Essays on European Economic and Monetary Integration

Gaetano D'Adamo

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Relatore: Prof. Riccardo Rovelli

Coordinatore: Prof. Andrea Ichino

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Overview

This doctoral thesis aims at contributing to the study of two aspects of European economic and monetary integration: exchange rate stabilization between Countries that have not adopted the euro yet and the Euro Area, and real and nominal convergence of Central and Eastern European Countries (CEECs). Each Chapter is self-contained, and covers these aspects of European integration from both a theoretical and empirical perspective. Each part of this research is made up of a theoretical framework, which I have tried to keep as straightforward as possible, and a more structured empirical part.

In particular, the first two chapters deal with the issue of exchange rate stabilization between the euro area and non-euro Europe. In principle, we can think of several possible sources of reduction in exchange rate volatility: broadly speaking, extensive use of foreign exchange reserves and credit lines (Calvo and Reinhart, 2002), direct interest rate intervention, for example changing the policy interest rate in step with the anchor country, or "involuntary" exchange rate stabilization, for example as the result of increased business cycle convergence (Giavazzi and Mishkin, 2007). Chapter 3 discusses the issue of real convergence of CEECs from an original perspective: by testing which macro sector has been driving wage determination in a country, we can detect potential sources of international imbalances arising in the process of catching up.

Chapter 1 discusses nominal exchange rate stabilization in Europe from the point of view of the *de jure* vs. *de facto* flexibility literature. In particular, it reviews measures of de facto exchange rate flexibility as developed by Calvo and Reinhart (2002) and Frankel and Wei (2008) and applies them to

14 european countries. Since the end of the 1990s, due to several crises of fixed exchange rate arrangements, we could witness a polarization of *de facto* exchange rate regimes in the world: either fully flexible exchange rates, coupled with inflation targeting, or strict pegs and currency unions. However, previous studies (Fischer, 2004) have challenged this view, and in the 2000s a literature has flourished on measures of de facto exchange rate flexibility: in other words, in order to assess the relative merits of alternative exchange rate arrangements it is important to know what countries are actually doing, rather than what they declare. Since a regime of managed floating, such as a narrow band or crawling peg, can be prone to speculative attacks even when there are no credibility problems on the Central Bank's side, Central Banks may have the incentive to declare they are floating and then deviate from their official statements. The rationale for exchange rate management in disguise is at least twofold: first, a depreciated exchange rate can be used as a mean of protection of domestic industries (Levy-Yeyati and Sturzenegger, 2007); second, if the country's debt is denominated in a foreign currency, the dominant currency is potentially a good anchor (Svensson, 2003).

For European countries that have not (yet) joined the EMU, there may be another potential reason for managing the exchange rate *vis à vis* the euro: the creation of a large neighboring currency union, with which they are highly economically and financially integrated, in 1999 may have provided these countries a natural anchor. Indeed, while the polarization of *de facto* exchange rate regimes has occurred in Europe as well, exchange rate volatility (as measured by the mean absolute deviation) has decreased in the last decade with respect to the past. Was that the result of smaller foreign exchange and macroeconomic shocks or active exchange rate management?

At the basis of the literature on fear of floating there is the idea that, in order to detect the actual regime that a country is pursuing, one should not look at movements in asset prices and reserves. In fact, on average, the higher the level of flexibility, the higher the volatility of the exchange rate and the lower the volatility of reserves should be. The paper by Calvo and Reinhart (2002) introduced the use of priors to measure such volatility. Calvo and Reinhart (2002) opened the way to a large set of empirical works proposing alternative approaches to detect de facto exchange rate regimes. This strand of literature can be divided into two groups: one, larger, attempting to classify exchange rate regimes based on the degree of flexibility (a subsample containing Calvo and Reinhart, 2002; Ghosh et al., 2002; Reinhart and Rogoff, 2004, Levy-Yeyati and Sturzenegger, 2003, 2005 and 2007; Ball and Reyes, 2008), and one smaller, aimed at estimating weights in currency baskets when a country is known to follow a basket peg (for example Frankel and Wei, 1994; Bénassy and Quéré, 1999; Ohno, 1999; Frankel, 2008; Frankel and Wei, 2008).

In the first chapter of this doctoral thesis I begin by showing, by means of a stylized theoretical framework, how priors on the policy interest rate, the exchange rate and foreign exchange reserves can be informative on the *de facto* exchange rate policy pursued by the central Bank. I then review the works of Calvo and Reinhart (2002) and Frankel and Wei (2008) and apply them to 14 European non-euro countries, as opposed to a small group of benchmark floaters (Australia, Canada, New Zealand, United States and Japan). I use monthly data from 1980 until 2009 (when available; for former communist countries the starting date is after 1993), a sample period when most of these countries have adopted different monetary policy regimes characterized by varying degrees of de facto exchange rate flexibility.

In order to be more precise in the comparison of different exchange rate arrangements, unlike Calvo and Reinhart I classify Inflation Targeting (IT) as a separate regime. In fact, several studies (Svensson, 2000; Clarida, 2001; Gali and Monacelli, 2005) have shown that CPI Inflation Targeting tends to reduce exchange rate fluctuations: the Central Bank responds to changes in the real exchange rate indirectly, because they affect inflation. As a result, CPI Inflation Targeting may be observationally equivalent to managed floating if we only looked at exchange rate volatility. We show this by a stylized theoretical model and, to avoid this confusion, we list IT separately from free floats. Using exchange rate flexibility measures and estimating weights in currency baskets allows us to (i) detect potential cases of *fear of floating*, i.e. exchange rate management in disguise; (ii) measure the implicit weight that was placed on the euro by the non-euro countries, with respect to other international reserve currencies; (iii) investigate whether such alternative approaches do in fact give consistent results.

Chapter 2 discusses the issue of exchange rate stabilization coming from interest rate intervention. In particular, as we will see below, I propose an approach for the estimation of the Central Bank interest rate rule in a small open economy explicitly taking into account the case of "fear of floating". The country of interest is Sweden, which is also included in the sample in Chapter 1, since it is one of the countries for which we could observe the most striking exchange rate stabilization vis à vis the euro since 1999 (see Chapter 1). As it was discussed above, a regime of Inflation Targeting can have the side effect of stabilizing the exchange rate and thus be observationally equivalent to a managed float (Clarida, 2001). It is still discussed in the literature whether an Inflation Targeter should keep an eye on the exchange rate. In principle, exchange rate movements should only matter indirectly, since, depending on the degree of exchange rate pass through, they have an impact on inflation. According to Svensson (2003), there is no reason for separate exchange rate objectives in the Central Bank's objective function; moreover, using the nominal exchange rate or money growth as an intermediate target is suboptimal with respect to forecasted CPI inflation as it causes higher output and inflation volatility (Svensson, 1996).

Targeting the exchange rate using the policy interest rate would also determine, according to Taylor (2001) and Edwards (2006) excessive interest rate volatility, which is not observed in practice. Since, however, we have seen that a large strand of literature has shown that deviations from de facto flexible exchange rate regimes are indeed present, we might ask whether fear of floating can occur through interest rate intervention. In the case of European non-euro countries, moreover, the large degree of real and financial integration may make sure that Central Banks in small open economies are not masters in their own house: Reade and Volz (2009) have shown using a Cointegrated VAR that Swedish market interest rates (the Stibor) are driven by Euro area interest rates (Euribor); in this sense, euro area monetary policy spills over on Sweden. There is a large literature that estimates interest rate rules using the so-called Taylor (1993) Rule; however, the coefficients in this rule are not identified since they are convolutions of structural and preference parameters (Svensson, 1996), and therefore they cannot be interpreted as describing the weight of alternative macroeconomic variables in the loss function of the Central Bank. For this reason, alternative approaches have been proposed in the literature to estimate central bank preferences. Cecchetti et al. (2002) estimate the relative weights on output and inflation variability in the Central Bank's objective function that minimize the distance between the estimated and the optimal interest rate response to structural economic shocks; such shocks are, in turn, identified within a SVAR model. Favero and Rovelli (2003) solve the optimization problem of the Central Bank in the case of the U.S., subject to the structure of the economy as defined by an aggregate supply and an aggregate demand equation; a similar approach is followed by Collins and Siklos (2004). I follow Favero and Rovelli and extend their model to the case of a Small Open Economy: therefore, in Chapter 2, I estimate the preferences of the Swedish Riksbank solving the Central Bank's optimization problem subject to an aggregate demand curve, an aggregate supply curve and an equation for the real exchange rate, under alternative Inflation Targeting regimes: Strict IT (i.e. only inflation is in the loss function), Flexible IT (the output gap is included), IT with interest rate stabilization and smoothing, Fear of Floating (exchange rate smoothing appears in the loss function). Within a stylized model, I also show that even in strict (CPI) Inflation Targeting the Central Bank will respond to output and real exchange rate fluctuations; thus, even if the response to these variables in the case of Flexible IT and Fear of Floating is larger, we cannot say anything on preference weights unless we estimate separately the parameters describing the structure of the economy and those describing Central Bank's preferences.

Chapter 2 discusses two further issues related to the estimation of Central Bank preferences: the relevance of interest rate smoothing and the use of real time vs. revised data. Empirical works estimating interest rate rules consistently find a large coefficient on the previous period interest rate, generally above 0.8. This finding has generally been interpreted as the Central Bank indirectly targeting output fluctuations. However, the importance of interest rate smoothing as a monetary policy objective *per se* has been criticized by Cecchetti (2000); more recently, Consolo and Favero (2009) suggested that the large coefficient on interest rate smoothing is the result of a weak instrument problem in the GMM estimation of Forward-Looking Taylor Rules. As far as the use of real time vs. revised data is concerned, Orphanides (2001) suggests that, since macroeconomic data are subject to large revisions, estimating the monetary policy rules using revised data may be misleading. Since in the case of Sweden Central Bank forecasts (which are, by definition, real-time), are available, I use them to estimate preference weights, while I use revised data to estimate the structural model.

Chapter 3 investigates the issue of real and nominal convergence of Central and Eastern European Countries (CEECs) from the point of view of the labor market. In particular, this chapter tests the validity of one of the crucial assumptions of the Balassa-Samuelson hypothesis, namely that the traded sector is the leader in wage determination. More precisely, theoretical models of spillovers in wage determination (for example, Aukrust (1977)'s Scandinavian Model of Inflation) assume that wages in the traded sector (T) grow in step with productivity; since there is free inter-sectoral labor mobility wages, then, equalize across sectors. In countries that are in the process of catching up, productivity growth in the traded goods sector is higher, and therefore the non-traded sector (N) firms will have to increase prices and the overall price level will rise, a result which is in line with the so-called internal version of the Balassa-Samuelson hypothesis (Froot and Rogoff, 1995). The increase in the CPI due to the process of convergence will, in turn, determine a real exchange rate appreciation (the so-called external version of the Balassa-Samuelson hypothesis). The issue of real and nominal convergence in CEECs is especially relevant because those countries that are members of the E.U. will eventually adopt the euro, if they haven't already, and structural excess inflation resulting from the process of convergence will influence the outcome of monetary policy and the Maastricht convergence criteria.

