 2009 issuance dates, respectively).

In case of Poland, the market expectations have shifted toward later dates of euro adoptions and at lower probabilities, from 52% for 2012 entry date reached in 2002 to in 2007 calculated maximum probability at 20% for the furthest date of 2016 euro adoption. Things improved somewhat in 2008 to slightly correct back in 2009 when the most optimistic entry dare was 2018/2019 with only 30% probability.

Starting from rather sceptical expectation at below 20%, Slovakia followed a strictly increasing trend between 2001 and 2003. Afterwards, until 2005/2006 market expectations were slightly less optimistic before they started improving again. Nevertheless, based on calculations obtained via the EMU calculator methodology, one can see a bias towards entry dates which are further in the future. In the end, Slovakia

adopted the euro in January 2009, which reached its maximum probability in 2007 at only 50% market expectancy. This is a very pessimistic outcome, since Slovakia was strongly committed to join the euro area in not more that two years after the Slovak koruna joined the ERM II on 28 November 2005. The explanation for market acting this way might be a speculation played against the Slovak koruna, which among other (real-convergence) factors had an appreciating impact on the koruna, leading to its re-alignment on 17 March 2007 and again on 28 May 2008.

Comparing the outcomes reached for the CEE-4 countries with calculations done using the same method for Italy (with the euro area being represented by the German interest rate swaps data), we obtain increasing probabilities based on all base years 1996, 1997, 1998, and stable 100% probabilities based on 1999 year of issuance. This means that based on 1997 as the issuance year, the highest probability is then reached for 2007-2009 entry dates respectively at around 50%, 70% and 100% market expected probability. These calculations are however very sceptical about the real euro (ECU) adoption date in 1999, at around 25%. Entering the monetary union in 2001 was seen as more possible at a just below 50% probability foreseen by financial markets. This outcome might be influenced by underdeveloped financial markets, for at the time trading with interest rate swaps was still infrequent and volatile.

Table 8: Probability of being in the euro area (chronological development), corresponding with figure 12.

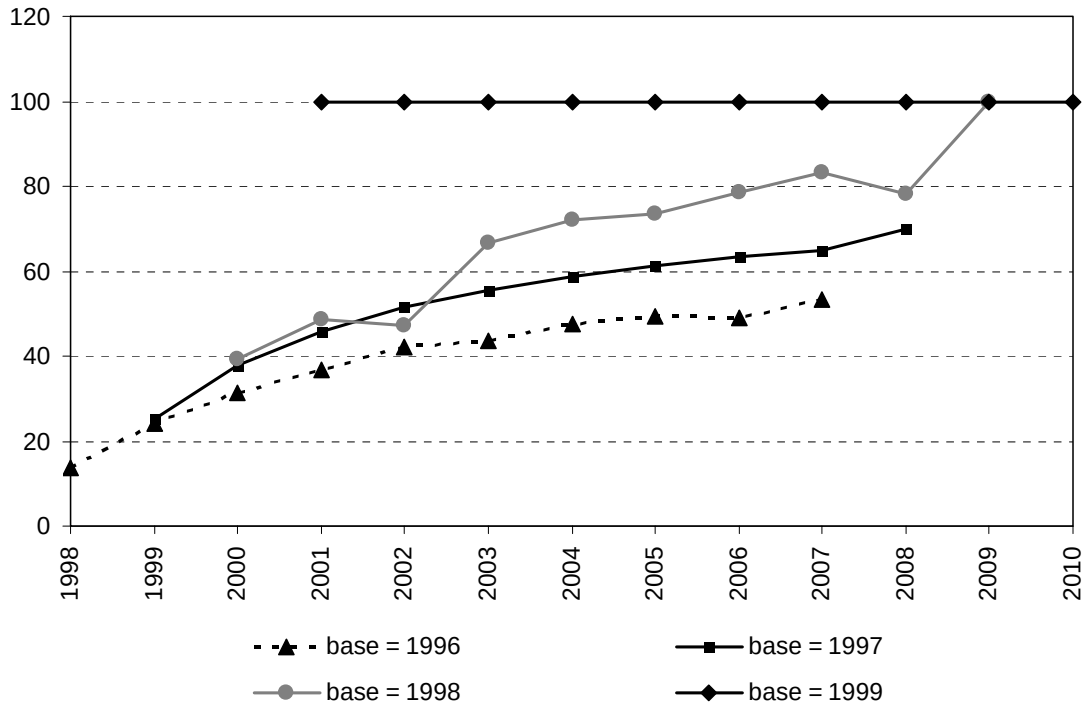
CZ		Date of euro adoption																
		2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Date of issuance of interest rate swaps	2001	16.94	27.04	25.75	29.45	33.22	37.10	38.83	40.16	41.26								
	2002		27.27	29.96	38.05	36.01	37.24	40.56	44.60	51.07	53.46							
	2003			44.90	68.17	75.74	65.53	61.75	59.99	61.74	67.40	64.64						
	2004				2.85	4.87	4.20	3.07	6.34	6.94	11.12	11.23	12.13					
	2005					31.01	51.29	73.13	75.97	77.37	83.41	75.05	78.83	79.07				
	2006						24.90	40.18	50.18	57.16	61.48	65.65	68.69	70.93	72.67			
	2007							24.77	37.74	45.72	51.60	56.11	59.99	62.89	64.94	66.80		
	2008								26.56	39.60	37.83	43.87	47.42	51.58	55.34	60.41	65.19	
	2009									5.60	16.48	21.61	35.37	51.00	61.59	67.37	70.37	71.01

HU		Date of euro adoption																
		2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Date of issuance of interest rate swaps	2001	11.79	18.47	25.66	32.87	49.62	54.92	57.70	61.14	62.65								
	2002		12.82	23.25	31.95	38.54	42.71	47.61	51.72	55.02	58.73							
	2003			11.92	21.15	29.28	35.75	41.24	45.97	50.16	53.63	56.42						
	2004				12.20	20.55	27.24	32.85	37.72	42.13	45.87	49.16	51.97					
	2005					6.15	10.04	13.42	16.83	20.16	23.61	27.12	30.50	33.68				
	2006						3.44	6.14	8.54	10.95	13.52	16.22	18.86	21.65	24.20			
	2007							7.76	11.49	14.24	16.62	19.08	21.71	24.47	27.42	30.17		
	2008								5.35	9.25	10.84	13.93	16.85	20.09	23.45	26.78	29.51	
	2009									8.42	15.21	19.90	23.54	27.02	30.30	33.27	36.23	39.02

Source: Bloomberg, own calculations.

Figure below shows the situation of Italy at the time when it was at the stage of considering joining the monetary union in 1999. This figure depicts the following: Probability of Italy being converged to the monetary union (presented in my calculations by the German interest rate swaps data) was at the time of considering the joining in 1999 very low, close to 20%. Convergence to the German level, as suggested by financial markets during the years 1996-1998 was much slower than necessary for successful monetary union entry. This might have caused problems later on and ended up in the situation where Italy appeared during the financial crisis times. Similar picture might be expected for the case of other countries from southern periphery of Europe. Seeing the Italian case, this method might serve much better in case of countries that are far less converged to the euro area that they would need to be in case they want to enter the monetary union.

Figure 14: Italy versus Germany



Source: Bloomberg, own calculations.

8 MEASURING FINANCIAL MARKETS' ASSESSMENT OF THE EURO ADOPTION: THE ROLE OF AMBIGUITY AVERSION

The following chapter shows how the weaknesses of the SPC method can be handled by using the DPC approach based on short-term dynamics of forward spreads. Methodologically this concept is then based on the theory of ambiguity aversion within a dynamic stochastic equilibrium model. The SPC is based on the same main equation, however, it relies on a developed general equilibrium model behind components of the unknown $f^{OUT}(T)_t$ variable. The general equilibrium model is an abstraction from a real economy, relying on various necessary assumptions but considering various representative economic agents, distinguished with regard to their risk aversion and behaviour on financial markets. It makes the model more fitting to individual countries, despite the fact that some of these countries might have already reached high level of convergence with the euro area. However, such a model is very vulnerable to sudden shocks in economic developments and therefore cannot be used in times affected by the financial crisis.

8.1 Utilizing the Short-term Dynamics of Forward Spreads

The fundamental equation (8.1) break down the actual market spread between future interest rate swaps of analysed countries and the euro area (ACT) into the fundamental part (FEQ) that can be explain by economic rationale and into a short-term noise component. This relationship neglects short-term influences that may cause day-to-day fluctuations in the observed forward spreads.

$$(f_{t,\tau,T} - f^*_{t,\tau,T})^{ACT} = (f_{t,\tau,T} - f^*_{t,\tau,T})^{FEQ} + \varepsilon_{t,\tau}\,, \tag{8.1}$$

Where $f_{t,\tau,T}$ and $f^*_{t,\tau,T}$ are domestic and foreign interest rate forwards as of time t, with horizon τ (standing for the time of possible entering of the euro area) and maturity T.

Deriving the fundamental part from actual financial market data (forward interest rate swaps), I need to clarify which factors might be behind the noise (facing a similar problem as with the approximation of $f^{OUT}(T)_t$ in the SPC method). In fact, it is difficult to explain short-term fluctuations with relatively stable fundamentals, such as the factors behind the expected future interest rate spread. At the same time, a simple paradigm of frictionless markets dominated by rational agents who maximize their expected utility needs to be kept. The working assumption is that modern financial markets always clear and reaches an equilibrium situation.

Therefore, one needs a model that allows multiple equilibria (reached with market clearing supply and demand sides) supported by one set of macroeconomic and market fundamentals. One possible option to solve this problem is a general equilibrium model with uncertainty-averse agents, developed by Rigotti and Shannon (2005). This model is suitable for financial markets that are characterized by robust indeterminacy in equilibrium prices and allocations for any specification of initial endowments, which is the case of multiple equilibria under a given set fundamentals.

8.1.1 Equilibrium Indeterminacy

The distinction between risk and uncertainty (ambiguity) is a promising way of addressing various financial market puzzles. In the Knightian sense, as in Knight (1921), agents face risk when they know the probability distribution of an event.[30] The event is uncertain when its probability distribution is unknown. Since the expected utility is not readily defined in this framework, there has to be an alternative way of modelling preferences of agents.

[30] Knight distinguishes between a risk and uncertainty. He argues that this difference is very important to financial markets agents. In his words, risk is characterised by randomness that can be measured and price-in financial market instruments, while uncertainty brings randomness and frictions that cannot be treated in a systematic way.

Theories of ambiguity aversion of representative agents have become increasingly studied recently.[31] The uncertainty can be modelled also by means of the Choquet expected utility, as in Schmeidler (1989), or using maximum expected utility, as in Gilboa and Schmeidler (1989). However, as Rigotti and Shannon (2005) note, these models were found to yield indeterminate equilibrium outcomes only in limited circumstances. This contrasts with generic indeterminacy stemming from Bewley preferences made under uncertainty after an inertia assumption is introduced (i.e. expecting that there exists a status quo and an alternative is accepted only if it is preferred to the status quo).

Applying Riggoti and Shannon's general equilibrium model with multiple priors probability distribution (as in Bewley (2002)), preferences between various consumption bundles are made based on an expected utility for all priors, which a representative agent considers to be reasonable. The larger the utility, the more preferable a bundle is. However, in case of incomplete preferences, it might not be possible to exactly compare several consumption bundles.

Incomplete preferences over uncertain outcomes could be rationalized in the context of the term structure of interest rate spreads. Agents may estimate the future interest rate differential using an econometric model (perhaps similar to J.P. Morgan's or Favero's approach discussed in chapter 7). However, they cannot be certain about the accuracy of their models and the completeness of the selected variables. Even if they believe in specification of the model they use, its parameters cannot be exactly estimated due to a limited number of observations. The mean and a variance of future interest rate spreads can be estimated only with an error. In effect, these methods obtain not a single distribution of future interest rates, but rather a set of distributions, perhaps characterized by confidence intervals of means and variances. Viewed from a Bayesian perspective, they arrive at a joint distribution of parameters and variables and lose information coming from various distributions and their statistical characteristics.

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[31] An incomplete list of more recent research on the subject and its application includes Mukerji and Tallon (2004a,b); Barillas, Hansen and Sargent (2007) and Hansen, Sargent (2007). Backus, Routledge, and Zin (2004) provide an overview on modelling exotic preferences.

There are two different types of agents in the market – agents who do not mind uncertainty and uncertainty-averse agents. On the one hand, agents which do not care about uncertainty would maximize their expected utility using the estimated distribution of given parameters and calculate a posterior forecast. On the other hand, uncertainty-averse agents would make a different choice. They are indifferent to the outcomes associated with any of the admissible distributions but care about the uncertainty underlying these outcomes. In other words, an agent who is maximizing his expected utility cares even about a marginal difference between the market value and his theoretical price, while uncertainty-averse agents do care mainly about the uncertainty and do not mind a difference in the market value unless this difference is really significant.

8.1.2 Ambiguity Aversion in the Context of EMU Calculators

This section shows that ambiguity aversion may explain the existence of an interval of forward spreads that are all consistent with one set of fundamentals. First, some further notation needs to be introduced. All the (swap) contracts I am dealing here with are of the same maturity. Therefore, for simplicity, the subscript T indicating their maturity can be dropped.

Furthermore, let

$$x_\tau = r_\tau - r_\tau^*$$

denote the future spread as of date τ.

Let y_τ be a Bernoulli-distributed variable for which:

$y_\tau = 1$ ……. if the country is an EMU member at time τ

and $y_\tau = 0$ ……. if it is not.

Since the money markets fully integrate under EMU membership, rational agents must believe that $x_\tau = 0$ in such a case. This assumption is consistent with assumptions made in the SPC method, where we assumed that $f(T)_t - f^{EMU}(T)_t = 0$ in case a country is in the euro area at a time T. While in the SPC methodology, where the $f^{OUT}(T)_t$ variable was approximated by one-year forward interest rate swap traded at a date t, in the DPC case facing non-EMU set-up (when $x_\tau \neq 0$) this x_τ variable is a random variable described at time *t* by some probability distribution function. This random variable is thus changing in time, which gives the probability calculator a dynamic character.

Agents face uncertainty and so their beliefs about x_τ may be characterized by more than one distribution. Denote by $\Gamma_{t,\tau}$ a collection of distribution functions that agents consider reasonable. Formally, the distributions of the future interest rate spread conditional on EMU membership at time τ as perceived by market participants at time *t* can be written as

$$p_t(x_\tau = 0 \mid y_\tau = 1) = 1 \tag{8.2}$$

$$p_t(x_\tau \mid y_\tau = 0) \in \Gamma_{t,\tau} \tag{8.3}$$

Agents are also uncertain about the marginal distribution of y_τ. This uncertainty about the Bernoulli distribution is described by a subset $\Pi_{t,\tau}$ of a unit interval so that

$$p_t(y_\tau = 1) \in \Pi_{t,\tau}$$

The joint distribution of the EMU-membership indicator y_τ and the spread x_τ can be factorized as

$$p_t \equiv p_t(x_\tau, y_\tau) = p_t(x_\tau \mid y_\tau) p_t(y_\tau)$$

and therefore the set of reasonable joint distributions $H_{t,\tau}$ is

$$H_{t,\tau} = \{p_{t,\tau} : p_t(x_\tau) = p_t(x_\tau \mid y_\tau = 1) p_t(y_\tau)\}$$

$$\text{for any } p_t(y_\tau = 1) \in \Pi_{t,\tau} \tag{8.4}$$

while $p_t(x_\tau \mid y_\tau)$ satisfies (8.2) and (8.3)

If the distribution of future spreads and EMU membership is exogenous for market participants, it is possible to use the indeterminacy result of Rigotti and Shannon. They show that any equilibrium with a set of beliefs is also equilibrium with a larger set of beliefs. Moreover, if there is a unique equilibrium only with risk but with no uncertainty then with a decreasing uncertainty all equilibriums under uncertainty converge to that risk equilibrium as the uncertainty shrinks.

Let us further assume that there exists equilibrium only with a risk for every distribution in $H_{t,\tau}$ and denote by $\widetilde{H}_{t,\tau}$ a set of their risk-neutral counterparts. Any $p_{t,\tau} \in \widetilde{H}_{t,\tau}$ can be factorized as

$$\widetilde{p}_t \equiv \widetilde{p}_t(x_\tau, y_\tau) = \widetilde{p}_t(x_\tau \mid y_\tau)\widetilde{p}_t(y_\tau) \tag{8.5}$$

The definitions of $\widetilde{\Gamma}_{t,\tau}$ and $\widetilde{\Pi}_{t,\tau}$ follow:

$$\widetilde{\Gamma}_{t,\tau} = \{\widetilde{g}_{t,\tau} : \widetilde{g}_t(x_\tau) = \widetilde{p}_t(x_\tau \mid y_\tau = 0)\}$$

$$\text{for any } \widetilde{p}_{t,\tau} \in \widetilde{H}_{t,\tau} \tag{8.6}$$

$$\widetilde{\Pi}_{t,\tau} = \{\pi_{t,\tau}^{EMU} : \pi_{t,\tau}^{EMU} = \widetilde{p}_t(x_\tau \mid y_\tau = 1)\}$$

$$\text{for any } \widetilde{p}_{t,\tau} \in \widetilde{H}_{t,\tau} \tag{8.7}$$

Finally, for a particular $\widetilde{p}_{t,\tau}$ relationship (8.1) can be rewritten as

$$f_{t,\tau,T} - f^*_{t,\tau,T} = E[\widetilde{p}_{t,\tau}(x_\tau)] = E\{\widetilde{p}_{t,\tau}[E(\widetilde{p}_{t,\tau}(x_\tau \mid y_\tau))]\} =$$

$$= \widetilde{p}_{t,\tau}(y_\tau = 0)E[\widetilde{g}_{t,\tau}(x_\tau)] = (1 - \pi_{t,\tau}^{EMU})E[\widetilde{g}_{t,\tau}(x_\tau)] \tag{8.8}$$

Obviously, there might exist an interval of forward rate differentials consistent with agents' beliefs.

Let us, for example, assume that

$$\widetilde{\Pi}_{t,\tau} \in \left\langle B^L_{t,\tau}, B^H_{t,\tau} \right\rangle$$

and also that

$$\gamma^L_{t,\tau} = \inf_{\widetilde{g}_{t,\tau} \in \widetilde{\Gamma}_{t,\tau}} E[\widetilde{g}_{t,\tau}(x_\tau)]$$

and

$$\gamma^H_{t,\tau} = \sup_{\widetilde{g}_{t,\tau} \in \widetilde{\Gamma}_{t,\tau}} E[\widetilde{g}_{t,\tau}(x_\tau)] .$$

At the same time, the union of all admissible $E[\widetilde{g}_{t,\tau}(x_\tau)]$ is assumed also to be an interval. Then it follows from (8.8) that the equilibrium forward rate differential falls in the interval between $\left\langle B^L_{t,\tau}, B^H_{t,\tau} \right\rangle$ where

$$B^L_{t,\tau} = (1 - \pi^H_{t,\tau})\gamma^L_{t,\tau}$$

and

$$B^H_{t,\tau} = (1 - \pi^L_{t,\tau})\gamma^H_{t,\tau} .$$

The size of this band depends on the level of the EMU-membership probability and on the magnitude of the uncertainties involved. By way of example, assuming that the estimated expected future spread is 200 b.p., the 95% confidence interval of this estimate is 150 b.p. One might then consider $\gamma^L_{t,\tau} = 125$ b.p. and $\gamma^L_{t,\tau} = 275$ b.p. Unless agents are completely sure that a country will be a member state at a given date τ, there could be an interval of equilibrium forward spreads. For instance, if the uncertainty $\widetilde{\Pi}_{t,\tau} \in \langle 0.9;1 \rangle$ then any forward spread in the interval between 0 and 35 b.p. can represent the equilibrium. However, considering the same uncertainty about EMU membership but for a lower probability level; such as $\widetilde{\Pi}_{t,\tau} \in \langle 0.4;0.5 \rangle$ the band of equilibrium spreads would be much wider, between 62.5 b.p. and 165 b.p.

8.1.3 Band of Inaction with Fully Optimizing Speculators

This sub-chapter splits market agents even further than to those which do and do not care about uncertainty. It argues that a band of inaction may arise even when the most relevant agents do not care only about uncertainty and maximize their expected utility. Based on this argument, I assume that there are two types of market participants - hedgers and speculators.

Hedgers enter financial market to unload their idiosyncratic interest rate position. They could be banks with a mismatch between their assets and liabilities, or corporations that trade swaps to exploit their comparative advantage in certain market segments. They need to act in a timely manner; one can assume that they do not have any predictive ability regarding the future interest rate path. In terms of a model developed by Rigotti and Shannon, they can be viewed as uncertainty averse, and considering *any* distribution of future spreads reasonable.

Speculators, on the other hand, are maximising their expected utility. They do not need to enter financial market at an exact point of time, depending on their financial needs. They can act according to their developed forecasting models, gather sufficient information and enter the market at their expected optimal point of time, i.e. when they can maximise their future utility. These agents do actually determine the market price and make it informative. I assume that they have no natural position in the future interest rate spread and thus they do not have any hedging needs.

Let us now consider the speculator's problem. If his theoretical future value is higher than the market forward value, then he might consider opening a long forward position. However, he would enter into a deal only if the expected return is high enough to compensate for the risk involved. Abstracting from correlations of such investment with returns of other contracts then the expected return per unit of a standard error should be positive. Assuming that there is an upper bound for the Sharpe ratio of any available contract, any deal with a higher Sharpe ratio would be just too good and thus quickly arbitraged away.

Let $\lambda_t^{\max}$ denote the Sharpe ratio of the market portfolio and write this condition as

$$\frac{E(return)}{\sqrt{\text{var}(return)}} \leq \lambda_t^{\max} \tag{8.9}$$

In the context of standard asset pricing models $\lambda_t^{\max}$ could be identified with the Sharpe ratio of the market portfolio. Let $\hat{p}_{t,\tau}$ and $\hat{g}_{t,\tau}$ denote the forecast distributions that characterize beliefs of the speculator as of time *t*, and define

$$\hat{\pi}_{t,\tau} = \hat{p}_{t,\tau}(y_\tau = 1)$$

and

$$\Sigma_{t,\tau}^2 = \text{var}[\hat{g}_{t,\tau}(x_\tau)].$$

Then his expectations of the future interest rate spread and its variance are:

$$E[\hat{p}_{t,\tau}(x_\tau)] = E\{\hat{p}_{t,\tau}(E[\hat{p}_{t,\tau}(x_\tau \mid y_\tau)])\} = (1-\hat{\pi}_\tau)E[\hat{g}_{t,\tau}(x_\tau)]$$

$$\text{var}[\hat{g}_{t,\tau}(x_\tau)] = E\{\hat{g}_{t,\tau}(\text{var}[\hat{g}_{t,\tau}(x_\tau \mid y_\tau)])\} + \text{var}\{\hat{g}_{t,\tau}(E[\hat{g}_{t,\tau}(x_\tau \mid y_\tau)])\} =$$

$$= (1-\hat{\pi}_\tau)\Sigma_{t,\tau}^2 + \hat{\pi}_\tau(1-\hat{\pi}_\tau)E[\hat{p}_{t,\tau}(x_\tau)^2] \tag{8.10}$$

The expected profit from a long position in the forward spread is therefore

$$E[\hat{p}_{t,\tau}(x_\tau - (f_{t,\tau} - f_{t,\tau}^*))] = (1-\hat{\pi}_\tau)E[\hat{g}_{t,\tau}(x_\tau)] - (f_{t,\tau} - f_{t,\tau}^*) \tag{8.11}$$

and the variance of this profit is

$$\text{var}[\hat{p}_{t,\tau}(x_\tau - (f_{t,\tau} - f_{t,\tau}^*))] = (1-\hat{\pi}_\tau)(\Sigma_{t,\tau}^2 + \hat{\pi}_{t,\tau}E[\hat{g}_{t,\tau}(x_\tau)^2] \tag{8.12}$$

It follows from (8.9) that

$$|(1-\hat{\pi}_{t,\tau})E[\hat{g}_{t,\tau}(x_\tau)] - (f_{t,\tau} - f_{t,\tau}^*)| \leq \lambda_t^{\max}\sqrt{(1-\hat{\pi}_{t,\tau})\{\Sigma_{t,\tau}^2 + \hat{\pi}_{t,\tau}E[\hat{g}_{t,\tau}(x_\tau)^2]\}} \tag{8.13}$$

Inequality (8.13) shows us that there is an interval of admissible forward spreads consistent with a single set of fundamentals reflected in speculators' beliefs $\hat{\pi}_{t,\tau}$, $E[\hat{g}_{t,\tau}(x_\tau)]$, $\Sigma^2_{t,\tau}$. The right-hand side of inequality (8.13) shows the maximum deviation of the forward spread from the theoretical value which is not arbitraged away. It also defines a band of inaction; any forward spread within the band may represent some market equilibrium. Thus, within the band the forward spread may fluctuate erratically, responding to the immediate supply and demand conditions. But forward-looking agents would prevent the price from moving beyond the band's boundary.

8.1.4 Model Predictions

When markets are not completely sure that the country will be a member of the monetary union, i.e. when $\hat{\pi}_{t,\tau} < 1$, then the width of this band is positive.

The less precise is the market estimate of the non-EMU conditional spread (i.e. the greater is $\Sigma^2_{t,\tau}$), the wider is the band. At the same time, the greater is the estimated non-EMU spread $E[\hat{g}_{t,\tau}(x_\tau)]$, the wider is the band. For wider bands it could be more difficult to detect any error correction. Therefore, it could be more difficult to find any error correction for countries with a history of volatile and high interest rate spreads. These may be countries that are less integrated into the European trade or countries with a history of high inflation, which is not the case of countries analysed within the thesis.