As we have stated above, according to Balassa (1964), since developing countries start with a depreciated exchange rate and a lower price level, during the process of convergence they will experience excess inflation and an increasing real exchange rate. Such appreciation should not, in principle, harm international competitiveness, as long as wages in T do not grow ahead of productivity. But is it necessarily the case that T is the leader in wage determination, or we can think of alternative feedback effects across sectors? In fact, if N or the public sector is actually the leader in wage setting, then convergence may be accompanied by excessive wage growth and therefore competitiveness loss. During the last decade, a large empirical literature has investigated the relevance of the Balassa-Samuelson effect for CEECs (just to name a few, Egert (2002, 2003, 2007 and 2010); Egert et al. (2006), Coricelli and Jazbec (2004); Fischer (2004), Mihaljek and Klau (2003)), and the result is generally that, on one hand, the B-S effect itself can only account for a small part of the excess inflation and real exchange rate appreciation witnessed in those countries; on the other hand, other factors might be at play, for example the shift in consumption towards higher quality goods (i.e. Engel's Law, see Egert (2007)) and an increase in the share of services in the consumption basket. According to Fischer (2004), the investment demand channel has also played an important role: in particular, rising productivity in any sector raises the equilibrium capital stock in the economy and thus raises investment demand; this, in turn, pushed prices up.

Quite surprisingly, the literature on the B-S effect has so far put considerably little attention on testing the model hypotheses, except for the issue of the composition effect of the consumption basket in Egert (2007). In particular, no work to date tests the assumption that the traded sector leads wage setting, while for example Egert (2002) only focuses on relative wage developments, i.e. discusses how the wage ratio across the two sectors seems to have remained constant, and thus wage equalization seems to hold. However, there are at least two arguments against the assumption that T leads wage setting. On one hand, firms in N are not subject to international competition and therefore can increase prices following a rise in the real producer wage (i.e. the labor cost). Thus, in a sense, unions have more bargaining power in N and can extract a mark-up in the wage over productivity (Friberg, 2007); this, in turn, may spill over to wages in T. On the other hand, wage setting in the public sector is influenced by political considerations (Demekas and Kontolemis, 2000) rather than productivity; public sector wages can also be assumed to be exogenous with respect to the business economy (Ardagna, 2007). If the public sector leads wage determination and envy externalities and other forms of social comparisons are present (Oswald, 1979), then wages in the business economy may grow above productivity, pushing the price level up. Overall, there is limited empirical literature on the issue of spillovers in wage determination. Lamo et al. (2008) investigate wage leadership between the private and public sector in 18 OECD countries and find that, while the results are ultimately country-dependent, private sector wages seem to exert stronger effect on public wages than the reverse; prices play an important role in the transmission mechanism. Friberg (2007) does not find evidence in favor of the so-called "Scandinavian Model" of wage determination, that postulates the wage leadership of the traded sector, in the case of Sweden, while Demekas and Kontolemis (2000) show that in Greece public sector wages were weakly exogenous with respect to private wages, while Christou et al. (2007) find bi-directional causality in the case of Romania.

The objective of Chapter 3 is to test the assumption of wage leadership in the case of CEECs from a broader perspective, that is including traded, non-traded and public sector wages. Since CEECs are in the process of catching up, spillovers in wage determination may cause wage costs to grow ahead of productivity, and thus the catching-up process may occur at the cost of large international imbalances. This can be amplified in countries that are in a fixed exchange rate arrangement, or have already adopted the euro, because the nominal exchange rate cannot correct for the excess inflation. The analysis is performed by means of a Cointegrated VAR (CVAR): the models of wage determination that I will sketch make precise and testable assumptions on the relationships we discussed: constancy of the wage ratio (which would imply free inter-sectoral labor mobility), which sector has been driving wage determination, i.e. was weakly exogenous, and whether there was a stronger form of wage leadership, with absence of short-run effects coming from the other sectors. All of these assumptions can be conveniently tested within a Cointegrated VAR framework. Finally, I analyze the process of adjustment after a shock to the leading sector's wage using Impulse Response Analysis.

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Chapter 1

Measuring Exchange Rate Flexibility in Europe

1.1 Introduction

The question behind this chapter is the following: did the introduction of the euro influence exchange rate policy in the European countries outside the EMU? In other terms, we want to gain insight on the de facto exchange rate regimes of European countries that did not adopt the euro, in order to assess whether Central Banks have deviated from their official statements and put some weight on the stabilization of the euro exchange rate instead. To this end, we will employ methods recently developed by the literature on *de facto* exchange rate regime classification and the estimation of weights in currency baskets, in particular Calvo and Reinhart (2002) and Frankel and Wei (2008), over alternative *de jure* regimes that were adopted in the period 1980-2009, and compare the results we get with those of five benchmark floaters: Australia, Canada, Japan, New Zealand and the U.S.

Since the 1990s, a gradual polarization of official (de jure) exchange rate regimes characterized the international monetary system, with intermediate regimes gradually disappearing as countries were increasingly lying on two extremes: either full flexibility and Inflation Targeting, or strict pegs and currency unions. However, previous works (for example, Frankel (1999) and Levy-Yeyati and Sturzenegger (2005)) showed that, from a de facto point of view, the majority of countries still lies in the shaded area between these extremes.

The introduction of the euro in 1999 might have influenced exchange rate policies outside the euro area for two main reasons, one voluntary and one involuntary. In the former case, the rationale for stabilizing the exchange rate vis à vis the euro might be the high degree of economic and financial integration with the EMU, so that by minimizing exchange rate volatility a base for lower output and inflation volatility is created at home too. In the latter case, the non-euro country might find itself following the monetary policy of the ECB, either because the business cycles in the two areas are highly correlated (Giavazzi and Mishkin, 2007) or home market interest rates are driven by euro area interest rates (Reade and Volz, 2009) and exchange rate stabilization is therefore, in a sense, unintentional.

Using regime classification methods allows us to approach this issue in two ways. First, for those countries which experienced a regime switch in the corresponding sample period, we can find whether the behavior of reserves and exchange rates was actually different across the alternative official regimes. On the other hand, the Frankel and Wei (2008) method for estimating currency weights makes it possible to detect the importance of the euro as an informal anchor with respect to other international reserve currencies. For countries that did not experience an official regime switch, we can employ de facto classification schemes to detect whether the exchange rate regime was indeed stable and consistent with what announced.

The main results of this paper are the following. First of all, the move to inflation targeting in Europe has brought about higher exchange rate flexibility, but up to a level that is not comparable to non-european benchmark countries. Second, the Euro has acquired a relevant role as an informal reference currency even for non-european countries, more than the sum of its main constituent currencies. Third, among the intermediate regimes, various forms of managed floating have on average been more costly (i.e. characterized by higher exchange rate and reserves volatility) than membership of ERM and ERM II. These results point to the same direction as Van Dijk et al. (2011) who have shown, using dynamic conditional correlations, that the correlation between the US Dollar exchange rate of four European currencies, namely the Swedish Krona, the Swiss Franc, the U.K. Pound and the Norwegian Krone and the euro has increased both after the launch of the euro at the end of 1996 and its formal introduction in 1999. Following this result, the authors state that

> [...] non-euro countries may wish to gain maximum positive spill-over effects by keeping their currencies more in line with the euro[1]

so that the benefits of lower exchange rate variability are achieved without the drawbacks of joining the Monetary Union (namely the loss of monetary policy independence). Moreover, in the case of Switzerland, Reynard (2008) has pointed out the stabilization role of the euro, which has reduced the fluctuations of the Swiss Franc against the U.S. Dollar.

The paper is structured as follows: after a brief review of the literature on exchange rate regimes classification, in Section 3 I present the theoretical framework of reference; Section 4 introduces the data; in Section 5, consistent with the theoretical framework, several theoretical priors are tested empirically using the Calvo and Reinhart (2002) approach. The weights attached to the main international reserve currencies are estimated in Section 6 using Frankel and Wei (2008)'s approach. Section 7 concludes.

1.2 Review of the Literature on Exchange Rate Regimes Classification

The relative advantages and disadvantages of flexible and fixed exchange rate regimes are still widely discussed. On one hand, under a peg, the lack of nominal exchange rate adjustment can result in price distortions and misallocation of resources; the need to defend a peg in case of speculative attacks can result in costly real interest rate spikes (Calvo, 1999); there is some evidence as well that output volatility is higher and output growth tends to be lower (Levy-Yeyati and Sturzenegger, 2003) [2]. On the other hand, by reducing relative price volatility, a peg is likely to stimulate investments and trade, and this can have a positive impact on growth.

For small open economies, since the 1990s the move towards flexible exchange rates was coupled to the adoption of Inflation Targeting (in U.K., Sweden, Chile, New Zealand, Israel, to name but a few). When we consider Inflation Targeting - and indeed the majority of the countries in the sample

[1] Van Dijk et al. p. 20.

[2] Levy-Yeyati and Sturzenegger (2003) find evidence of significantly lower GDP growth in the case of pegs for developing countries, but the same result does not hold for industrial countries.

that will be introduced in Section 4 is currently Inflation Targeting -, due to the pass-through effect of the exchange rate on prices, one might ask whether the Central Bank should control exchange rate movements directly. More precisely, a Central Bank should keep an eye on exchange rate developments if it has the objective of keeping inflation low and stabilize output, because (real) exchange rate movements have an impact on the price of imported goods and on aggregate output. Svensson (2000) showed within a small open economy model that flexible CPI inflation targeting can in fact reduce the volatility of output and the real exchange rate while keeping inflation under control, a result that is shared with Gali and Monacelli (2005). Svensson (2003) acknowledges that it is possible for Central Banks to engage in exchange rate smoothing, i.e. to use the monetary policy instrument in order to limit the volatility of the exchange rate or stabilize the real exchange rate to some "potential level" . In his model, this would mean that deviations of the exchange rate from target are in the loss function of the Central Bank together with inflation deviation from target and the output gap. However, he also suggests that there should be no reason for Central Banks in advanced economies to have separate exchange rate and inflation objectives in setting their monetary policy. Exchange rate smoothing resulting from IT would therefore only be a side effect and depend on the degree of exchange rate pass-through and the share of imported final goods. These results are in agreement with Clarida (2001), who states that

> in practice, a monetary policy aimed at achieving only domestic objectives may also serve to stabilize the exchange rate,[· · ·] and thus be difficult to distinguish from a policy of maintaining the exchange rate within a band. [3]

In other words, if we only looked at exchange rate volatility, Inflation Targeting may be observationally equivalent to a managed float.