There is some ambiguity as regards the dependence on the time horizon τ. There may be two factors pulling in opposite directions. The perceived probability of entry $\hat{\pi}_{t,\tau}$ is at least in the baseline scenario – non-decreasing as a function of horizon. This would lead to a narrowing band. On the contrary, the forecasting error $\Sigma^2_{t,\tau}$ increases with the horizon, making the inactivity band wider. The actual balance of the two effects depends on the features of the individual countries. The first effect could be weak for countries that are likely to join soon because for them $\hat{\pi}_{t,\tau}$ is quite high already for short horizons. The second effect is likely to be stronger for countries that are for some reason

more difficult to analyze. This is the case of the CEE-4 countries, which are already very close to the euro area countries in macro-economic terms.

Moreover, for given beliefs regarding the non-EMU spread, the band width also depends on the perceived probability $\hat{\pi}_{t,\tau}$.

In particular, for

$$\Sigma^2_{t,\tau} > \{E[\hat{g}_{t,\tau}(x_\tau)]\}^2$$

the band monotonically widens with declining $\hat{\pi}_{t,\tau}$, otherwise there is a point

$$\hat{\pi}^*_{t,\tau} = \frac{\{E[\hat{g}_{t,\tau}(x_\tau)]\}^2 - \Sigma^2_{t,\tau}}{2\{E[\hat{g}_{t,\tau}(x_\tau)]\}^2} \in (0;1)$$

that maximizes the size of the region where prices are not informative.

This dependence is important for the reliability of the DPC, which may be relatively high when $\hat{\pi}_{t,\tau} \to 1$ but declines quickly when EMU membership becomes less likely.

8.1.5 Noise Distribution

The goal of this section is to provide a link between relationship (8.1) and the models of sections 8.1.2 and 8.1.3. The reality is more complicated than simple two-period models. Agents are heterogeneous, and there will be trading between times t and τ. Therefore, one can hardly expect any sharp breaks at the edges of the indifference interval. It might be more natural to view them as fuzzy reflecting barriers which push the market back with intensity negatively dependent on the distance between the market price and the barrier.

The reflecting barriers can be modelled so that the forward spread walks randomly when it appears far enough from any of the barriers, but is pushed strongly back if it approaches a barrier or even moves beyond it. Therefore, when the band is wide enough one might note almost no error correction, but for a narrow band the error correction could be very strong.

The nonlinear error-correction behaviour of $f_{t,\tau}$ and $f^*_{t,\tau}$, which depends on the spread's distance from the barriers $B^L_{t-1,\tau}$ and $B^H_{t-1,\tau}$, may take the form

$$\Delta f_{t,\tau} = k(f_{t-1,\tau} - f^*_{t-1,\tau} - B^L_{t-1,\tau}) + k(f_{t-1,\tau} - f^*_{t-1,\tau} - B^H_{t-1,\tau}) + \varepsilon_{t,\tau} \tag{8.14}$$

$$\Delta f^*_{t,\tau} = k^*(f_{t-1,\tau} - f^*_{t-1,\tau} - B^L_{t-1,\tau}) + k^*(f_{t-1,\tau} - f^*_{t-1,\tau} - B^H_{t-1,\tau}) + \varepsilon^*_{t,\tau} \tag{8.15}$$

where … $k(x) = ae^{-\frac{b}{a}x}$ ….. for $x \geq 0$

… $k(x) = -x + a$ ….. for $x < 0$

Here parameter *b* controls how thick the barrier is, while parameter *a* determines how strongly it pushes back. Moreover, parameter *a* must depend on the width of the band. While it needs to accommodate narrow bands, it must also allow for almost independent drift within a wide band.

A convenient form might be

$$a = A \tanh \frac{B^H_{t-1,\tau} - B^L_{t-1,\tau}}{A},$$

where parameter $A > 0$ represents the maximum push for the very wide bands as $\lim \tanh(x) = 1$ for $x \to \infty$.

Finally, function $k^*_{t,\tau}$ is defined analogically, replacing *a*, *b*, *A* by a^*, b^*, and A^*. In this specification, when far enough from any of the barriers the variable can follow almost a random walk with a very small drift towards the middle point of the band.

In the empirical part I use a linear approximation of equations (8.14) and (8.15). However, a nonlinear specification is useful for interpretation of the estimated linear error correction coefficients. They represent the average reaction, which is low for bands that are wide relative to the size of shocks and high for narrow bands. As discussed above, the width of the bands is related to the uncertainty and also to the level of perceived EMU probability.

The linear approximation of (8.14) and (8.15) can be written as

$$\Delta f_{t,\tau} = \alpha_L (f_{t-1,\tau} - f^*_{t-1,\tau} - B^L_{t-1,\tau}) + \alpha_H (f_{t-1,\tau} - f^*_{t-1,\tau} - B^H_{t-1,\tau}) + \varepsilon_{t,\tau} \tag{8.16}$$

$$\Delta f^*_{t,\tau} = \alpha^*_L (f_{t-1,\tau} - f^*_{t-1,\tau} - B^L_{t-1,\tau}) + \alpha^*_H (f_{t-1,\tau} - f^*_{t-1,\tau} - B^H_{t-1,\tau}) + \varepsilon^*_{t,\tau} \tag{8.17}$$

For simplicity I assume that

$$\alpha_L = \alpha_H = 2\alpha$$

and

$$\alpha^*_L = \alpha^*_H = 2\alpha^* .$$

Then I may rewrite the error correction as

$$\Delta f_{t,\tau} = \alpha (f_{t-1,\tau} - f^*_{t-1,\tau} - \beta_{t,\tau}) + \varepsilon_{t,\tau} \tag{8.18}$$

$$\Delta f^*_{t,\tau} = \alpha^* (f_{t-1,\tau} - f^*_{t-1,\tau} - \beta_{t,\tau}) + \varepsilon^*_{t,\tau} \tag{8.19}$$

I may interpret $\beta_{t,\tau}$ as an approximation of $(f_{t-1,\tau} - f^*_{t-1,\tau})^{FEQ}$. If it moves only slowly with time *t* or if it is constant (β_C) then

$$\Delta f_{t,\tau} = \alpha (f_{t-1,\tau} - f^*_{t-1,\tau} - \beta_C) + \varepsilon_{t,\tau} \tag{8.20}$$

$$\Delta f^*_{t,\tau} = \alpha^* (f_{t-1,\tau} - f^*_{t-1,\tau} - \beta_C) + \varepsilon^*_{t,\tau} \tag{8.21}$$

can represent an error correction mechanism for the cointegrating relationship (8.1), where α is a speed of adjustment parameter on the way to the euro area (i.e. convergence) and α^* is a speed of divergence from the euro area (divergence). Therefore, the higher the parameter α the faster the convergence and thus the more feasible euro adoption time τ based on financial market data as of the time t. Analogically, the higher the parameter α^*, the better it is for the country to stay outside the common monetary union at the time τ, due to a remaining high speed of divergence.

8.2 Estimation Technique

If the time series of $f_{t,\tau}$ and $f^*_{t,\tau}$ are not stationary, then equation (8.1) defines a cointegrating relationship between them. If the non-stationarity of the estimated forward spread can be rejected and the series do not diverge, then I may estimate the error-correction model

$$\Delta f_{t,\tau} = \alpha_1 + \alpha_C (f_{t-1,\tau} - f^*_{t-1,\tau} - \beta_{t,\tau}) + \psi(L)\Delta f_{t,\tau} + \phi(L)\Delta f^*_{t,\tau} + \eta_t \tag{8.21}$$

$$\Delta f^*_{t,\tau} = \alpha^*_1 + \alpha^*_C (f_{t-1,\tau} - f^*_{t-1,\tau} - \beta_{t,\tau}) + \psi^*(L)\Delta f_{t,\tau} + \phi^*(L)\Delta f^*_{t,\tau} + \eta^*_t \tag{8.22}$$

Using this error-correction model I analyzed the dynamics of forward differentials against euro rates for the CEE-4 countries. I also considered it useful to do the same analysis for some other countries with a zero or negligible chance of adopting the euro any time soon. Benchmark results for these countries might help to assess the overall usefulness and consistency of the method. Suitable candidates in this respect are Denmark (narrow ERM II band, opt-out clause), Sweden (outside the ERM II band, no opt-out clause, but *de facto* opt-out), and the UK (outside the ERM II, opt-out clause), all of which are analysed within this chapter. This analysis is included in the Annex.

Because I replace $\beta_{t,\tau}$ in (8.18) and (8.19), in chapter 8.1.5, by a constant β_C, there is a trade-off as regards the sample length of available time series data. On the one hand, the country's prospects of joining the union may evolve over time, so the time series should be as long as possible to capture the dynamic properties of market fundamentals. On the other hand, in case of abrupt and unexpected economic developments the error term in equations (8.18) and (8.19) as well as (8.20) and (8.21) would increase significantly, to a large extent undermining the robustness and reliability of this innovative method. In this respect a shorter sample would be more desirable.

As a compromise in the aftermath of the recent financial crisis I choose to estimate the above specification for the four-month period running up to mid-2006, which is a cut-off date for the method used in chapter 8 (i.e. an approach based on the short-term dynamics of forward spreads). This way the obtained results are not disturbed by the financial turmoil-related impact on more recent time-series data. Robustness of this

method based on data up to mid-2006 is very high, while the interest rates series after this date are influenced by high market volatility first due to expected market problems and later because of an impact of financial crisis. Looking at very positive robustness checks of the method for the time until summer 2006, I expect that the method would be possible to be used again when financial markets stabilise for a sufficiently long period of time.

Comparing the results obtained on this shorter sample with results of chapter 7, one can see that the DPC results suggest somewhat earlier optimal entry dates but still quite in line with the SPC. Therefore, for the years that are not covered by the more innovative and sophisticated DPC approach (i.e. for the years after summer 2007), I will look at the outcome of the method based on the SPC which is for various reasons far less disturbed by the recent financial turmoil.

In the stochastic method, for the shorter sample period, I estimate the average error correction coefficients for each country and horizon and tested the residuals for stationarity. I employ the augmented Engle-Granger (AEG) test for residual-based cointegration in the long-run with a constant and time trend. The short-run mechanism is examined using the Error Correction Mechanism (ECM) model.

Section 8.1.4 suggests that several regularities should be observed. First, from the discussion of equation (8.13) it follows that the higher is the perceived probability of EMU entry, the tighter should be the no-arbitrage band. For a given disturbance size, a higher perceived probability should lead to higher linear error correction coefficients. Therefore, prospective EMU entrants might exhibit higher coefficients as the forward horizon increases. This indeed holds true, with the caveat that a perceived distribution of non-EMU future spreads does not depend too much on the horizon. The latter can be the case of the Czech Republic with its stable monetary policy and already low inflation target, while Slovakia for example articulated in the past its willingness to join the EMU as soon as possible. Thus the error-correction coefficients do not necessarily need to be an increasing function of the maturity horizon; they should be high already for short horizons. Therefore, they may even decline for long horizons as a result of increasing $\Sigma_{t,\tau}^2$.

Conversely, for countries with no EMU prospects one should observe no horizon dependence. Moreover, for countries with independent monetary policy, such as the UK or Switzerland (analysed in the Annex), one might even expect no cointegration and for countries with low π_t^{EMU} but closely linked to the EMU, for example by a fixed exchange rate regime (such as Denmark), cointegration should be detected due to presumably low uncertainty $\Sigma_{t,\tau}$. Higher uncertainty regarding the conditional non-EMU spread and a higher expected value thereof, should lead to a wider band and consequently to lower coefficient estimates. Therefore, countries with a history of relatively high and volatile spreads could have weaker error correction. Thus, I might expect Poland and Hungary to exhibit lower coefficients than, for example, the Czech Republic.

Furthermore, since a small country's forward interest rate is more likely to be converging to the euro rate than vice versa, it seems reasonable to expect that most of the adjustment would happen through changes in $f_{t,\tau}$ rather than $f_{t,\tau}^*$. Therefore, I might expect $\alpha_C \leq 0$ and $\alpha_C^* \approx 0$.

As in SPC method, forward contracts are traded for several maturities and horizons, but the implied forward interest rates usually have to be estimated. Estimation is possible using government bond yields or interest rate swap rates, following Nelson-Siegel-Svensson (see chapter 7.4). This estimation is mostly technical and, compared to other potential difficulties, relatively easy to implement. It may, however, gain importance when the absolute difference between forward rates is low relative to the potential errors introduced by the estimation methods. While Favero et al. (2000) estimate instantaneous forward rates from government bond yields using the specification of Svensson (1994), applied in the SPC case, Lund (1999) derives instantaneous forwards from the zero-coupon curve estimated using the bootstrap method, as in for example Anderson (1996), with linear interpolation from interest rate swaps. Others, like J.P. Morgan (1997) or Angeloni and Violi (1997), directly used forward rates with finite maturity (five- and one-year maturity respectively), also derived from interest rate swap rates.

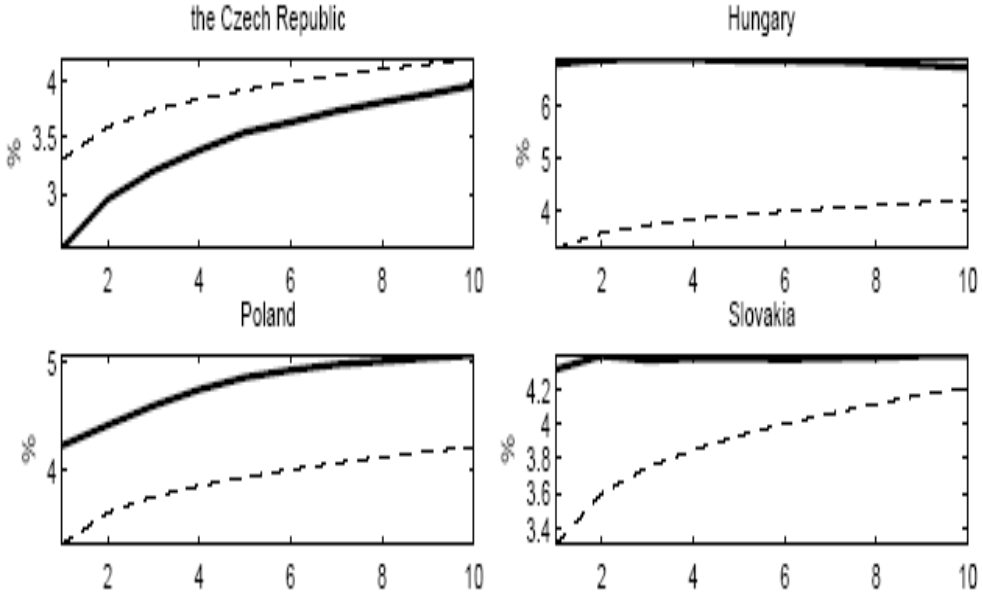
For estimating forward rates, I prefer to use benchmark interest rate swaps rather than government bond yields. The main reason is that government bond yields are

standardized and have a favourable structure, which allows for derivation of precise zero-coupon curves. This is important because I deal with relatively narrow forward spreads and therefore tried to avoid any interpolation and ad hoc specification. Hence, in this chapter I did not follow Favero et al. (2000) or Lund (1999) in estimating instantaneous forward interest rates from the Nelson-Siegel-Svensson specification, but rather adapted the approach of Angeloni and Violi (1997).

I estimated one-year forward interest rates directly from benchmark interest rate swaps, quoted in annual maturities. In general, the data on the benchmark interest-rate swap curves are of very good quality but some large outliers may occur. I checked the data very carefully and cleaned these obvious outliers due to data errors. Used data, as of end-April 2006 are presented in figure 15. Figure 15 presents only a snapshot of the interest rate swap yield curves for several countries in comparison with the euro benchmark curve (plotted as a dashed line). Figures showing the dynamics of forward rates in relation to euro rates as well as the source data are presented in the Annex.

Figure 15: Interest rate swap curves as of 25 April 2006 (CEE-4 countries)

(solid line – interest rate swap denominated in domestic currency, dashed line – interest rate swap denominated in the euro; maturity in years)



Source: own calculations.

8.3 Estimation Output

This chapter elaborates shortly on the estimation output for the Czech Republic, Hungary, Poland, and Slovakia. They are presented in separate sub-chapters below and in tables presenting estimated error correction coefficients for the CEE-4 countries. Tables 8 (i)-(iv) use critical values of the cointegration AEG-test for 1 %, 5% and 10 % as devised by Mac Kinnon for this test, for all the countries being -3.9, -3.34 and -3.04, respectively.

In tables presented for CEE-4 countries parameters α, α^*, and βstand for the following:

α … speed of adjustment (convergence towards the euro area)

α^* … euro adjustment parameter

β … equilibrium spread

Based on these parameters the convergence process in individual cases can be evaluated and a comparison among CEE-4 economies can be made.

8.3.1 Czech Republic

Table 9 (i): Estimated Error Correction Coefficients for the Czech Republic

	Horizon								
CZECH REP.	**1*2**	**2*3**	**3*4**	**4*5**	**5*6**	**6*7**	**7*8**	**8*9**	**9*10**
AEG τ-test value	-2.423	-3.499	-5.531	-5.683	-6.534	-6.966	-8.703	-7.506	-8.393
α_czk	-0.153	-0.215	-0.304	-0.340	-0.461	-0.587	-0.765	-0.953	-0.919
(p-value)	(0.002)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
α*_czk	-0.027	-0.039	0.040	-0.007	-0.014	0.013	-0.070	0.005	0.070
(p-value)	(0.478)	(0.396)	(0.425)	(0.899)	(0.806)	(0.787)	(0.198)	(0.932)	(0.269)
β_czk	-0.440	-0.232	-0.141	-0.107	-0.080	-0.083	-0.069	-0.035	-0.008
s.e.	[0.013]	[0.011]	[0.012]	[0.012]	[0.010]	[0.011]	[0.011]	[0.011]	[0.013]
LM test CZK	0.913	0.304	0.966	0.573	0.058	0.381	0.376	0.791	0.549
LM test EU	0.583	0.881	0.277	0.525	0.795	0.368	0.244	0.196	0.956

Source: own calculations.

Looking at the AEG cointegration test, the implied forward spreads for the Czech Republic can be considered cointegrated at 5% confidence level for all horizons over two years and with 10% confidence for all longer maturities. This is a very good outcome due to the fact that a horizon of less than two years is not important (because of the minimum two-year period of participating in ERM II).

Moreover, in the case of the Czech Republic all speed of adjustment parameters α_{CZ} are significantly negative (implying the correct way of convergence towards EMU) and of an intuitive size. They increase with the forward horizon and become almost unity from eight-year horizon onwards. As they are calculated on data from mid-2006, this means these countries are expected that with almost 100% probability they are converged to the euro area from 2015 onwards and ready to adopt the euro anytime from 2015 onwards. This finding is also reassured by the fact that the euro adjustment parameter α^*_{CZ} is insignificant.

The negative value of the equilibrium spread β_{CZ} should not be surprising given the main characteristics of the Czech economy. These include an inflation target of the

Czech National Bank that is quite close to that of the euro area, and real appreciation, which apparently stems from the converging economy. These two factors imply trend appreciation of the Czech koruna and, through the interest parity condition, low domestic interest rates.

The results suggest that for short horizons the markets focus on domestic macroeconomic indicators and the inflation forecast of the Czech National Bank, while the long end is likely to be driven by EMU pricing. The current trading practice seems to be in line with such an understanding, as has been confirmed in informal discussions with fixed income dealers. This interpretation, if true, would have important consequences for the monetary policy of the Czech National Bank. It would mean that even now it can steer only a part of the forward curve. The closer the unification date gets, the less power its monetary policy will have.

8.3.2 Hungary

Table 9 (ii): Estimated Error Correction Coefficients for Hungary

	Horizon								
HUNGARY	**1*2**	**2*3**	**3*4**	**4*5**	**5*6**	**6*7**	**7*8**	**8*9**	**9*10**
AEG τ-test value	-2.724	-1.581	-1.755	-1.928	-2.387	-5.797	-3.524	-4.762	-3.513
α_hu	-0.211	-0.046	-0.027	-0.046	-0.072	-0.122	-0.231	-0.275	-0.267
(p-value)	(0.004)	(0.390)	(0.575)	(0.316)	(0.260)	(0.125)	(0.014)	(0.005)	(0.009)
α*_hu	0.025	-0.007	0.004	-0.004	-0.004	0.000	-0.017	0.001	0.012
(p-value)	(0.341)	(0.798)	(0.890)	(0.845)	(0.834)	(0.989)	(0.463)	(0.971)	(0.675)
β_hu	3.259	3.214	3.118	2.975	2.772	2.547	2.246	1.980	1.748
(p-value)	[0.019]	[0.020]	[0.022]	[0.024]	[0.024]	[0.021]	[0.021]	[0.021]	[0.022]
LM test HU	0.632	0.290	0.609	0.356	0.872	0.388	0.517	0.430	0.821
LM test EU	0.673	0.277	0.717	0.066	0.314	0.364	0.413	0.703	0.227

Source: own calculations.

Looking at the AEG cointegration $\tau -$ test, the implied forward spreads for Hungary can be considered cointegrated at 5% confidence level for all horizons over six years, signalling an indication of long-term cointegration relationship between Hungarian and euro-area rates. The error correction coefficients are low in absolute terms and the estimation results for Hungary reveal a slower convergence towards the European interest rates than in the other CEE-4 countries.

Speed of adjustment parameters α_{HU} are significantly negative until the seven-year-maturity horizon (implying the correct way of convergence towards the euro-area) but are not significant for the rest of the time span, while the euro adjustment parameter α_{HU}^{*} is significant for all maturities.

Positive but declining value of the equilibrium spread β_{HU} speaks in favour of convergence towards lower interest rates, which would be more in line with the interest rates in euro area.

8.3.3 Poland

Table 9 (iii): Estimated Error Correction Coefficients for Poland

	Horizon								
POLAND	**1*2**	**2*3**	**3*4**	**4*5**	**5*6**	**6*7**	**7*8**	**8*9**	**9*10**
AEG τ-test value	-2.397	-1.969	-2.597	-3.555	-4.018	-3.631	-3.236	-2.563	-5.869
α_pl	-0.063	-0.047	-0.057	-0.070	-0.111	-0.106	-0.175	-0.146	-0.169
(p-value)	(0.037)	(0.087)	(0.107)	(0.061)	(0.058)	(0.034)	(0.017)	(0.020)	(0.017)
α*_pl	-0.010	-0.009	0.005	0.005	0.007	0.000	-0.011	0.002	0.008
(p-value)	(0.454)	(0.580)	(0.756)	(0.765)	(0.755)	(0.992)	(0604)	(0.932)	(0.768)
β_pl	0.951	1.153	1.245	1.201	1.038	0.932	0.804	0.713	0.622
(p-value)	[0.034]	[0.030]	[0.030]	[0.029]	[0.021]	[0.020]	[0.021]	[0.020]	[0.022]
LM test PL	0.080	0.206	0.675	0.749	0.968	0.410	0.775	0.845	0.472
LM test EU	0.107	0.744	0.617	0.106	0.171	0.499	0.397	0.372	0.417

Source: own calculations.

The AEG cointegration $\tau-$test shows that the implied forward spreads for Poland can be considered cointegrated at 5% confidence level for all horizons over four years (with the exception of an eight-year maturity).

However, as in the case of Hungary, the Polish rates exhibit rather weak tendency to revert to euro rates for longer horizons. Speed of adjustment parameters α_{PL} are significantly negative at 5% confidence level until six-year-maturity horizon, which as in the case of Hungary implies a correct way of convergence towards the euro-area. The adjustment parameter is not significant for the rest of the time span, while the euro adjustment parameter α^{*}_{PL} is significant but very close to zero for all maturities. Poland's historically high and volatile interest rates are consistent with this result.

The equilibrium spread β_{PL} is positive for all maturities. After increasing until the maturity of three years, it declines afterwards in favour of convergence towards lower interest rates, closer to the rates of euro area.

8.3.4 Slovakia

Table 9 (iv): Estimated Error Correction Coefficients for Slovakia

	Horizon								
SLOVAKIA	**1*2**	**2*3**	**3*4**	**4*5**	**5*6**	**6*7**	**7*8**	**8*9**	**9*10**
AEG τ-test value	-2.104	-2.227	-3.399	-2.588	-7.309	-8.205	-9.192	-8.931	-7.142
α_sk	-0.033	-0.080	-0.282	-0.218	-0.720	-0.757	-0.814	-0.764	-0.453
(p-value)	(0.277)	(0.123)	(0.003)	(0.005)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
α*_sk	0.011	0.036	0.050	0.010	0.046	-0.026	-0.041	-0.041	0.040
(p-value)	(0.525)	(0.248)	(0.308)	(0.871)	(0.317)	(0.465)	(0.465)	(0.481)	(0.425)
β_sk	0.454	0.294	0.197	0.116	0.038	0.029	-0.027	-0.078	-0.160
(p-value)	[0.026]	[0.015]	[0.012]	[0.009]	[0.012]	[0.016]	[0.011]	[0.012]	[0.013]
LM test SK	0.535	0.409	0.265	0.985	0.987	0.196	0.249	0.162	0.052
LM test EU	0.198	0.372	0.827	0.371	0.664	0.624	0.628	0.613	0.561

Source: own calculations.