It has been discussed in the literature why a Central Bank would pursue an exchange rate policy that is different from what is officially declared. One reason is that an exchange rate band or a peg is prone to speculative attacks when the markets perceive that the commitment to maintain the parity is no longer credible; in order to defend the parity, the Central Bank may thus be forced to engage in costly interest rate spikes. Such speculative attacks can occur even when there is no credibility problem on the Central Bank's

[3] Clarida (2001), p.15.

side, making the prophecy of the abandonment of the parity self-fulfilling.

An additional reason, for highly dollarized (or euroized) economies where a large share of domestic credit is denominated in foreign currency, monetary policy is *de facto* constrained due to the relevance of the exchange rate channel in affecting the value of loans.

Exchange rate regimes can be classified according to a *de jure* or *de facto* scheme: the former says what countries claim they are doing, the latter is based on empirical analysis of the behavior of exchange rates, reserves, money supply and so on. In recent years there has been a growing empirical literature, on which the present paper draws, aimed at estimating the degree of exchange rate flexibility, and thus distinguishing *de facto* exchange rate regimes from *de jure* regimes. Indeed, many countries that announce the intention to float actually informally manage the exchange rate in order to avoid excessive volatility: research on exchange rate flexibility is based on the idea that, rather than the official label of the regime, what countries do can be better described by movements in asset prices and foreign exchange reserves. It is important to stress that these studies do not focus on exchange rate volatility alone: the bilateral exchange rate of country A may be less volatile than that of country B only because country A was subject to smaller macroeconomic shocks [4].For this reason, the focus is on both exchange rates and reserves.

According to the IMF classification, there are four exchange rate arrangements: Floating, Fixed, Managed Float and Limited Flexibility. Until 1997, the IMF's Annual Report on Exchange Rate Arrangements and Exchange Restrictions was completed asking each country to self-report their exchange rate regime: this is the de jure classification scheme. Such classification method was upgraded in 1997 and the Report now follows a new approach that is closer to the de facto classification schemes presented below. Appendix 1 reports a Chronology of de jure exchange rate regimes in Europe, where we also included Inflation Targeting as a separate regime.

The view that the world is moving towards a polarization of exchange rate regimes (i.e. either strict pegs/currency unions or freely floating) has been proved to be not correct, among others, by Calvo and Reinhart (2002) and Reinhart and Rogoff (2004). Many countries actually lie in between; the fact that countries put in place an exchange rate policy that is different from

[4] As we will see in Section 5, this was the case of Canada in the last decade.

what they officially claim has been labeled *Fear of Floating* by Calvo and Reinhart (henceforth CR); Levy-Yeyati and Sturzenegger (2007), however, argue that in most of the cases it is a fear of appreciation. The motivation behind such exchange rate management in disguise would be the view of a depreciated exchange rate as a means of protection for domestic industries [5].

As we have argued above, from an official point of view there are four types of exchange rate regimes: fixed or peg, limited flexibility, managed floating and freely floating. Limited flexibility includes exchange rate arrangements in Europe during the ERM era, while a peg is a stricter commitment towards fixed rates, such as currency board arrangements. The CR classification scheme is based on several priors on the behaviour of exchange rates and reserves under different exchange rate regimes: in particular, pegs should be characterized by higher reserve and lower exchange rate volatility than floats. How is volatility defined in this literature? CR define it as the probability that the monthly percentage change exceeds some threshold: if a country's exchange rate and reserves behave significantly differently from the benchmark countries, this is a sign of "Fear of Floating". We will outline in detail and apply CR's methodology in Section 5.

Reinhart and Rogoff (2004) (henceforth RR) reclassified exchange rate arrangements for 153 countries from the end of World War II to 2001, finding that, in the large majority of cases, the de facto exchange rate regime was different from the de jure regime. All of the countries in our sample were also in Reinhart and Rogoff's. In particular, they use monthly observations of the absolute percentage change in the bilateral exchange rate vis à vis a reference currency, calculating the probability that the exchange rate remains within a one, two or 5 percent band. A country is classified as a peg if it is officially pegging and a dominant reference currency can be identified. If inflation is larger than 40%, RR classify the corresponding country as "freely falling" or "hyperfloat". Their approach allows them to identify de facto pegs/crawling pegs, de facto narrow bands, free floats and, as a residual regime, managed floats.

[5] Levy-Yeyati, Sturzenegger (2007), p.4

Ball and Reyes (2008) criticized CR's approach on the ground that it does not identify Inflation Targeting (IT) as a separate regime. In fact, they argue that CR's methodology can be misleading with IT regimes since CPI Inflation Targeting can have the side effect of reducing exchange rate volatility, and therefore honest inflation targeters might incorrectly be classified as fear of floaters. With respect to pegs, IT regimes should exhibit higher correlation between inflation and the real interest rate and lower correlation between the real interest rate and the exchange rate: for this reason, to detect fear of floating, they use simple OLS to test whether the move to higher flexibility in current IT regimes did bring about such change in correlations. However, from the point of view of the correlation between the real interest rate and the exchange rate, their approach does not provide clear results, since out of 17 Inflation Targeters only Brazil and Chile appeared to have had a lower correlation after adopting IT. For these reasons, we will nevertheless employ CR's methodology, but taking Ball and Reyes' critique seriously by classifying IT as a separate regime.

As discussed by CR, it is preferable to use priors in place of descriptive statistics such as the mean absolute deviation, since the former avoid the problem of outliers, which give excessive weight to observations corresponding to large devaluations [6]. Descriptive statistics are, however, used by Levy-Yeyati and Sturzenegger (2003, 2005 and 2007): the classification criteria they employed are in fact based on three variables: "exchange rate volatility", measured as the average of absolute monthly percentage change in the nominal exchange rate relative to the relevant anchor currency; "volatility of exchange rate changes", measured as the standard deviation of monthly percentage changes in the exchange rate; "volatility of reserves", that is the average of the absolute monthly change in dollar-denominated foreign exchange reserves relative to the monetary base. The strand of literature that we discussed so far is aimed at estimating the degree of exchange rate flexibility when the relevant anchor currency for the country at hand is known or can be easily identified. The limit of these approaches is therefore that, on one hand, if a country is officially a floater or IT, the choice of the bilateral exchange rate to take into account is, to some extent, arbitrary; on the other hand, the results may be misleading if the regime is in fact

[6] Calvo, Reinhart (2002), p. 384.

a (strict or flexible) basket peg. A different approach has been set up by Frankel and Wei (1994) to estimate the weights in a currency basket: when a country adopts a basket peg, it seldom announces which currencies are included in the basket and their weights. If we regress the change in the value of a currency (expressed as its SDR exchange rate [7]) on the change in the value of some international reserve currencies, we can derive the weights in the basket. In case of a strict peg, OLS is especially appropriate since the model is linear and yields an almost perfect fit. However, it is less on firm grounds and potentially not correctly specified if the basket peg allows for some flexibility (for example, it has a band or moving band). Therefore, it could not be used to disentangle Fear of Floating episodes. In order to merge the techniques to infer exchange rate flexibility and those to estimate the weights in a currency basket Frankel and Wei (2008) (henceforth FW) extended their original approach, including an "exchange market pressure" (*emp*) variable in the regression which accounts for reserves and exchange rate variability. The coefficient on emp is zero in the case of a strict peg, and increases up to one as exchange rate flexibility increases.

A caveat regarding the limit of regime classification literature is necessary. These approaches are not structural analyses of the determinants of exchange rate movements; rather, they detect empirical regularities that allow one to distinguish between "pure floaters" and different levels of exchange rate management or pegging, regardless of how the exchange regime is officially classified. They are not aimed at estimating the policy weight attached by the Central Bank to exchange rate stabilization: nevertheless, they can tell us whether the country at hand has indeed changed its monetary policy when it announced a regime switch, and whether such change was consistent with the announcement, or, alternatively, whether its exchange rate policy remained stable as it was announced.

1.3 Detecting the de facto exchange rate regime

In principle, a Central Bank can control exchange rate movements in at least two ways: either through the policy interest rate, changing it in step with the anchor country (an example in this sense is Denmark) or by

[7] See Frankel and Wei (2008) for a discussion on the choice of the SDR as definition of *value of a currency*.

direct intervention using foreign exchange reserves or credit lines. We will outline two simple and stylized models to derive priors on the behavior of reserves, interest rates and exchange rates across alternative regimes. The first one relies on Taylor Rules (Taylor, 1992) as a means of estimating the interest rate rule of a Central Bank; the second one is known as the monetary approach (see Frenkel, 1976). Assume we have only two countries: a home country and a foreign country (F) and that the evolution of the domestic output gap, x, is described by the Aggregate Demand curve:

$$x = \alpha_x \cdot x^F - \alpha_r(r - \overline{r}) + \alpha_q \cdot \Delta q + \vartheta \tag{1.1}$$

where the domestic output gap depends on net foreign demand for domestic goods (which, in turn, would depend on the foreign business cycle), the gap between the real interest rate and the target rate, and the change in the real effective exchange rate q; ϑ is an excess demand shock as in Svensson (2003).

CPI inflation, by definition, depends on domestic inflation and imported inflation:

$$\pi^c = \xi \cdot (\pi^F + \delta \cdot \Delta q) + (1 - \xi) \cdot \pi \tag{1.2}$$

where ξ is the share of imported goods in the CPI, δ is the degree of exchange rate pass-through and π is domestic inflation. Domestic inflation, in turn, depends on the output gap:

$$\pi = \phi_x \cdot x + \nu \tag{1.3}$$

where ν is a cost-push shock as in Svensson (2000, 2003). Both ν and ϑ are zero-mean with variance respectively equal to σ_ν^2 and σ_ϑ^2. The evolution of CPI inflation can thus be described by an Aggregate Supply curve like:

$$\pi^c = \beta_x \cdot x + \xi \cdot (\pi^F + \delta \cdot \Delta q) + \eta \tag{1.4}$$

where $\beta_x = \phi_x \cdot (1 - \xi)$.
Monetary policy is described by a Forward-Looking Taylor Rule: [8]

$$i = \overline{r} + \overline{\pi} + \gamma_\pi E[(\pi^c - \overline{\pi})|\Omega] + \gamma_x E[x|\Omega] + \gamma_q \Delta q \tag{1.5}$$

i.e. the level of the policy rate set by the central bank depends on the target real interest rate, the inflation target (the sum of the two can be interpreted as the target nominal interest rate) and is higher when inflation is above target and/or there is a positive output gap, or when the effective exchange rate weakens (q increases). By simply projecting the AS and AD curves, which form the Central Bank's information set, in (1.5), the following result is obtained:

$$\begin{aligned} i =& \overline{r} + \overline{\pi} + \gamma_\pi[(1-\xi)\cdot\pi + \xi(\pi^F + \delta\Delta q) - \overline{\pi}] + \gamma_x[\alpha_x x^F - \\ &- \alpha_r(r - \overline{r}) + \alpha_q \Delta q] + \gamma_q \Delta q \end{aligned} \tag{1.6}$$

Given this very general rule, we can see that a central bank can use the policy interest rate to react to exchange rate changes directly, via the last term in (1.6), and indirectly, since the exchange rate affects CPI inflation via imported inflation and the output gap via resource utilization. In order to maintain price determinacy it must also be that $\gamma_\pi > 1$ (see Woodford, 2003). Notice that Inflation Targeting should focus on the real exchange rate, while managed floats, pegs and limited flexibility regimes focus on a target level of nominal (bilateral) exchange rate. From this point of view, we can see why a policy in an IT country aimed directly at stabilizing the nominal exchange rate would be evidence of fear of floating.