The AEG cointegration $\tau-$test for Slovakia implies that the Slovak forward interest rate spreads can be considered cointegrated with the European ones at 10% confidence level for all horizons over five years (and for three-year maturity), which refers to the year 2011.

The estimated error correction coefficients are negative and high in absolute terms from the five-year maturity horizon onwards, signalling a strong and fast convergence (in a correct declining manner) towards the European interest rates in comparison with other CEE-4 countries.

However, results obtained for Slovakia are not as clear as for the Czech Republic. One could argue that if the interest-rate swap market signals a likely date for EMU enlargement - say τ^* - then after τ^*, the error correction coefficient α should remain as negative as at time τ^* and the fundamental spread β_C should remain as close to zero as at τ^*. Bearing this in mind, one may be tempted to test, for example, whether

the estimated parameter α_{SK} for the horizon *9*10* is significantly lower in absolute terms than the ones for shorter maturity horizons.

However, one would perhaps be expecting too much from this new method at this stage. Recall that the linear model (8.21) and (8.22) was inspired by non--linear error-correction relationships (8.14F) and (8.15). Taking this into account, one should not be surprised by some irregularities.

The linear method was indeed chosen for simplicity and as a first approximation. To overcome its obstacles, one should ideally estimate a properly chosen non--linear specification directly, which is however behind a scope of the thesis and can serve as a future research topic.

8.4 Comparison of Results

Table 10 below summarises results obtained for the countries presented in the preceding chapters. A comparison of the convergence process towards the euro area interest rates can be then made based on presented coefficients of speed of convergence (α), euro adjustment (α^*) and calculated equilibrium spread (β) of each country's interest rates vis-à-vis the euro area.

Table 10: Summary of obtained results

	α	***α****	***β***	**Most probable euro adoption date**
CZ	-0.953	insignificant	-0.035	**2015**
HU	-0.231	insignificant	2.246	**2014**
PL	-0.106	insignificant	0.932	**2013**
SK	-0.282	insignificant	0.197	**2010**

Source : own calculations.

Based on data traded at the end of April 2006 table 10 summarises results obtained with a newly developed methodology estimating a speed of convergence, divergence and equilibrium spread between countries' interest rates and the euro area forward rates.

Stationarity of results and robustness of the method is tested, as presented in previous sections 8.3.1 to 8.3.4.

Reading from financial market data, the most probable horizon after which a country would adopt the euro is considered to be in absolute terms the highest speed of convergence α (significant at 5% level of confidence). The market-assumed most probable date of euro area entry is then obtained adding to the year 2007 the number of years equal to the maturity horizon when the speed of convergence α is the highest and significant with 5% confidence. The speed of divergence is in all these cases insignificant, supporting validity of obtained results.

Reading from table 10, the optimal euro adoption dates according to financial market participants would be the following years: 2015 for the Czech Republic, 2014 for the case of Hungary, 2013 for Poland, and 2010 for the case of Slovakia. These seem to be realistic results, quite in line with the timeliness communicated by national authorities specified in the Convergence Programmes.

Comparison with results obtained through the SPC and their evaluation on the background of national euro adoption strategies as presented in the Convergence Programmes is presented in chapter 9.

9 COMPARISON OF RESULTS, SURVEYS AND NATIONAL STRATEGIES

This chapter presents a comparison and summary of the results which were obtained using the SPC and DPC method. Results obtained with these two methods can be then compared with euro adoption plans according to published convergence programmes (CP, as in table 3), presented in section 6.1.5 and summarised in table 11. Reuters polls conducted in May 2006 and in April 2009 are presented in table 12.

Table 11: Summary of results based on the SPC and DPC.

	SPC	DPC	CP
CZ	2016-2017	2015	2010 and later
HU	2016-2017	2014	no date
PL	2016	2013	no date
SK	2016	2010	2009

Source: own calculations.

Note: 1) EMU calculators are based on average results based on 2006 and 2007 data.
2) Dynamic method is based on 25 April 2006 data.
3) Convergence Programme was issued during 2006 (varies for different countries).

Table 12: Reuters poll on EMU expansion: "In what year do you expect the following countries to formally adopt the euro?" – conducted in May 2006 and April 2009.

	May 06			Apr 09		
	Mean	**Latest**	**Earliest**	**Mean**	**Latest**	**Earliest**
Czech Rep.	***2011***	2015	2010	***2014***	2015	2012
Hungary	***2013***	2015	2012	***2014***	2016	2012
Poland	***2012***	2015	2010	***2014***	2016	2012

Source: Reuters.

(i) Czech Republic

Based on financial market data until the end of 2006, the SPC is slightly less optimistic with regard to euro adoption than the DPC. The latter expects the Czech Republic to adopt the euro in 2015 while the calculators see the entry date around 2016 and 2017. Reuters polls collected in May 2006 were overly optimistic, speaking in favour of euro adoption already in 2011. The span of responses was however quite large, between 2010 and 2015, with the mean at 2011 (see table 12). The official Convergence Programme, issued by the European Commission in March 2007, is in line with these results, as it spelled out the year 2010 and onwards as an official timeline for the euro adoption.

(ii) Hungary

Also in the case of Hungary, the SPC based on 2006 data is slightly less optimistic with regard to euro adoption than the DPC. The latter expects Hungary to adopt the euro already in 2013, i.e. one year earlier than according to results of the SPC. Market views based on Reuters poll of that date follow a similar time span, suggesting years 2012 (the earliest estimate) to 2015 (the latest date) with the mean estimate being 2013 (i.e. in line with the DPC). The Hungarian Convergence Programme, issued in December 2006 by the European Commission, as well as the Hungarian national euro-adoption strategy did not mention an exact time estimate for Hungary's EMU entry.

(iii) Poland

The results of the SPC and DPC are quite different in Poland's case. The SPC based on data until the end of 2006 expect Poland to enter the euro area in 2016 while the dynamic-method results speak in favour of the year 2013 as an EMU entry date. Reuters poll of May 2006 were even more optimistic, expecting the year 2012 as an entry time. Similar to the Czech case, the time span of the poll was rather wide, with the earliest estimates in 2012 and the latest ones only in 2015. Poland's official euro-adoption strategy at that time did not mention any approximate date for Poland's EMU entry.

(iv) Slovakia

Rather surprisingly, the results of the two market-based methods diverge most in the case of Slovakia. While the SPC delivers very late EMU entry dates for Slovakia, results of the DPC are the earliest euro adoption dates in comparison with other CEE-4 countries. The DPC is also fully in accord with the poll conducted by Reuters that May (with a spread between 2008 and 2013) and is very close to the Slovak communication towards the public via the Convergence Programme published in December 2006, which claimed that Slovakia would enter the common European monetary area in 2009 (and this has really happened).

(v) Summary

Comparing the CEE-4 countries among each other, the SPC delivers comparable euro adoption dates for all countries, between 2016 and 2017. Interestingly, for all CEE-4 countries these are the latest possible entry dates for all maturities, i.e. the calculated years of feasible entry are always the ones furthest away (with the highest maturity) from traded year of used financial market instruments. This signals that market still believes in continuous further convergence of these countries towards the euro area. In contrast, based on the same financial series the DPC estimates earlier EMU entry dates delivers more optimistic results, from 2010 (Slovakia; i.e. quite close to the reality) through 2013 and 2014 (in case of Poland and Hungary, respectively) to 2015 (Czech Republic).

Reuters polls conducted in May 2006 expected the earliest entry dates in case of Hungary (with the mean in 2013), followed by the Czech Republic (2011), Poland (2012), and Slovakia (2010). For the Czech Republic and Slovakia the market polls led in the same direction as communicated EMU entry timeline published in Convergence Programmes at the end of 2006 (in case of Slovakia, with 2009 communicated as the expected year of euro adoption) or the beginning of 2007 (in case of the Czech Republic, assuming the euro area entry from 2010 onwards).

While the DPC is much more sensitive to financial market frictions and therefore has to stop before the impact of financial market turmoil on forward interest rates, the SPC can be used even at more volatile data. Besides an increase of robustness of SPC with bigger

interest-rate spreads, its reliability also increases in time. Looking at results based on SPC for data until July 2009, the probabilities of euro adoption for the time span between 2012 and 2019 varies across the CEE-3 countries. For all of these economies the probability is the highest at the end of the time horizon, from 2018 expected entry year onwards. This is also in line with recent sceptical approach towards the role of the euro as a stable international currency.

Reuters survey conducted in May 2010 presents an expected euro adoption date as foreseen by the average financial markets' participant. The survey outcomes are years 2016 in case of the Czech Republic and 2015 for Hungary and Poland. A shift in euro adoption expected entry dates (in particular in case of Poland) was caused by a recent instability in the euro area facing global financial crisis. Once the situation is more stable in the euro area then also the expected euro adoption dates might be closer than at current conditions.

CONCLUSIONS

This thesis deals with how the perception of financial markets on economic and monetary union enlargement can be measured. Two methods, the SPC and DPC, were developed that provide market-based information on possible dates for a monetary union entry. The capabilities of the methods were assessed using the euro adoption process of the CEE-4 countries: the Czech Republic, Hungary, Poland, and Slovakia. In addition, data of other European countries were used to demonstrate that the methods developed here can be used for other economies as well. Results obtained employing both methods and Reuters opinion polls for the CEE-4 countries are then used to check whether markets' views have been consistent with national euro adoption strategies.

The first approach to measure markets' views, the SPC, is based on a concept using static forward interest rates. The second approach, the DPC, employs an indicator that makes use of short-term dynamics of forward spreads. The more traditional SPC uses the current level of forward interest rate spreads to measure the probability of the euro adoption within a given time span. The difficulty with this method is the requirement to estimate a hypothetical path for interest rates while a country is still outside of the euro area. To remedy this problem, the DPC was developed to recover additional information by analysing the short-term dynamics of these spreads. The DPC is therefore more suitable in case of countries where the non-EMU future interest rates scenario is very close to the euro area future interest rates. However, the price to pay for this advantage is that the DPC quickly looses its robustness in case of unstable financial market conditions. As a consequence, the DPC is impossible to use in times of financial turmoil, such as the recent financial and economic crisis.

As an illustration, both the SPC and DPC were applied to financial market data traded in 2006 to obtain years when the euro adoption in CEE-4 countries would be the most probable according to the market. A comparison of the results showed that the SPC predicted later dates than the DPC. The SPC delivered comparable results for all CEE-4 countries, spanning between 2016 and 2017. On the contrary, the DPC yielded a wider range from 2010 (Slovakia; i.e. very close to the reality) through 2013 and 2014 (in case of Poland and Hungary, respectively) to 2015 (the Czech Republic). This was contrasted

with views expressed by financial market participants in a Reuters opinion survey conducted in May 2006. The survey participants predicted in average the earliest euro adoption in case of Slovakia (2010) followed by the Czech Republic (2011), Poland (2012), and Hungary (2013). It is interesting that the Reuters survey suggested that market expectations were in agreement with available EMU entry timelines published in national convergence programmes. From the differences between the Reuters survey and SPC/DPC predictions one may conjecture that there was information in the market pricing that was not equally accessible through (or adequately reflected by) respondents of the opinion poll.

The SPC results calculated conducted based on financial data until summer 2009 deviate strongly from poll predictions. The DPC method is unfortunately not applicable (even though it can be expected to deliver reasonable outcome again in the future once the financial markets will have stabilised for a sufficiently long period of time) but the SPC reveals that market uncertainty as embodied in SPC calculations is not fully shown in Reuters poll. One reason can be wider coverage of the SPC calculations that is based on internationally traded liquid financial market instruments. Another reason might be a tendency of polls' respondents not to reveal openly all information they might have.

In conclusion, using the measures developed in this thesis sheds light on information and uncertainties priced into markets that are not reliably reflected in the available opinion polls. This may enable national authorities and other interested parties to steer more smoothly through the stages of the euro adoption process. At the very least, it reveals a need for better communication of the pursued monetary union entry strategies towards, in particular, the financial markets and the public at large. Therefore, measuring financial markets' expectations about the timing of the euro adoption can be a useful tool for policy making.

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ANNEX

Annex 1: Monetary Policy

Czech Republic

The Czech National Bank's (CNB) monetary policy objective is set forth in Article 98 of the Constitution of the Czech Republic and in Article 2 of Act No. 6/1993 Coll., on the Czech National Bank. According to these legal provisions, the CNB is in particular required to maintain price stability. Without prejudice to its primary objective, the CNB shall further support the general economic policies of the Government leading to sustainable economic growth. The CNB endeavours to fulfil this objective within an inflation targeting regime. Under its monetary policy regime based on inflation targeting, the central bank publicly pre-announces an inflation target (expressed as annual growth in the consumer price index) that it aims to achieve.