In particular, we can use (1.6) to write the policy rules of central banks following different monetary and exchange rate policy strategies. For a country that is in a Fixed, Managed Float or Limited Flexibility regime, the rule becomes:

$$i = \overline{i} + \gamma_s \Delta s^9 \tag{1.7}$$

s is the nominal exchange rate vis à vis the reference currency and $\gamma_s > 0$.

[8]This rule is as general as possible, within this simple model, since we haven't said anything specific on the monetary policy rule. Below we will insert the appropriate restrictions.

[9]By UIP reasoning, the target level of the nominal interest rate is equal to the reference country's target plus a risk premium.

The policy rate is thus equal to the target nominal interest rate (which, with free capital mobility, is equal to the foreign interest rate), and tends to be higher when the currency weakens and lower otherwise. This policy is clearly described, for example, in the Danmarks Nationalbank's *Introduction to Monetary and Fixed Exchange Rate Policy.* Denmark has a fixed exchange rate vis à vis the euro area, and the DNB states that

> [$\cdots$] when the foreign-exchange market is calm, the fixed-exchange-rate policy means that Danmarks Nationalbank adjusts its interest rates in step with the ECB's adjustments. In a situation with upward or downward pressure on the krone or a sustained inflow or outflow of foreign currency, Danmarks Nationalbank unilaterally changes its interest rates in order to stabilise the krone.

The monetary policy regime that is most common in non-euro Europe is Inflation Targeting. All IT Central Banks follow flexible forms of Inflation Targeting, where some weight in the objective function is attached to output stabilization as well. Ball and Reyes (2008) ignore flexible inflation targeting, stating that they treat IT in their study

> [$\cdots$] to mean strict and honest IT. [$\cdots$] Interest rate interventions for exchange rate reasons associated with output concerns but not inflation target concerns would be empirical evidence of Fear of Floating.[10]

This is, in my opinion, an overly restrictive hypothesis, since it has been acknowledged (Svensson (2000), Gali and Monacelli (2005)) that strict CPI Inflation Targeting results in higher output variability, which can be hardly socially acceptable, with respect to flexible IT, and IT Central Banks generally have output stabilization among their declared objectives (for example, in Sweden, U.K. and Australia, to name but a few).

Equation (1.6) for a country that engages in *honest* flexible CPI inflation targeting has $\gamma_q > 0$, and therefore becomes:

$$\begin{aligned} i =& \overline{r} + \overline{\pi} + \gamma_\pi \left[(1-\xi) \cdot \pi + \xi(\pi^F + \delta \Delta q) - \overline{\pi} \right] + \\ & \gamma_x \left[\alpha_x x^F - \alpha_r (r - \overline{r}) + \alpha_q \Delta q \right] \end{aligned} \tag{1.8}$$

From the above rule, we can see that indeed a honest inflation targeter will react to exchange rate changes, because the exchange rate is a predictor of

[10] Ball, Reyes (2008), p. 313.

inflation; in particular, the change in the interest rate following a depreciation in the (trade-weighted) currency is:

$$\frac{\partial i^{IT}}{\partial q} = \gamma_\pi \xi \delta + \gamma_x \alpha_q > 0 \tag{1.9}$$

The responsiveness of the policy interest rate to (nominal effective) exchange rate movements depends on the weight on inflation in the policy rule, γ_π , the level of openness as described by ξ, the degree of exchange rate pass-through to inflation, δ, and the impact of the exchange rate changes on output. In this framework, I define an IT country of the "Fear of Floating" (FF) type, using Calvo and Reinhart's (2002) terminology, as one that is pursuing exchange rate objectives separate from its official policy targets, as in Ball and Reyes (2008), with $\Delta q > 0$ and therefore

$$\frac{\partial i^{FF}}{\partial q} = \gamma_\pi \xi \delta + \gamma_x \alpha_q + \gamma_q > \frac{\partial i^{IT}}{\partial q} \tag{1.10}$$

Interest rates variability is therefore higher than in honest IT; it must be noted, however, that one more element characterizes FF episodes: if the (implicit) target value of the currency is defined in nominal terms of one reference currency rather than a basket or a trade-weighted index, then the nominal exchange rate should enter the policy function, and the central banks would react to changes in that exchange rate, which makes the policy more similar to that of an exchange rate targeter. For a strict floater, monetary policy can be described here by a standard forward-looking Taylor Rule with weight placed on domestic inflation, rather than CPI inflation, as in the original Taylor Rule, and therefore (1.6) becomes:

$$i = \overline{r} + \overline{\pi} + \gamma_\pi \left[\pi - \overline{\pi}\right] + \gamma_x \left[\alpha_x x^F - \alpha_r (r - \overline{r}) + \alpha_q \Delta q\right] \tag{1.11}$$

and thus, even in the case of the most committed floaters, the interest rate responds to changes in the exchange rate, because of its role in influencing the output gap:

$$\frac{\partial i^{F}}{\partial q} = \gamma_x \alpha_q < \frac{\partial i^{IT}}{\partial q} \tag{1.12}$$

In sum, policy interest rate variability is highest in pegs, managed floats and fear of floating episodes, lower for IT and floating regimes. Moreover, the correlation between the real interest rate and the nominal exchange rate is higher the lower the *de facto* degree of flexibility (see Ball and Reyes, 2008). While, from a descriptive point of view, this simple framework could allow us to classify exchange rate regimes based on interest rate volatility and the correlation of the policy interest rate with inflation and the nominal exchange rate, it would be hard to do it in practice. In fact, as it was pointed out by Svensson (1996), Taylor Rule coefficients cannot be interpreted structurally, because they are convolutions of structural parameters, i.e. parameters that depend on the structure of the economy, and the parameters describing the preferences of the Central Bank. For this reason, using the above analysis we cannot infer the weight actually attached by the Central Bank on the exchange rate unless we first identify the structural parameters. In Chapter 2 I propose an approach for the estimation of Central Bank preferences in a Small Open Economy, starting from the optimization problem of the Central Bank, that takes into account the case of fear of floating as a separate regime.

Thus, we will go back to interest rate rules there. In this Chapter, instead, we will focus on the other source of exchange rate stabilization we outlined at the beginning of this section: foreign exchange intervention through international reserves. Central Banks use foreign exchange reserves, as well as other hidden channels like credit lines to maintain the desired value of the currency with respect to one or more reference currencies. In theory, foreign exchange reserves should never change in case of committed floaters, and variability should be higher the less flexible the exchange rate and in particular in situations of financial turbulence (for example, speculative attacks). In reality, this is not the case: reserves change even for the most committed floaters, and also for reasons other than exchange rate stabilization . Indeed, Taylor (2001) and Edwards (2006) claim that if the Central Bank took exchange rate movements into account in setting the policy interest rate, this would result in excessive interest variability, which is not observed in practice. If a Central Bank is actually pursuing an IT strategy but also has a separate exchange rate smoothing objective, therefore, it is likely to use instruments different from the policy interest rate to that end. To discuss this point, I sketch a monetary model of exchange rate determination (Frenkel, 1976). In the monetary approach the value of a currency depends, as for any asset, on supply and demand of the currency itself. The level of interest rates will influence demand through international financial inflows/outflows. Central Banks can, however, use foreign exchange reserves to affect supply and demand of the domestic currency. Suppose again you only have two countries, a home and a foreign (F) country. Total demand for real-money holdings in each country is determined by the private sector demand. Private sector demand is determined by: (i) transaction purposes, where, for simplicity, only home country goods are demanded; (ii) investment / speculative purposes, depending on the level of domestic interest rates; thus, the equilibrium in the money market is given by:

$$\frac{M^D}{P} = X_h^a e^{bi}$$

And the same holds for the foreign country. Purchasing power parity is assumed to hold:

$$P^F = S \cdot P$$

Taking logs, we can define the exchange rate as clearing the differences in relative demand and supply of domestic and foreign currency (lower case letter indicate the log of the corresponding variable):

$$s = a(x^F - x) + b(i^F - i) + (m^F - m) \tag{1.13}$$

Equation (1.13) states the well-known result of the monetary approach, that the level of the exchange rate tends to fall (the currency appreciates) when domestic interest rates are higher than foreign rates, when there is an expansion in domestic monetary base relative to foreign monetary base, and it also depends on relative output.
If a Central Bank is targeting the exchange rate, when it sees an undesired change in the exchange rate (for example, an increase), it can either change the interest rate to a level higher than the target country, or reduce the monetary base by increasing its foreign exchange reserves, or a mix of the two. By using monetary instruments, the Central Bank can manage, at least in the short run, to keep the exchange rate stable while maintaining an independent interest rate policy.

The models outlined in this section, albeit very stylized, allow us to list some theoretical priors on the volatility of several variables (exchange rates, reserves and interest rates; the definition of volatility we use will be clarified in Section 5) in alternative exchange rate regimes. In the empirical part of this chapter, we will classify regimes combining information coming from

Reinhart and Rogoff (2004) on *de facto* exchange rate regimes with official regimes as declared by the central banks, and include Inflation Targeting as a separate regime, in order to avoid, as possible, mixing different regimes. Table 1.1 summarizes these priors, where "high", "low" and "intermediate" are in relative terms. In the remainder of the paper, we will focus on exchange rates and reserves. We can identify six regimes: Peg, Limited Flexibility, Managed Floating, Inflation Targeting, Floating and Freely Falling. Limited flexibility includes all regimes within the ERM I and II; Managed Floating collects all flexible forms of exchange rate smoothing (crawling pegs/bands, narrow bands, basket peg and so on). Freely Falling is included because it identifies periods of extreme instability of the exchange rate, and this allows us to avoid watering down the results.

	Exchange rate volatility	Reserves volatility	Policy rate volatility
Peg	Nil/Low	High	High
Man. Float			
Ltd. Flex.	Low	High	High
Fear of Floating			
Freely Falling	High	High	High
Infl. Targeting	Interm.	Low	Low
Float	High	Low	Low

Table 1.1: Classification of exchange rate regimes according to theoretical priors.

The strand of literature that has been discussed so far is aimed at estimating the degree of exchange rate flexibility when we know the relevant - or possible - anchor currency for the country that is being studied. As we stated in Section 2, the limit of these approaches is that, on one hand, if a country is officially a floater or IT, the choice of the bilateral exchange rate to take into account is, to some extent, arbitrary; on the other hand, the results may be misleading if the real regime is in fact a (strict or flexible) basket peg. For this reason, in Section 6 we will employ Frankel and Wei's [2008] approach to infer the relative importance of the main international reserve currencies.

1.4 The Data

This work applies the regime classification schemes of Calvo and Reinhart (2002) and Frankel and Wei (2008) in order to observe the evolution of European monetary integration and to show the extent to which such alternative classification schemes provide consistent results. The dataset is monthly and composed of 19 countries and 47 exchange rate regimes over 1980:01 - 2009:12. It includes 14 European countries and 5 non-European benchmark floaters. The former group is quite heterogeneous as far as official monetary policy and attitude towards the EMU and EU are concerned: three countries are not EU members (Norway, Iceland, Switzerland), two are EU members that recently adopted the euro (Slovakia and Estonia), two are ERM members (Latvia and Denmark, and the latter has opted out of EMU), two have a currency board (Bulgaria and Lithuania) and the remaining six are EU members within an IT regime (Sweden, United Kingdom, Czech Republic, Poland, Hungary, Romania); out of these, the UK has opted out of EMU. The set of "benchmark floaters" is made up of New Zealand, Australia, United States, Canada and Japan. Australia, Canada and New Zealand are Inflation Targeters. The empirical analysis spans the 1980-2009 period, dividing it in three sub-periods: the ERM era (from 1980 to October 1992), the post-ERM era (November 1992 to 1998), and the Euro era (1999 to 2009). The rationale for dividing the overall sample period in three sub-periods is twofold: first, to separately apply regime classification methods to the euro era; second, because international exchange rate and reserves volatility, aside from regime shifts, might have changed across the 30 years included in the sample, especially in Europe, and this way we are left with more homogenous periods. Data come from the IMF's International Financial Statistics and National Central Banks. Actual reference sub-periods, however, vary from country to country, depending on shifts in official exchange rate regimes and data availability. In particular, as far as Central and Eastern European (CEEC) countries are concerned, due to data availability the analysis is performed only from 1993 on, and the exact starting year is different from country to country. The bilateral exchange rate taken into consideration in both approaches is against the euro (German Mark) for the European countries and the USA since (until) 1999, and the US dollar for non-European countries, as in CR [11]. During the ERM era, the parities were defined with respect to the European Currency Unit (ECU); however, it was the Bundesbank which had the leading role in the system, and the Mark was the main reserve currency in the region and also had the largest weight in the ECU basket [12].

1.5 Fear of Floating: the Calvo−Reinhart Approach

Given these stylized models, we can introduce CR's theoretical priors that should hold over alternative exchange rate regimes. If we take a threshold ω for the monthly percentage change in a particular variable, then the following priors should hold:

- lower exchange rate variability in fear of floating episodes and pegs with respect to free floats and inflation targeting:

$$P\left(\Delta s < \omega | Peg, FF\right) > P\left(\Delta s < \omega | Float, IT\right) \tag{1.14}$$

- higher reserve variability in fear of floating episodes and pegs with respect to free floats and inflation targeting:

$$P\left(\Delta F < \omega | Peg, FF\right) < P\left(\Delta F < \omega | Float, IT\right) \tag{1.15}$$

What (1.14) says is that the probability that the monthly percentage change (in absolute value) in the exchange rate is lower than some threshold ω (for example, 2.5% in CR) for pegs / managed floats / fear of floating is lower than the probability that the change in the exchange rate lies within such bands in a floating regime or IT. In other words, exchange rate variability is higher in floating regimes than in de facto pegs and managed floats. Inequality (1.15) states that the probability that the monthly percentage change (in absolute value) in foreign exchange reserves is lower than some threshold (in CR's paper 2.5%) in case of a peg or fear of floating episode is higher than the probability that the change in foreign exchange reserves lies within such narrow bands in the case of a floating regime. The reason is that if a country is trying to manage the exchange rate in order to reduce

[11] Actually, CR use only the bilateral exchange rate against the DM for European countries because their dataset is entirely pre-euro, while BR use first the DM and then the euro.

[12] As a robustness check, the empirical analysis in both approaches was also done using the ECU in place of the DEM and the FFR, and results were consistent.

its volatility using foreign reserves, then we should observe a high volatility in the latter. Freely falling regimes are an outlier in this sense, since they should present at the same time high exchange rate volatility and high reserves volatility. Both CR and BR also use a prior similar to (1.14) and (1.15) for the interest rate, using a 4% (400 basis points) threshold. Such prior, in the present analysis, would not be informative since interest rate variability is much lower than that in the CR sample [13]. As discussed in Section 3, in an exchange rate arrangement different from a free float, the volatility of the exchange rate should be low. As pointed out by prior (1.14), the probability that the monthly percentage change in the exchange rate is lower, in absolute terms, than some threshold ω should be higher when there is some form of exchange rate smoothing with respect to a pure float. We estimate this probability as the mean probability over 2-year rolling windows. In this Section we observe the empirical distribution of the monthly percentage change in the bilateral exchange rate, Δs, using two thresholds: 1%, as in CR and Ball and Reyes (2008) and 2.25%, as when ERM was in place. The 1% threshold is also used by Reinhart and Rogoff to identify *de facto pegs* or *crawling pegs*.

Figure 1.1 pictures the exchange rate and reserves volatility as defined here for the six regimes in our sample. From a visual inspection, on average, our priors are confirmed, and we notice that Managed Floats, with respect to Limited Flexibility, are characterized by higher exchange rate and reserves volatility, and are thus, in a sense, more costly, as if maintaining the parity required, on average, larger reserve intervention.

Tables 1.2-1.4 present the results of the Calvo-Reinhart approach on exchange rate volatility over the three subperiods introduced in section 4; tables 1.5-1.7 concentrate on foreign exchange reserves volatility.In each table, the countries are grouped according to their exchange rate regime, using the criteria outlined in Section 3. This classification allows us to test the validity of priors (1.14) and (1.15) on two dimensions: first, to see whether, on an aggregate level, theoretical priors on the behaviour of exchange rates and reserves over different regimes hold. Second, we will test whether they hold for each country, in order to detect fear of floating episodes.

[13]The only occasion when the change in the interest rate was higher than 4% within a month was in September - October 1992, during the speculative attacks that led to the collapse of the ERM.

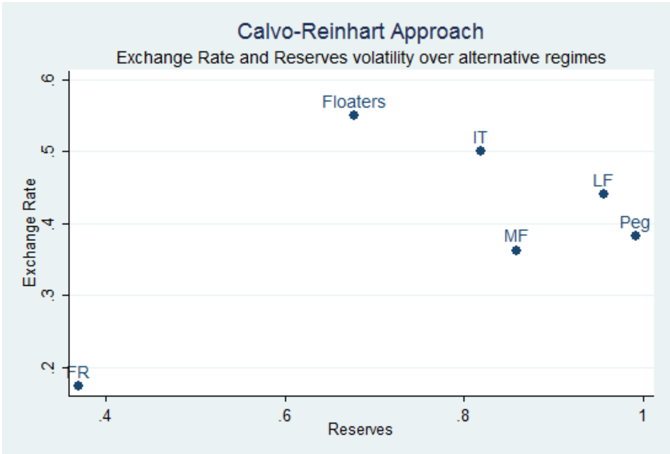

Figure 1.1: Summary results of the Calvo-Reinhart Approach.

Table 1.2 shows the relevant figures in the sample during the ERM era; for each country/regime, the sample period is also indicated. The results in Table 1.2 confirm prior (1.14); countries with a floating regime systematically exhibit higher bilateral exchange rate volatility, except for Canada, with respect to countries that adopted a managed float. Later in this section, tests on the difference of the means are performed in order to test whether such difference is statistically significant. Table 1.3 summarizes the results for the 1992:11-1998:12 period. After the crisis in the fall of 1992, Sweden, Norway and the UK abandoned the limited flexibility arrangement. While Sweden and the UK never went back to limited flexibility, and rather moved to Inflation Targeting, Norway left its currency free to float only until the end of 1994, when a managed float vis à vis a basket of currencies was adopted. Again, the prediction of prior (1.14) is fulfilled, although a test on the means will be needed to state the significance of the differences. Countries that were listed as in a pure float or Inflation Targeting exhibit a higher volatility of the nominal exchange rate.

The story shown in Table 1.4, that is after the introduction of the euro is, at first, quite puzzling. The figures for Pegs, Managed Floating and Limited Flexibility arrangement are quite similar to each other, as expected. As far as inflation targeters are concerned, we notice that during the ten years after the introduction of the euro, bilateral exchange rates vis à vis the euro have exhibited remarkable stability. European Inflation Targeters, except

Regime	Country	Period	Probability that the monthly % change falls within ±1%band	within ±2.25% band
Floaters	Australia	01.1984-10.1992	32.4%	67.3%
	Japan	01.1980-10.1992	30.5%	59.3%
	New Zealand	03.1985-12.1989	35.9%	70.7%
	United States	01.1980-10.1992	18.4%	53.5%
	Canada	01.1980-12.1990	79.6%	98.9%
Ltd. Flex.	Norway	01.1980-10.1992	56.5%	90.1%
	Denmark	10.1980-09.1992	93.4%	98.6%
	Switzerland	01.1980-10.1992	64.3%	94.2%
	Sweden	06.1985-10.1992	74.2%	99.4%
	United Kingdom	10.1990-09.1992	58.3%	95.8%
	United Kingdom	01.1980-09.1990	42.1%	71.0%

Table 1.2: Exchange Rate Volatility during the ERM years.

Regime	Country	Period	Probability that the monthly % change falls within ±1%band	within ±2.25% band
Floaters	Japan	01.1984-10.1992	32.4%	67.3%
	United States	01.1980-10.1992	30.5%	59.3%
Inf.Targ.	New Zealand	11.1992-12.1998	53.7%	85.4%
	Australia	01.1993-12.1998	39.5%	78.9%
	Canada	11.1992-12.1998	66.5%	98.8%
	Sweden	01.1993-12.1998	40.5%	78.4%
	United Kingdom	11.1992-12.1998	43.2%	83.8%
Ltd.Flex.	Denmark	10.1990-09.1992	90.5%	98.6%
	Switzerland	11.1992-12.1998	64.9%	98.6%
Man.Float	Norway	01.1993-12.1998	77.4%	97.3%
	Bulgaria	01.1997-12.1998	93.4%	98.6%
	Czech Rep.	01.1993-12.1998	64.3%	94.2%
	Hungary	01.1993-12.1998	45.8%	78.7%
	Poland	05.1993-12.1998	34.3%	75.6%
	Slovak Rep.	01.1993-12.1998	53.8%	88.5%
Peg	Estonia	01.1993-12.1998	100%	100%
	Latvia	01.1993-12.1998	99.9%	100%
	Lithuania	01.1995-12.1998	99.8%	99.8%
Free Fall	Bulgaria	01.1994-12.1996	30.5%	44.8%
	Lithuania	01.1993-12.1994	0%	0%

Table 1.3: Exchange Rate Volatility after the collapse of ERM.