The inflation target of the CNB took the form of a continuous band descending evenly from an interval of 3% to 5% in January 2002 to an interval of 2%-4% in December 2005. For the period from January 2006 until January 2010 the target was set horizontally at 3% with a tolerance band of one percentage point in either direction. In March 2007, a new inflation target of 2% was announced with effect from January 2010. As before, the CNB shall ensure that actual inflation does not differ from the target by more than one percentage point on either side. This reduction in the inflation target reflected, in particular, the change in longer-term perspective for inflation targeting in the Czech Republic triggered by postponing the euro adoption date beyond the originally envisaged 2010 horizon and the prevailing low-inflationary environment of the Czech economy, exhibited in inflation expectations anchored at low levels. Lower inflation in the Czech Republic in line with the new target further increases the chances of meeting the Maastricht price stability criterion in the future.

The CNB continues to view its inflation targets as medium-term in nature. Actual inflation may temporarily deviate as a result of exogenous shocks, such as changes to indirect taxes. The medium-term focus of the monetary policy is reflected also in the

use of the quarterly forecast that includes the reaction function of the CNB. In its monetary policy decision-making the Bank Board of the CNB assesses the latest CNB forecast and evaluates the risks of non-fulfilment of this forecast. Based on these considerations, the Bank Board votes whether and how to change the settings of monetary policy instruments. The main monetary policy instrument takes the form of repo tenders mostly of two-weeks duration.

Hungary

As for the other CEE-4 countries, the primary statutory objective of the Hungarian National Bank (MNB) is price stability. According to the Central Bank Act, price stability shall be achieved and maintained, in line with EU regulations and international practice. The central bank tries to keep inflation at a low level through pursuing a predictable and credible monetary policy. Bearing this in mind, the most important objective of economic policy followed by Hungarian authorities is to ensure stable economic growth that is sustainable over a long term.

The MNB conducts its monetary policy under an inflation targeting regime, and it aims to achieve the targets set jointly with the Government within this framework. Since June 2001, an inflation targeting framework for monetary policy has been followed, with the targets set for December 2001 and December 2002. Subsequently, the inflation targets were set on an annual basis up to the end of 2006, for at least two years ahead. In August 2005, with effect as of 2007, the Government and the MNB jointly adopted an explicit medium-term inflation target consistent with price stability, which was defined as an average 3% rise in consumer prices index. The authorities also agreed that a maximum ±1 percentage point deviation of the Consumer Price Index from the 3% inflation target is acceptable in terms of maintaining price stability. The MNB assess and communicates fulfilment of the inflation target on a quarterly basis, in statements by the Monetary Council issued simultaneously with the publication of the Quarterly Report on Inflation, and on a yearly basis in its Annual Report.

Poland

As in the other CEE-4 countries, also in Poland is the basic objective of the monetary policy to ensure price stability. In order to achieve this, the National Bank of Poland (NBP) has followed a direct inflation targeting strategy since 1999. Every year the Monetary Policy Committee (MPC) publishes the Monetary Policy Guidelines, providing an outline for the monetary policy in a shorter, one year perspective. In the Guidelines released in September 2008, the MPC confirmed that direct inflation targeting was an effective method of ensuring price stability. Since the beginning of 2004, the National Bank of Poland has pursued a continuous inflation target at the level of 2.5% with a permissible fluctuation band of +/- 1 percentage point.

In 2008, the Government approved the Road Map for Euro Adoption in Poland, which targeted 2012 for compliance with the Maastricht Criteria and adoption of the euro. In order to complete this goal, the Road Map envisioned entry into ERM II in the second quarter of 2009. The recent financial crisis, however, destabilized the Polish złoty exchange rate, through turbulence in financial markets and sharp deterioration in global economic activity, which negatively affected the prospects of economic growth in Poland (although to a lesser extent than in the rest of CEE-4 region as well as in the EU). As entry by a country into ERM II should be preceded by a short period where exchange rate volatility does not significantly exceed the level observed for other entrants into ERM II, current volatility in the złoty exchange rate delayed the Polish ERM II entry plans.

Slovakia

In 1998 Slovakia abolished the exchange rate peg against a currency basket and moved to an implicit inflation targeting regime. Monetary policy steps were geared towards meeting an implicit year-end inflation target, taking into consideration exchange rate developments, particularly with regard to the euro.

An amendment to the Národná banka Slovenska (NBS) Act in 2001 changed the primary objective of monetary policy to price stability, and in January 2005 explicit

inflation targets for the period from 2005 to 2008 were announced. More specifically, the HICP inflation targets were below 2.5% and 2% for the end of 2006 and 2007/2008, respectively. At the end of November 2005, the Slovak koruna joined ERM II and since the beginning of 2009 Slovakia has smoothly adopted euro, and thus also the monetary policy of the euro area.

Annex 2: Bootstrapping procedure

In order to find out the forward interest rate implied by the swap curve it is convenient first to derive the term structure of interest rates (the zero-coupon yield curve). As shown below this is possible without any approximation for only some types of swaps, but fortunately, in practice, the suitable swaps are often used. Let $B_{t,M}$ be the price of the discount bond with maturity M applicable at time t. Further, let $I_t^M(m,v)$ denote the interest rate fixed for the floating swap with maturity M as of trade date t, which is based on the floating rate with maturity m. Let the fixed leg of the swap be settled v times a year and let all interest rates be expressed in terms of annual compounding. For simplicity I abstract from any credit risk.

Then the present value of the cash flow for the fixed leg of the swap $I_t^M(m,v)$ on the unit notional amount is given by

$$PV_{fixed} = [(1 + I_t^M(m,v))^{\frac{1}{v}} - 1] \sum_{k=1}^{vM} B_{t,\frac{k}{v}} \tag{A1.1}$$

Further, let $f_{t,\tau}$ be the forward rate as of the trade date t at horizon τ and maturity \$T\$ based on the term structure of risk free bonds. Using this term structure of forward rates, swap sellers can hedge their exposure to interest rate risk. [32] The present value of this hedged floating leg's cash flow of the interest rate swap is then

$$PV_{floating} = \sum_{k=1}^{vM} [(1 + f_{t,jm,m})^m - 1] B_{t,(j+1)m} \tag{A1.2}$$

The non-existence of arbitrage opportunities further dictates the relationship between discount rates and forward rates obviously expressed as

$$\frac{B_{t,jm}}{B_{t,(j+1)m}} = (1 + f_{t,jm,m})^m \tag{A1.3}$$

[32] Swap sellers receive fixed rate and pay floating rate payments.

so when it is substituted in (A1.2) for $(1+f_{t,jm,m})^m$ one may write

$$PV_{floating} = \sum_{k=1}^{\frac{M}{m}} B_{t,jm} - B_{t,(j+1)m} \tag{A1.4}$$

and since most of the terms in this series cancel it is possible to conclude that

$$PV_{floating} = 1 - B_{t,M} \tag{A1.5}$$

Since both the fixed leg and the hedged floating leg represent streams of certain payments, the no-arbitrage condition on the swap rate is that the present values of both payment streams are equal, therefore

$$[(1+I_t^M(m,v))^{\frac{1}{v}} - 1]\sum_{k=1}^{vM} B_{t,\frac{k}{v}} = 1 - B_{t,M} \tag{A1.6}$$

This formula relates prices of discount bonds and interest rate swap rates. Further, if a sufficient number of interest rate swaps is traded, then it is possible to use this formula to calculate prices of discount bonds recursively. After some straightforward algebraic manipulations it follows from (A1.6) that

$$B_{t,\frac{1}{v}} = \frac{1}{(1+I_t^{\frac{1}{v}}(m,v))^{\frac{1}{v}}} \tag{A1.7}$$

$$B_{t,M} = \frac{1+\sum_{k=1}^{vM-1} B_{t,\frac{k}{v}}}{(1+I_t^M(m,v))^{\frac{1}{v}}} - \sum_{k=1}^{vM-1} B_{t,\frac{k}{v}}, \quad \text{for } M > \frac{1}{v} \tag{A1.8}$$

(A1.8) shows that if prices of discount bonds with maturities $\frac{1}{v}, \frac{2}{v}, \frac{3}{v}, \ldots, \frac{vM-1}{v}$ are known, then knowledge of the swap rate $I_t^M(m,v)$ enables determination of the discount factor $B_{t,M}$.

If these discount bond prices are known, then, similarly to (A1.3), one may obtain the implied forward rates of maturity $\frac{1}{v}$ as

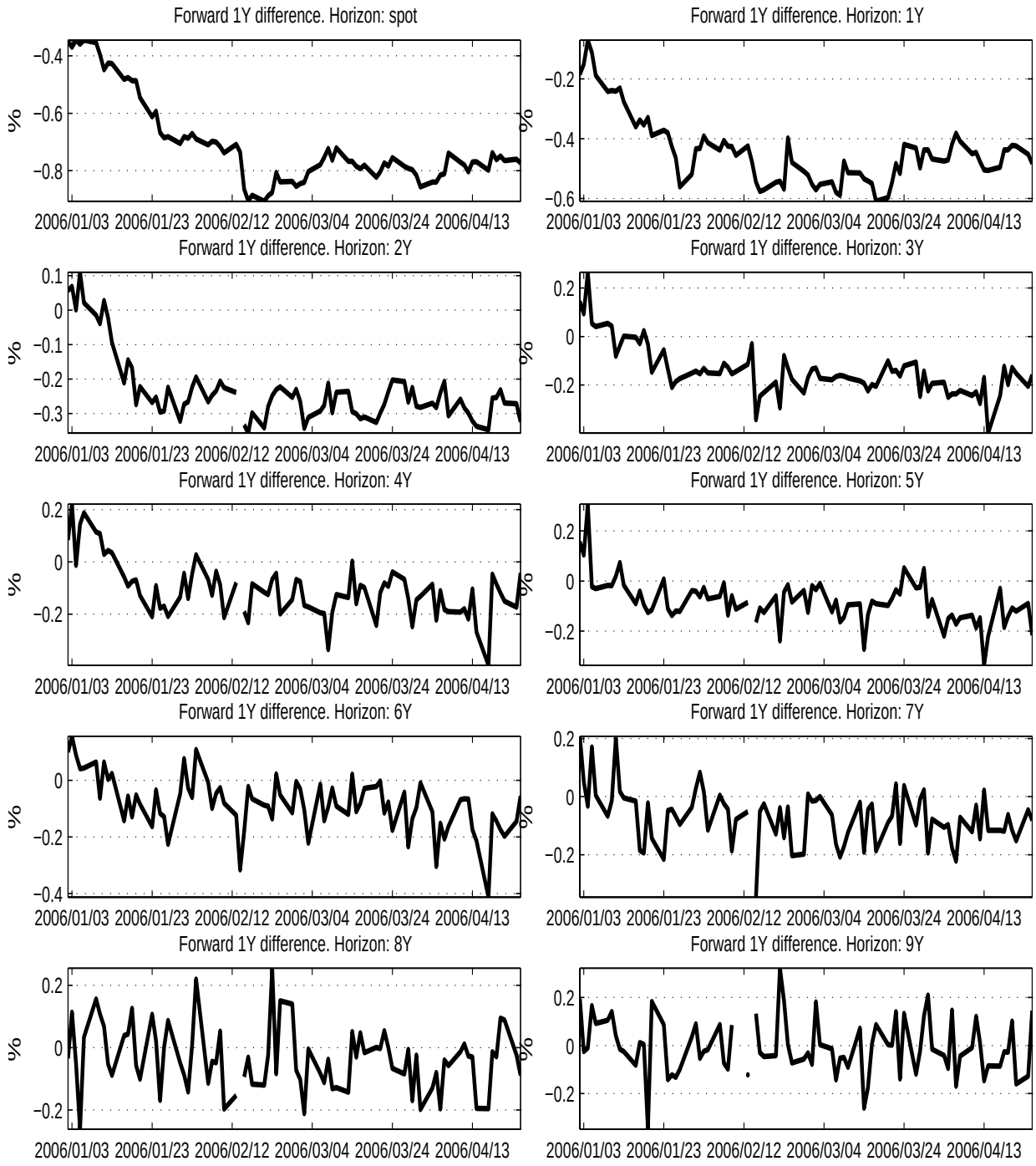
$$f_{t,\frac{k-1}{v},\frac{1}{v}} = \left(\frac{B_{t,\frac{k-1}{v}}}{B_{t,\frac{k}{v}}} \right)^{\frac{1}{v}} - 1 \qquad \text{(A1.9)}$$

The possibility of performing this procedure hinges on the condition that there are enough points on the swap curve in relation to the settlement frequency of the fixed part of the swap contracts. In particular, there must be vT equally spaced swap rates to allow determination of the vT discount factors. On the contrary, there is no such condition on the maturity of the underlying floating rate. Fortunately, and perhaps not surprisingly, swap rates are often quoted for maturities in whole years and with annual settlement, i.e. v=1, which facilitates the empirical analysis.