Regime	Country	Period	Probability that the monthly % change falls within ±1%band	within ±2.25% band
Floaters	Japan	01.1999-12.2009	35.0%	66.2%
	United States	01.1999-12.2009	29.6%	66.6%
Infl.Targ.	Australia	01.1999-12.2009	27.5%	61.8%
	New Zealand	01.1999-12.2009	27.2%	61.4%
	Canada	01.1999-12.2009	79.6%	82.1%
	Sweden	01.1999-12.2009	68.0%	97.3%
	United Kingdom	01.1999-12.2009	56.6%	88.2%
	Norway	03.2001-12.2009	51.5%	84.2%
	Switzerland	01.1999-12.2009	80.5%	98.4%
	Czech Rep.	01.1999-12.2009	59.0%	94.8%
	Poland	01.1999-12.2009	35.8%	66.4%
	Hungary	08.2001-12.2009	54.0%	87.0%
	Romania	01.2005-12.2009	44.5%	74.9%
	Iceland	01.2001-12.2009	38.6%	69.4%
Man.Float	Romania	04.2001-12.2004	25.2%	65.2%
	Slovak Rep.	01.1999-10.2005	66.5%	91.0%
	Hungary	01.1999-07.2001	87.0%	96.9%
	Norway	01.1999-02.2001	71.9%	99.0%
Ltd.Flex.	Denmark	01.2009-12.2009	100%	100%
	Slovak Rep.	11.2005-12.2008	39.6%	83.3%
	Latvia	01.2005-12.2009	96.4%	100%
Peg	Bulgaria	01.1999-12.2009	91.3%	92.3%
	Estonia	01.1999-12.2009	100%	100%
	Lithuania/1	01.1999-01.2002	100%	100%
	Lithuania/2	02.2002-12.2009	100%	100%
	Latvia/1	01.1999-12.2004	95.1%	100%
Free Fall	Romania	01.1999-03.2001	32.3%	66.5%

Table 1.4: Exchange Rate Volatility after the introduction of the euro.

for Poland and Romania, present figures that are closer to those of peggers than to other IT countries. This is true in particular for Sweden, Switzerland and the Czech Republic. The case of Norway is interesting: after the basket peg was abandoned in march 2001, the euro exchange rate of the kroner became more volatile, but still remained within the range of what Reinhart and Rogoff would classify as a "de facto narrow band". However, this is not enough to state that the countries under consideration are in a de facto Fear of Floating regime, and further analyses are necessary.

We now move to the analysis of foreign exchange reserves volatility, that is prior (1.15) above. Interpreting the path of foreign exchange interventions is, however, less easy. In theory, in a pure float the change in foreign exchange reserves should be zero. However, this is not the case in reality. First of all, foreign exchange reserves vary due to valuation changes and interest earnings. Second, they are not only used for exchange rate stabilization purposes, as pointed out also by CR. This is true, in particular, for New Zealand, which in our case is especially interesting since it moved from managed float to a free float in 1985, and to Inflation Targeting in 1990. In the case of New Zealand, reserves fluctuate due to the Treasury's management of its overseas currency debt rather than foreign exchange market intervention [14]. Third, in order to manage the exchange rate, countries also engage in hidden foreign exchange transactions: credit lines were widely used by ERM countries during speculative attacks. Finally, countries may rely a lot on interest rate interventions as well, as it was the case during the ERM crisis in 1992 or in the managed float of Norway which started in 1995. Nevertheless, the path of foreign exchange reserves can be a good indicator of the actual exchange rate policy that is being pursued and is taken into consideration in most of the exchange rate regime classification literature. Moreover, we corrected reserves to take valuation changes and interest earnings into account following the assumptions made in Frankel and Wei (2008).

Tables 1.5-1.7 show the results of prior (1.15) in our dataset, divided by country and over the three sub-periods introduced above. In this case, the prior is not systematically fulfilled: during the first period (see Table 1.5) there is no clear difference between reserves volatility in floating coun-

[14]See Calvo, Reinhart (2002) p. 388.

Regime	Country	Period	Probability that the monthly % change falls within ±2.5% band
Floaters	Australia	01.1984-10.1992	39.9%
	Japan	01.1980-10.1992	78.2%
	New Zealand	03.1985-12.1989	19.8%
	Canada	01.1980-10.1992	16.4%
	United States	01.1980-12.1990	33.3%
Ltd.Flex.	Sweden	06.1985-10.1992	35.1%
	United Kingdom	10.1990-09.1992	70.8%
	Norway	01.1980-10.1992	31.9%
	Denmark	01.1980-10.1992	27.3%
	Switzerland	01.1980-10.1992	31.8%
Man.Float	United Kingdom	01.1980-09.1992	48.7%

Table 1.5: Reserves Volatility during the ERM years.

Regime	Country	Period	Probability that the monthly % change falls within ±2.5% band
Floaters	Japan	11.1992-12.1998	79.7%
	United States	11.1992-12.1998	66.5%
Inf.Targ.	New Zealand	11.1992-12.1998	32.5%
	Australia	01.1993-12.1998	57.9%
	Canada	11.1992-12.1998	34.0%
	Sweden	01.1993-12.1998	32.4%
	United Kingdom	11.1992-12.1998	71.6%
Inf.Targ.	Denmark	11.1992-12.1998	37.8%
	Switzerland	11.1992-12.1998	39.9%
Man.Float	Norway	11.1992-12.1998	42.3%
	Bulgaria	01.1997-12.1998	29.2%
	Hungary	01.1993-12.1998	28.2%
	Czech Rep.	01.1993-12.1998	29.4%
	Poland	05.1993-12.1998	46.9%
	Slovak Rep.	01.1993-12.1998	39.4%
Peg	Estonia	01.1993-12.1998	37.8%
	Latvia	01.1993-12.1998	52.3%
	Lithuania	01.1995-12.1998	21.2%
Free Fall	Bulgaria	01.1994-12.1996	17.3%
	Lithuania	01.1993-12.1994	9.1%

Table 1.6: Reserves Volatility after the collapse of ERM.

Regime	Country	Period	Probability that the monthly % change falls within ±2.5% band
Floaters	Japan	01.1999-12.2009	87.1%
	United States	01.1999-12.2009	74.9%
Inf.Targ.	New Zealand	01.1999-12.2009	22.9%
	Australia	01.1999-12.2009	30.4%
	Canada	01.1999-12.2009	71.3%
	Sweden	01.1999-12.2009	45.8%
	United Kingdom	01.1999-12.2009	42.3%
	Norway	03.2001-12.2009	47.0%
	Romania	01.2005-12.2009	65.5%
	Switzerland	01.1999-12.2009	68.0%
	Czech Rep.	01.1999-12.2009	74.7%
	Poland	01.1999-12.2009	56.1%
	Iceland	04.2001-12.2009	43.6%
	Hungary	08.2001-12.2009	54.5%
Man.Float	Iceland	11.1999-03.2001	37.5%
	Norway	11.1999-02.2001	19.5%
	Romania	04.2001-12.2004	47.7%
	Slovak Rep.	01.1999-10.2005	43.2%
	Hungary	01.1999-07.2001	29.7%
Ltd.Flex.	Denmark	01.1999-12.2009	47.7%
	Slovak Rep.	11.2005-12.2008	72.0%
	Latvia	01.2005-12.2009	45.8%
Peg	Latvia/1	01.1999-12.2004	38.9%
	Lithuania/1	01.1999-01.2002	41.4%
	Lithuania/2	02.2002-12.2009	38.3%
	Estonia	01.1999-12.2009	34.8%
	Bulgaria	01.1999-12.2009	34.4%
	Romania	01.1999-03.2001	26.0%

Table 1.7: Reserves Volatility after the introduction of the euro.

tries and in ERM countries: with the exception of Japan and the United Kingdom (the latter in its short-lasting ERM experience), the probability of the monthly percentage change exceeding 2.5% was always below 50%. In the second and third period, however, reserves volatility is systematically lower in the benchmark floater countries, Japan and the US, as well as Canada, but still higher for New Zealand and Australia. Besides, for countries that went through a regime switch and moved toward higher flexibility, reserve volatility has indeed fallen, although it remained at a level higher than benchmark floaters, but further statistical analysis would be needed. On average, however, prior (1.15) holds: official floaters have the most stable foreign reserves (i.e. the highest probabilities), IT countries have a quite higher reserves volatility, and is highest for limited flexibility, managed floats, pegs and, in particular, freely falling. So far, we have found several empirical regularities that can be summarized as follows: (i) during the ERM era, volatility of exchange rates in Europe was lower than that exhibited by countries listed as "benchmark floaters", as we expected a priori; (ii) After the collapse of the ERM, while Denmark remained in a limited flexibility arrangement, joining ERM II, the other western European countries moved, with different timing, to Inflation Targeting, while the CEEC went through a period of exchange rate instability, which appears in our approach as massive foreign exchange reserves intervention that was, however, not successful in keeping the exchange rate stable, as it is shown in Tables 1.3 and 1.6; (iii) Between 1999 and 2009, 9 European countries were in a regime of Inflation Targeting, but, at the same time, we observe, in tables 1.4 and 1.7, a remarkable stabilization of euro exchange rates and a relative increase in reserves volatility with respect to benchmark floaters. The U.K. and, in particular, Czech Republic, Sweden and Switzerland present values of exchange rate volatility that are closer to those of a de facto pegger as Denmark than to other IT countries. Similar conclusions can be drawn by looking at the variability of foreign exchange reserves, when the benchmark country is either Japan or the United States.