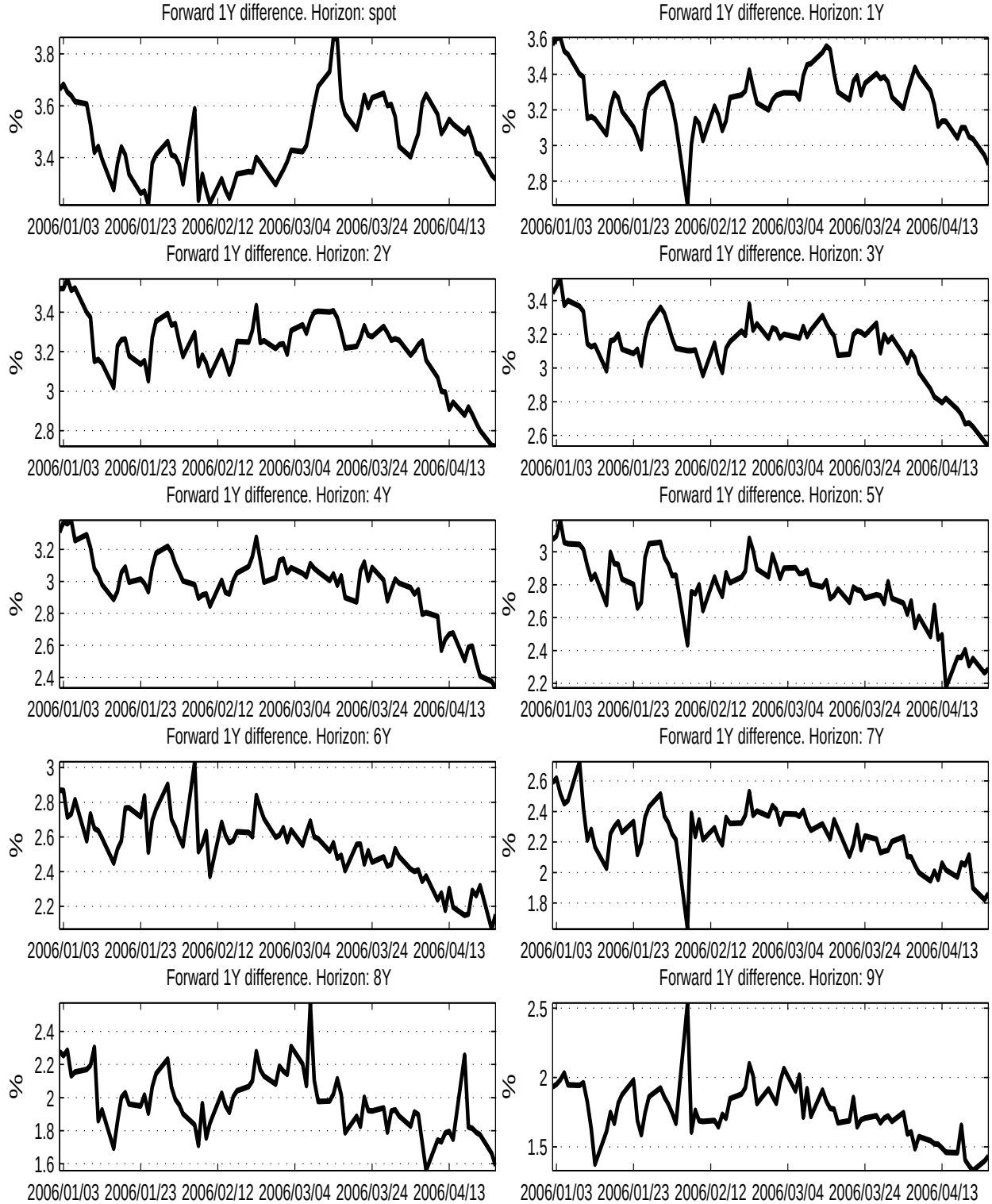
Annex 3: Forward interest rates CEE-4 countries

Figure A3: Forward interest rates CEE-4 countries

Czech Republic



Hungary


Forward 1Y difference. Horizon: spot
Forward 1Y difference. Horizon: 1Y
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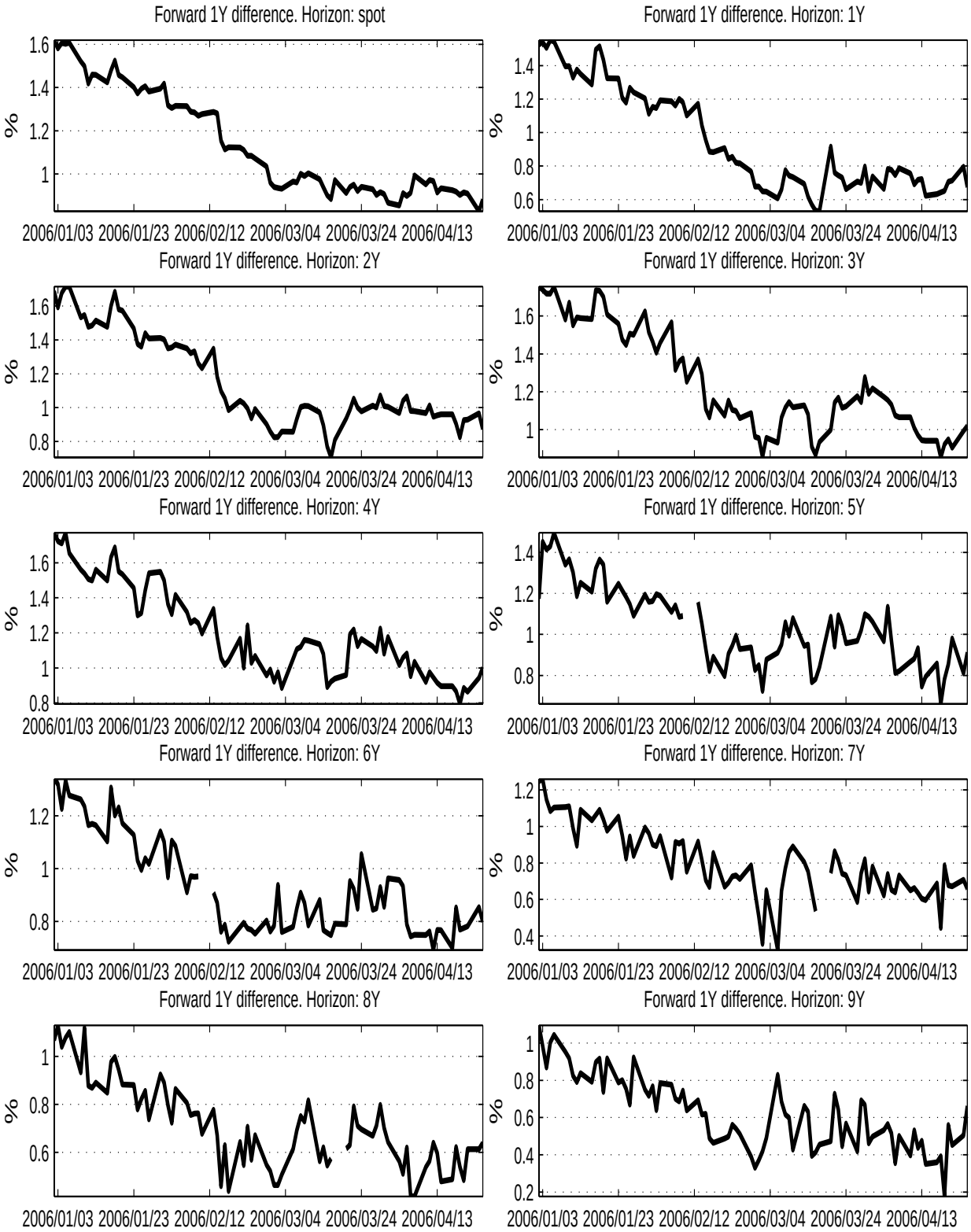
Poland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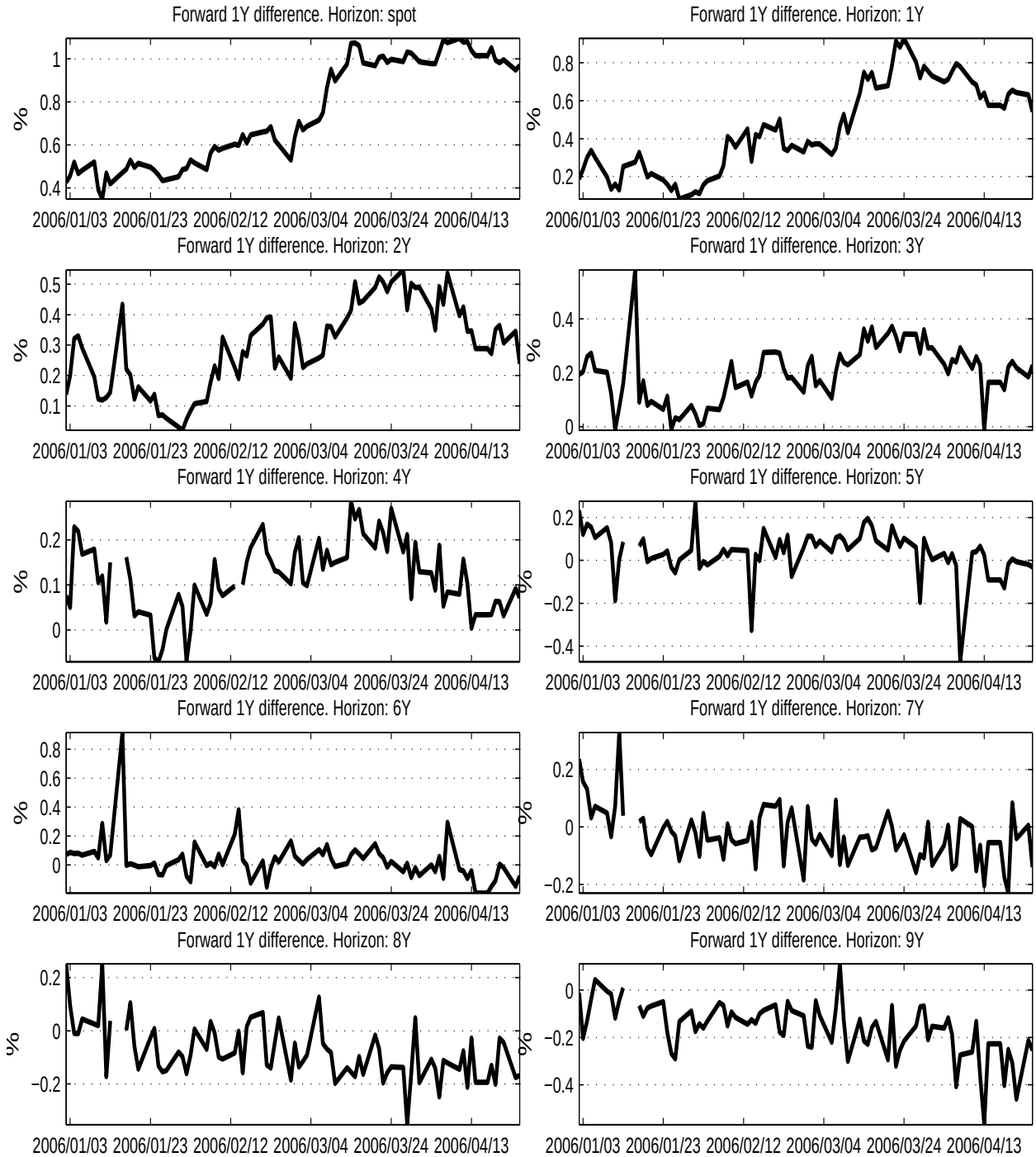
Slovakia


Forward 1Y difference. Horizon: spot
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2006/01/03 2006/01/23 2006/02/12 2006/03/04 2006/03/24 2006/04/13