However, we notice that, in most of the cases, adoption of inflation targeting (from either LF or MF) was associated with a fall in both exchange rate and reserves volatility. In order to check the validity of priors (1.14) and (1.15) we then performed hypothesis testing. First of all, as far as exchange

Benchmark:	Official Regime - 1980-1998					Official Regime - 1999-2009				
	FR	MF	Peg	LF	IT	FR	MF	Peg	LF	IT
USA	0%	66.7%	100%	100%	50%	0%	80%	100%	66.7%	66.7%
Japan	0%	100%	100%	100%	100%	0%	80%	100%	100%	66.7%
Canada	0%	0%	0%	0%	0%	0%	0%	60%	66.7%	44.4%
Australia	0%	83.3%	100%	83.3%	0%	0%	80%	100%	100%	66.7%
New Zealand	0%	50%	100%	83.3%	0%	0%	100%	100%	100%	66.7%
No. of cases	2	6	3	6	2	1	5	5	3	9

Table 1.8: T-tests. Proportion of cases where $P(\epsilon \leq |2.25\%|)$ is significantly higher than the benchmark

Benchmark:	Official Regime - 1980-1998					Official Regime - 1999-2009				
	FR	MF	Peg	LF	IT	FR	MF	Peg	LF	IT
USA	100%	100%	100%	66.7%	50%	100%	80%	100%	100%	100%
Japan	100%	100%	100%	83.3%	50%	100%	100%	100%	100%	100%
Canada	50%	33.3%	0%	16.7%	0%	100%	80%	100%	100%	88.9%
Australia	100%	66.7%	33.3%	50%	50%	100%	0%	0%	0%	0%
No. of cases	2	6	3	6	2	1	5	5	3	9

Table 1.9: F-tests. Proportion of cases where $P(\epsilon \leq |2.5\%|)$ is significantly lower than the benchmark

rates variability is concerned, t-tests on the equality of means of the prior (1.14) are presented in Table 1.8. Second, in Table 1.9 the results of F tests on the equality of variance in foreign exchange reserves are shown[15]. We ran F-tests instead of t-tests on prior (1.15) because in the case of reserves, unlike exchange rates, the variance is a good measure of variability since it is less affected by periodic devaluations [16]. We start from the tests on the mean value of the probability that the exchange rate change is lower than 2.25% in absolute value. As I stated above, our prior expectation is that this probability is highest for limited flexibility regimes and managed floating, lowest for free floaters, with inflation targeters in the middle.

The null hypothesis is that the mean probability (1.14) of country i is equal to the mean probability of benchmark floater j, while the alternative is $P_i < P_j$. Table 1.8 summarizes the results of this test, divided by regime and before/after the adoption of the euro. We do this because it allows us to see also whether European IT regimes are similar, from the point of view of exchange rate volatility, to non-European floating and IT regimes, and

[15]New Zealand does not appear among the benchmark countries because, as stated above, its reserves fluctuate because of the Treasury's management of its overseas currency debt, and thus test results would be misleading.

[16]See Calvo and Reinhart (2002), p. 400.

whether the euro era was peculiar from the point of view of exchange rate and reserves volatility.

As we expected, MF and LF regimes are significantly (at a 5%level) different from free floats (USA and Japan), as far as exchange rate volatility is concerned. Moreover, they are significantly different from the benchmark IT regimes, Australia and New Zealand, although in a lower number of cases. This proves that IT regimes are characterized by a lower exchange rate variability than free floats, and listing them as floaters might be misleading, as Ball and Reyes (2008) point out. In particular, before 1999, Canada had an extremely stable exchange rate vis à vis the U.S. Dollar; since the volatility of reserves was quite high, this might be evidence of fear of floating, while it was much less active since 1999, as the figures in Table 7 confirm. Therefore, at least for the first two sub-periods, it is not a good benchmark.
Since 1999, Inflation Targeters in Europe all presented significantly lower exchange rate variability than benchmark floaters, and in almost half of the tests (16 out of 33) exchange rate variability is significantly lower than that of the benchmark IT countries. The only European IT that showed exchange rate variability during the last 10 years comparable with that of the benchmark are Poland, Romania and Iceland; Sweden, the U.K., Norway and Switzerland had more stable exchange rates than all IT countries.

In sum, European currencies, regardless of the monetary policy regime, exhibited lower exchange rate volatility than non-European currencies; the Euro era, which was characterized by a move towards greater de jure flexibility [17] actually shows a stabilization of exchange rates. However, the increased stability of exchange rates might be the result of more synchronized business cycles, rather than active exchange rate policy. In order to get some insight on this point, I conducted F tests of the null hypothesis of the equality of variances of the monthly percentage change in foreign exchange reserves. The tests were run for each single country and (official) exchange rate arrangement with the above specified subperiods. Therefore, in each test, the null hypothesis is that the variance of reserves for a non-benchmark floater (European countries), σ^2_{EU}, is equal to that of the benchmark, σ^2_B, while the alternative hypothesis is that the European coun-

[17] Seven Countries abandoned regimes of managed floating to adopt Inflation Targeting, while none which was previously float / IT moved to managed float or entered the EMU.

try is not a committed floater/inflation targeter, and therefore $\sigma^2_{EU} > \sigma^2_B$. When the benchmark is the US or Japan, which are free floaters, if the regime of the European country is either the null hypothesis is either peg, limited flexibility, managed float or freely falling, the null is rejected at 5% in 58 out of 62 cases, and this is in agreement with our theoretical prior. When the benchmark is Canada or Australia, these figures are much lower; in particular, Australia appears to have engaged in large foreign exchange interventions since 1999, a result that will be confirmed in section 6. More interestingly, if we consider IT regimes, after 1999 the null is always rejected if the benchmark is Japan or the U.S., while it is rejected in 8 cases out of 9 when it is Canada. Therefore, regardless of the official monetary policy strategy, European countries intervene on foreign exchange markets more than committed floaters. Overall, we can state that IT regimes, in particular in Europe, exhibit remarkable exchange rate stability and seem to be very active on the foreign exchange market, contrary to what we would expect a priori. The motivation behind such interventions are not clear, and it may be evidence of fear of floating, in particular for Norway, Switzerland, Hungary, Sweden and, to a lesser extent, the U.K. In order to have a "flexibility index" showing which countries were floating the most, and the relative importance of international reserve currencies, we perform an alternative approach in the next section.

1.6 Estimating currency weights: the Frankel-Wei Approach

As we discussed in Sections 2 and 3, the Calvo-Reinhart approach can be misleading when the relevant de facto anchor currency is not clear or known or the country has a (*de jure* or *de facto*) basket peg. For this reason, we now move to merging the Fear of Floating approach with the Frankel and Wei (1994, 2008) approach for estimating weights in currency baskets. The idea of this methodology is the following: when a country adopts a basket peg, it seldom announces which currencies are included in the basket and their weights; thus, if we regress the change in the value of a currency on the change in the value of some international reserve currencies, we can derive the implicit weights that country has attached to alternative reserve currencies in its basket. In case of a strict peg, OLS regression is especially appropriate since the model is linear and yields an almost perfect fit. In this case, the regression equation would be:

$$\Delta s_t = c + \sum_{i=1}^{N} \omega_i \Delta X_{i,t} + u_t$$

Where s is the (log) value of the currency of interest and X is the value of the N currencies that form the (potential) basket (Euro, US Dollar,...). However, this approach is less reliable if the basket peg allows for some flexibility. In order to merge the techniques to infer exchange rate flexibility and those to estimate the weights in a currency basket, Frankel (2008) and Frankel and Wei (2008) (henceforth FW) extended their original approach. They run the following regression to estimate both the weights in a currency basket and the degree of exchange rate flexibility:

$$\Delta s_t = c + \sum_{i=1}^{N} \omega_i \Delta X_{i,t} + \kappa(\Delta emp_t) + u_t \tag{1.16}$$

where *emp* is the change in the "exchange market pressure index", and it is defined as:

$$\Delta emp_t = \Delta s_t + \Delta F_t \tag{1.17}$$

and F is the (log) value of Foreign Exchange Reserves, appropriately corrected in order to take valuation changes and interest rate earnings into account [18]. The expression for emp is given in (1.17); as noted by FW, however, the percentage change in reserves might not be a good indicator of central bank intervention when a country holds a relatively low level of reserves, since a change that is small in absolute terms may show up like a large intervention in percentage terms : therefore, when needed, I will also estimate equation (1.18) with emp defined as:

$$\Delta emp_t = \Delta s_t + \frac{F_t - F_{t-1}}{\Delta MB_{t-1}} \tag{1.18}$$

The ω_i coefficients capture the de facto weights on the constituent currencies (after we restrict their sum to 1), and the market pressure index is defined so that we should have $\kappa = 0$ when there is a strict peg (since $\Delta s_t = 0$, $\Delta emp_t = \Delta F_t$), $\kappa = 1$ in the case of a pure float (since $\Delta F_t = 0$, $\Delta emp_t = \Delta s_t$). However, as acknowledged by FW, this correspondence

[18]The full statistics of the regressions, as well as the codes are readily available on request.

would be perfect if countries used foreign exchange reserves only to intervene on the exchange market, and therefore the stock of reserves did not change otherwise. Unfortunately, this is not the case, and therefore countries will all lie in the [0,1] interval with the more committed floaters showing a higher coefficient. Countries with a higher degree of flexibility will also show lower R^2.[19] The vector X of foreign currencies includes the U.S. Dollar (USD), the Japanese Yen (JPY), the U.K. Pound (UKP), the German Mark (DEM)and the French Franc (FFR) until 1998:12, then the euro replaces the DEM and the FFR. From the list of countries for which the regression is performed, we omit here the U.S. and Japan, because the USD and he JPY have such an important role in world markets that one cannot reasonably take the value of other major currencies as exogenous.

In order to constrain the sum of the weights ω_i to 1, I rewrite equation (1.16) as:

$$\Delta s_t - \Delta UKP_t = \textstyle\sum_{i=1}^{N} \omega_i \left(\Delta X_i - \Delta UKP_t\right) + \kappa(\Delta emp_t) + u_t \text{ [21]}$$

and the weight of the UK Pound can be recovered subtracting the sum of the weights on other countries from 1. In order to reduce as much as possible the problem of parameter instability, since the weight attached to alternative reference currencies can change quite frequently, but still maintain a sufficient amount of degrees of freedom, each subperiod was further divided into samples of 3-5 years, and in case of official regime shifts within the period the exact dates were taken into account. In Table 1.11[22], which is reported in Appendix 2, I report the results by country, using both definitions of emp when data on the monetary base were available.

Broadly speaking, the results of this approach are the following: first, since its introduction, the Euro seems to have gained a role as a reference currency which outweighs that of its main constituent currencies before 1999, and it has replaced the U.S. Dollar as a reference currency in Europe. Second, official fixed exchange rate regimes, in particular since 1999, have

[19] There may be a problem of endogeneity of Δemp, as highlighted by Frankel and Wei (2008)[20]. In the case of so-called commodity currencies, i.e. the currency of countries that are specialized in the production of one or more commodities, so that international demand of their currency is highly related to the demand of that commodity, we can instrument emp using the relevant commodity price. Using this argument, I performed an IV regression for Canada, New Zealand, Australia and Norway and it yielded similar results as the OLS reported here.

[21] In the case of the U.K., I used the Swiss Franc to constrain the sum to 1.

[22] *** denotes significance at 1%;** at 5%;* at 10%.

remained stable and consistent with official announcements. Third, overall, the move to Inflation Targeting in non-euro Europe seems to have brought about higher exchange rate flexibility (i.e. a higher κ coefficient), but up to a level which, in particular in Sweden, Switzerland and Hungary, is not comparable to that of the benchmark inflation targeters. In other words, there seems to have been some activity in exchange rate management vis à vis the euro.