Table A3: Outcome SPC calculator – various base years

base = 2001	2003	2004	2005	2006	2007	2008	2009	2010	2011
CZ	16.94	27.04	25.75	29.45	33.22	37.10	38.83	40.16	41.26
HU	11.79	18.47	25.66	32.87	49.62	54.92	57.70	61.14	62.65
PL	12.01	18.83	23.73	28.04	32.19	36.06	39.56	42.78	45.69
SK	4.07	6.46	9.13	12.08	12.00	16.18	14.31	16.74	17.09

base = 2002	2004	2005	2006	2007	2008	2009	2010	2011	2012
CZ	27.27	29.96	38.05	36.01	37.24	40.56	44.60	51.07	53.46
HU	12.82	23.25	31.95	38.54	42.71	47.61	51.72	55.02	58.73
PL	15.58	23.48	29.30	33.95	38.66	42.95	46.80	50.26	53.38
SK	14.95	25.17	33.26	38.16	40.44	45.93	48.23	50.96	52.93

base = 2003	2005	2006	2007	2008	2009	2010	2011	2012	2013
CZ	44.90	68.17	75.74	65.53	61.75	59.99	61.74	67.40	64.64
HU	11.92	21.15	29.28	35.75	41.24	45.97	50.16	53.63	56.42
PL	13.00	18.34	24.59	29.87	34.86	39.92	44.27	47.75	50.92
SK	26.29	41.68	52.39	59.46	63.28	68.46	71.27	74.38	76.54

base = 2004	2006	2007	2008	2009	2010	2011	2012	2013	2014
CZ	2.85	4.87	4.20	3.07	6.34	6.94	11.12	11.23	12.13
HU	12.20	20.55	27.24	32.85	37.72	42.13	45.87	49.16	51.97
PL	6.30	8.83	13.15	18.03	22.96	27.65	31.81	35.46	38.65
SK	19.49	29.48	37.00	42.34	48.15	53.29	56.07	57.93	59.11

base = 2005	2007	2008	2009	2010	2011	2012	2013	2014	2015
CZ	31.01	51.29	73.13	75.97	77.37	83.41	75.05	78.83	79.07
HU	6.15	10.04	13.42	16.83	20.16	23.61	27.12	30.50	33.68
PL	8.02	12.79	15.39	20.65	21.37	25.34	29.51	33.07	36.54
SK	20.34	35.74	38.92	41.51	48.16	49.59	52.91	55.23	50.59

base = 2006	2008	2009	2010	2011	2012	2013	2014	2015	2016
CZ	24.90	40.18	50.18	57.16	61.48	65.65	68.69	70.93	72.67
HU	3.44	6.14	8.54	10.95	13.52	16.22	18.86	21.65	24.20
PL	10.71	10.30	7.06	4.95	6.65	8.53	11.17	14.04	17.65
SK	21.67	33.68	42.36	48.96	54.33	58.88	62.88	63.39	66.62

base = 2007	2009	2010	2011	2012	2013	2014	2015	2016	2017
CZ	24.77	37.74	45.72	51.60	56.11	59.99	62.89	64.94	66.80
HU	7.76	11.49	14.24	16.62	19.08	21.71	24.47	27.42	30.17
PL	n.a.	n.a.	n.a.	3.90	9.11	8.14	13.46	19.31	17.74
SK	49.06	64.55	65.68	73.57	72.56	71.99	76.43	76.85	76.53

base = 2008	2010	2011	2012	2013	2014	2015	2016	2017	2018
CZ	26.56	39.60	37.83	43.87	47.42	51.58	55.34	60.41	65.19
HU	5.35	9.25	10.84	13.93	16.85	20.09	23.45	26.78	29.51
PL	6.06	11.80	14.31	15.56	19.81	23.83	27.52	31.30	34.56
SK	66.16	66.38	74.18	77.89	79.94	82.25	80.15	79.73	82.74

base = 2009	2011	2012	2013	2014	2015	2016	2017	2018	2019
CZ	5.60	16.48	21.61	35.37	51.00	61.59	67.37	70.37	71.01
HU	8.42	15.21	19.90	23.54	27.02	30.30	33.27	36.23	39.02
PL	0.64	3.30	9.07	15.00	18.03	22.63	26.61	29.89	32.47
SK	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

Annex 4: Outcome DPC calculator - other countries

To obtain a better feel about the new methodology it might be useful to ponder the results for other countries that have distinctly different characteristics, namely, Denmark, Sweden, and the UK. Denmark participates in the tight ERM II regime, but has negotiated an opt-out clause. Sweden represents an EU country without an opt-out clause but outside of the ERM II, and the UK is both outside the ERM II and opting out.

After a referendum that rejected EMU membership in 2000, Denmark participates in the ERM II with a very narrow fluctuation band for its currency. No new referendum is planned and there is no chance of Denmark participating in the EMU in the foreseeable future. The effectively pegged exchange rate with free trade and capital flows means that the Danish central bank has to mimic the monetary policy of the ECB. Under such circumstances one might naturally expect Danish forwards not to diverge far from European ones. And indeed, there is cointegration between these pairs for all horizons, as table A4 shows. However, the speed of adjustment α_{DKK} does not reveal any dependence on horizon, which is intuitive.

Swedish forward rates are cointegrated with European ones and tend to be affected by the differential over the euro for almost any horizon. On the other hand, the European coefficient α^{*}_{SEK} again came out small and in most cases insignificant.

The future of UK's membership in the euro area remains highly un-certain. The pound floats freely and is a currency of global importance. Under such circumstances, one should expect no easily detectable short-term relationship between the dynamics of British and European forward rates. As demonstrated in table A4, the forward rates tend not to be cointegrated, and for cases where stationarity of the residuals cannot be rejected the error correction coefficients α^{*}_{GBP} are in-significant.

Table A4: Estimated Error Correction Coefficients for Denmark, Sweden and the United Kingdom

	Horizon								
DENMARK	**1*2**	**2*3**	**3*4**	**4*5**	**5*6**	**6*7**	**7*8**	**8*9**	**9*10**
AEG τ-test value	-2.520	-4.236	-6.569	-5.657	-5.003	-5.831	-6.313	-6.045	-7.711
α_czk	0.037	0.063	0.011	-0.078	-0.012	-0.153	-0.069	-0.140	-0.025
(p-value)	(0.605)	(0.535)	(0.925)	(0.571)	(0.911)	(0.270)	(0.652)	(0.243)	(0.862)
α*_czk	0.077	0.161	0.139	0.113	0.087	0.105	0.159	0.141	0.284
(p-value)	(0.279)	(0.099)	(0.206)	(0.425)	(0.402)	(0.371)	(0.206)	(0.265)	(0.057)
β_czk	0.117	0.119	0.117	0.118	0.116	0.123	0.120	0.122	0.121
s.e.	[0.006]	[0.005]	[0.005]	[0.004]	[0.004]	[0.004]	[0.004]	[0.005]	[0.005]
LM test DKK	0.652	0.073	0.194	0.041	0.146	0.525	0.472	0.137	0.207
LM test EU	0.758	0.083	0.183	0.124	0.106	0.457	0.050	0.419	0.514

	Horizon								
SWEDEN	**1*2**	**2*3**	**3*4**	**4*5**	**5*6**	**6*7**	**7*8**	**8*9**	**9*10**
AEG τ-test value	-2.849	-3.925	-4.660	-4.845	-5.637	-6.449	-7.274	-5.583	-6.398
α_czk	-0.115	-0.121	-0.183	-0.252	-0.238	-0.581	-0.658	-0.506	-0.500
(p-value)	(0.009)	(0.011)	(0.006)	(0.002)	(0.027)	(0.000)	(0.000)	(0.000)	(0.000)
α*_czk	-0.011	0.030	-0.010	-0.023	0.136	0.026	0.086	0.078	0.012
(p-value)	(0.772)	(0.498)	(0.862)	(0.750)	(0.139)	(0.758)	(0.345)	(0.383)	(0.886)
β_czk	-0.115	0.172	0.221	0.194	0.150	0.099	0.015	-0.052	-0.122
(p-value)	[0.012]	[0.012]	[0.010]	[0.007]	[0.006]	[0.006]	[0.006]	[0.007]	[0.008]
LM test HUF	0.440	0.392	0.367	0.543	0.989	0.981	0.493	0.970	0.350
LM test EU	0.914	0.660	0.108	0.157	0.558	0.315	0.695	0.933	0.282

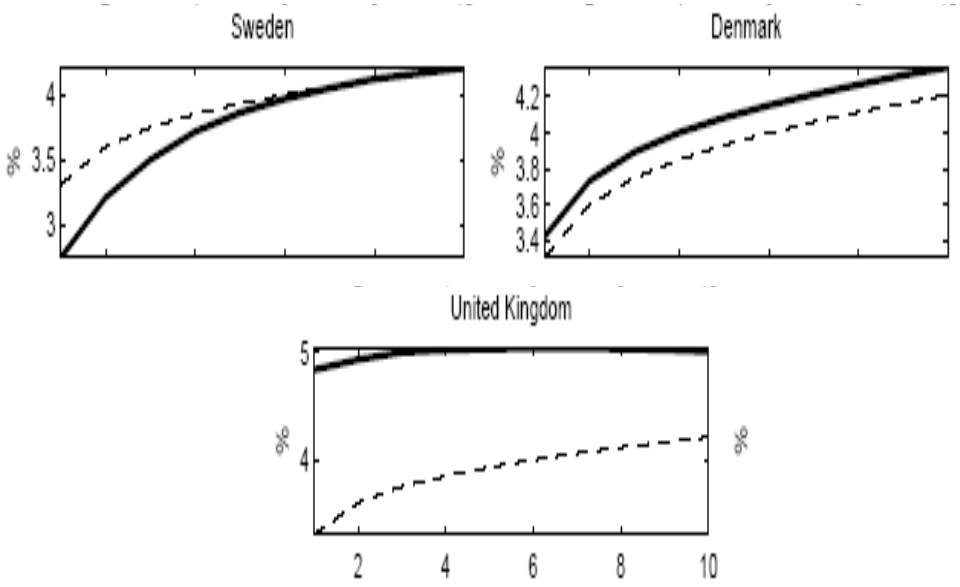
	Horizon								
UK	**1*2**	**2*3**	**3*4**	**4*5**	**5*6**	**6*7**	**7*8**	**8*9**	**9*10**
AEG τ-test value	-4.597	-4.517	-2.445	-2.116	-2.145	-3.647	-3.451	-3.522	-3.192
α_czk	-0.016	-0.046	-0.068	-0.058	-0.101	-0.145	-0.138	-0.186	-0.159
(p-value)	(0.629)	(0.238)	(0.100)	(0.087)	(0.019)	(0.003)	(0.003)	(0.002)	(0.002)
α*_czk	0.022	0.007	0.002	-0.004	-0.019	-0.034	-0.033	-0.032	-0.040
(p-value)	(0.540)	(0.836)	(0.955)	(0.915)	(0.597)	(0.398)	(0.395)	(0.491)	(0.429)
β_czk	1.203	1.134	0.959	0.810	0.687	0.546	0.382	0.232	0.086
(p-value)	[0.012]	[0.013]	[0.013]	[0.013]	[0.012]	[0.011]	[0.012]	[0.012]	[0.012]
LM test PLZ	0.318	0.565	0.298	0.210	0.808	0.948	0.808	0.134	0.141
LM test EU	0.363	0.760	0.712	0.467	0.404	0.348	0.654	0.866	0.578

Source: own calculations.

Note: Appropriate critical values of the AEG τ-test for 1 %, 5 % and 10 % are in all cases -3.9, -3.34 and 3.04 respectively.

Figure A4: Interest rate swap curves as of 25 April 2006 (Denmark, Sweden and the United Kingdom)

(solid line – interest rate swap denominated in domestic currency, dashed line – interest rate swap denominated in the euro; maturity in years)



Source: Bloomberg.

Annex 5: Official monetary policy strategies of non-euro area EU Member States

Table A5: Official monetary policy strategies of non-euro area EU Member States

Official monetary policy strategies of the non-euro area EU Member States			
	Monetary policy strategy	Currency	Features
Bulgaria	Exchange rate target	Bulgarian lev	Exchange rate target: peg to the euro at BGN 1.95583 lev per euro within the framework of a currency board arrangement.
Czech Republic	Inflation target	Czech koruna	Target: 3% ±1 percentage point until end- 2009; thereafter 2% ±1 percentage point. Managed floating exchange rate.
Denmark	Exchange rate target	Danish krone	Participates in ERM II with a ±2.25% fluctuation band around central rate of DKK 7.46038 per euro.
Estonia	Exchange rate target	Estonian kroon	Participates in ERM II with a ±15% fluctuation band around central rate of EEK 15.6466 per euro. Estonia continues with its currency board arrangement as a unilateral commitment.
Latvia	Exchange rate target	Latvian lats	Participates in ERM II with a ±15% fluctuation band around central rate of LVL 0.702804 per euro. Latvia continues with a fluctuation band of ±1% as a unilateral commitment.
Lithuania	Exchange rate target	Lithuanian litas	Participates in ERM II with a ±15% fluctuation band around central rate of LTL 3.45280 per euro. Lithuania continues with its currency board arrangement as a unilateral commitment.
Hungary	Inflation target	Hungarian forint	Inflation target: 3% ± 1 percentage point medium-term target since 2007. "Free floating" exchange rate.
Poland	Inflation target	Polish zloty	Inflation target: 2.5% ±1 percentage point (12-month increase in the CPI). "Free floating" exchange rate.
Romania	Inflation target	Romanian leu	Inflation target: 3.5% ±1 percentage point for end-2009 and end-2010. 3.0% ±1 percentage point for end-2011. Managed floating exchange rate.
Sweden	Inflation target	Swedish krona	Inflation target: 2% increase in the CPI with a tolerance margin of ±1 percentage point. "Free floating" exchange rate.
United Kingdom	Inflation target	Pound sterling	Inflation target: 2% as measured by the 12-month increase in the CPI[1]. In the event of a deviation of more than 1 percentage point, the Governor is expected to write an open letter on behalf of the Monetary Policy Committee to the Chancellor of the Exchequ

Source: ECB, Biannual Monetary Policy Exercise, December 2009.