The benchmark countries Australia, Canada, and New Zealand hold a low amount of reserves relative to the monetary base, and therefore using (1.17) for emp might be misleading; in general, they show significant and increasing κ coefficients, with the exception of Australia in the third subperiod, suggesting that they all were "honest" inflation targeters, with the coefficient on emp approaching 1 in the case of Canada after 1999 when emp is defined using (1.18), i.e. perfect flexibility. They also seem to have put some weight on the U.S. Dollar, but after 1999 the euro earned an important role.

Bulgaria, Estonia, Latvia and Lithuania all had strict pegs during the whole sample period. The estimates confirm the official fixed exchange rate regimes as listed in Appendix 1. In particular, Estonia pegged to the German Mark first, then the Euro; Latvia to the SDR (and interestingly the estimated coefficients approximate the weights of the constituent currencies of the SDR) until 2004:12, then the Euro, and Lithuania had a peg to the U.S. Dollar until 2002:01, then to the Euro. The same holds for Denmark, which has been a member of ERM for the whole sample period. Before the ERM crisis, it seems to have had a de facto strict peg to the DM, but then apparently put a larger weight on the franc. Since the introduction of the euro, however, it had a de facto peg to the latter with a weight not significantly different from 1.

Poland, the Czech Republic and Hungary have adopted IT in January 1999 (Poland and the Czech Republic) and August 2001 (Hungary), respectively. Before moving to IT, they put a large weight on the Dollar, but after the introduction of the euro the latter became the main implicit reference currency. κ is positive and significant after the introduction of IT, and larger for the Czech Republic and Poland (with $\kappa = 0.261$ and 0.368, respectively). Notice that up to 1999 the Czech Koruna was officially tied to the ECU, the Hungarian Fiorint to the German Mark and the Polish Zloty to a basket of DEM and USD. Our results confirm these official regimes, except in the case of the Czech Republic where the USD had a significant weight, too. Romania had a de facto freely falling regime until 1998:12, as shown in Reinhart and Rogoff (2004), and indeed the estimation using the Frankel-Wei approach here is not precise, with a low R^2. It has put a larger weight on the euro since 1999, and κ became significant after 2005, when IT was adopted.

Iceland officially pegged to a basket of currencies until 2001:04, and gradually decreased the weight put on the USD while increasing that on European currencies. After 2001:04, κ is positive and significant but quite low (around 0.08). The sample is interrupted at 2008:09 because, due to the financial crisis that occurred in october 2008 and the capital controls introduced, the convertibility of the Krona was suspended. According to our estimates, Norway pegged to a basket of currencies (DM, FFR, USD) until the adoption of inflation targeting in march 2001. Then the coefficient on emp increased and the euro became the only implicit reference currency. Sweden and Switzerland adopted IT in 1995 and 2001, respectively. In both cases, κ is significant in the euro era only at 10% and it is the lowest among all IT sample countries, (0.073 and 0.083, respectively, and lower using (18)). Moreover, the euro had a large weight, reaching 0.9 in the case of Switzerland. United Kingdom adopted Inflation Targeting after the end of the ERM, which it had joined only from 1990 until September 1992. While there is no evidence of fear of floating in this case, over the whole sample period it seems to have put some weight on the stabilization of the bilateral exchange rate with the Dollar, but since 1999.01 the euro acquired a significant role too.

1.7 Conclusions

This paper discussed the issue of exchange rate flexibility in European countries than are not in the EMU using two approaches recently developed by the literature on exchange rate regime classification, namely Calvo and Reinhart (2002) and Frankel and Wei (2008). The starting point was the observation that official regimes, from the point of view of exchange rate management, are moving towards a polarization: either free floats, coupled with Inflation Targeting, or pegs. Europe is no exception in this sense.

However, several empirical works in the so-called fear of floating literature proved this is not the case, and the official label of the regime is not always an accurate description of what countries do in practice. Our objective was to see whether this is the case also in Europe, especially since the creation of a large, neighboring currency union might have provided, for this group of small open economies, a natural anchor.

The results obtained by the CR and the FW approaches in this paper are generally consistent, and the conclusions are quite mixed. Fixed exchange rate arrangements have shown substantial stability across countries and, in particular, during the euro era. In some cases, however, when the euro is the formal anchor, we can see that indeed some weight on the US Dollar is present (for example, in Latvia after it joined ERMII). Inflation Targeting regimes in Europe appear to have brought about an increase in exchange rate flexibility, although generally not to a level comparable to that of the benchmark floaters; however, some weight on euro exchange rate stabilization seems to have remained in place: first of all, bilateral exchange rate volatility is significantly lower than that which has been observed for benchmark floaters and for non-European IT regimes. This is true, in particular, for Sweden, Switzerland, Norway, the Czech Republic and, to a lesser extent, the U.K. Second, European IT countries all made extensive use of foreign exchange reserves, more than both free floaters like the USA and Japan, and also more than an Inflation Targeter as Canada. However, all IT regimes seem to have intervened a lot in the foreign exchange market, contrary to what one would expect. This result seems to contradict the statement (see Svensson (2003), Taylor (2001) and Ball and Reyes (2008), for example) that Inflation Targeting regimes should not, and do not, have exchange rate objectives separate from that of inflation control. Since it is not clear why the Central Bank of an IT country would make such extensive use of foreign exchange reserves, the interpretation of this result should be further explored.

There may be evidence of fear of floating in Sweden, Switzerland and Hungary. While they have kept some exchange rate flexibility, they seem to have been active in exchange rate management vis à vis the euro. Moreover, even for the most committed floaters in Europe, the euro has been the most important (in some cases the only) informal reference currency.

In general, the euro era was characterized by higher exchange rate stability than the previous periods, confirming the findings of Van Dijk et al. (2011) who found that the correlation between the US Dollar exchange rate of the Swedish Krona, the Swiss Franc, the U.K. Pound and the Norwegian Krone and the euro has increased both after the launch of the euro at the end of 1996 and its formal introduction in 1999. Following this result, the authors state that "non-euro countries may wish to gain maximum positive spill-over effects by keeping their currencies more in line with the euro". Our findings, for what concerns the Swiss Franc and the Swedish Krona, go in the same direction. Limited Flexibility - ERM membership appears to be a more credible commitment to exchange rate management than managed floats, since - at least in this sample - it was characterized by both lower foreign exchange intervention and exchange rate volatility. Of course, this particular conclusion is subject to some caveats: the two regimes are not perfectly comparable, since the countries involved and the exchange rate targets are not identical; however, it is nevertheless interesting, and it is confirmed by the fact that we can observe this in countries that went through both regimes (for example, Switzerland, Norway and the U.K.). The euro has gained a relevant role as a reference currency since its introduction, even outside Europe, as its weight in the informal basket of European and non-european countries included in our sample was significantly larger than that of its main constituent currencies. Finally, in order to observe the evolution of both exchange rate flexibility and the weights given to foreign currencies over the sample period when structural breaks are not present, I also estimated the FW regressions for IT countries using 2-year rolling windows. As far as Europe is concerned, the results show both a stable exchange rate flexibility index and a high weight on the euro which, in most of the cases, was not statistically different from unity. Towards the end of the sample, when the financial instability that characterized the last months of 2008 increased the pressure on small currencies, we can witness a drop in the "weight" of the euro and - except for Hungary - a higher flexibility coefficient towards the end of the sample, suggesting that exchange rate stabilization was not a primary concern of Central Banks in this context. Rather, they might have enjoyed the benefits of having a weaker currency in a period of economic crisis.

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1.9 Appendix 1. Chronology of Exchange regimes

Table 1.10: Exchange rate regimes in 1980-2009 using a mixed de jure - de facto criterion

Country	Period	Regime	Anchor currency
Australia	01.1984-12.1992	Floating	
	01.1993-present	Infl. Targeting	
Bulgaria	01.1994-12.1996	Freely Falling	
	01.1997-12.1998	Peg	DEM
	01.1999-present	Peg	Euro
Canada	01.1980-12.1990	Floating	
	01.1991-present	Infl. Targeting	
Czech Republic	01.1993-12.1998	Managed Floating	DEM
	01.1999-present	Infl. Targeting	
Denmark	01.1980-12.1998	Ltd. Flexibility	DEM
	01.1999-present	Ltd. Flexibility	Euro
Estonia	01.1993-12.1998	Peg	DEM
	01.1999-12.2010	Peg	Euro
Hungary	01.1993-12.1998	Managed Floating	DEM
	01.1999-07.2001	Managed Floating	Euro
	08.2001-present	Infl. Targeting	
Japan	01.1980-present	Floating	
Iceland	01.1980-12.2000	Managed Floating	Basket
	01.2001-09.2008	Infl. Targeting	
Latvia	01.1993-12.2004	Peg	SDR
	01.2005-present	Ltd. Flexibility	Euro
Lithuania	01.1993-12.1994	Freely Falling	
	01.1995-02.2001	Peg	USD
	03.2001-present	Peg	Euro
New Zealand	01.1980-02.1985	Managed Floating	
	03.1985-12.1989	Floating	
	01.1990-present	Infl. Targeting	
Norway	01.1980-11.1992	Managed Floating	Basket
	12.1992-12.1994	Floating	

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Country	Period	Regime	Anchor currency
	01.1995-02.2001	Managed Floating	Basket
	03.2001-present	Infl. Targeting	
Poland	05.1993-12.1998	Managed Floating	DEM
	01.1999-present	Infl. Targeting	
Romania	01.1999-03.2001	Freely Falling	
	04.2001-12.2004	Managed Floating	Euro
	01.2005-present	Infl. Targeting	
Slovak Republic	01.1993-12.1998	Managed Floating	DEM
	01.1999-11.2005	Managed Floating	Euro
	12.2005-12.2008	Ltd. Flexibility	Euro
Sweden	06.1985-09.1992	Ltd. Flexibility	DEM
	10.1992-12.1994	Floating	
	01.1995-present	Infl. Targeting	
Switzerland	01.1980-12.1999	Managed Floating	DEM
	01.2000-present	Infl. Targeting	
United Kingdom	01.1980-09.1990	Managed Floating	DEM
	10.1990-09.1992	Ltd. Flexibility	DEM
	10.1992-present	Infl. Targeting	
United States	01.1980-present	Floating	

1.10 Appendix 2. Frankel-Wei approach.

Table 1.11: Results of the Frankel-Wei Approach

Australia

	1.17			1.18		
	84.01-92.10	92.11-98.12	99.01-09.12	84.01-92.12	93.01-98.12	99.01-09.12
dem	-0.814	-0.308		-0.704	-0.189	
	(0.589)	(0.305)		(0.592)	(0.266)	
ffr	0.693	0.149	0.556	0.109		
	(0.595)	(0.321)	(0.591)	(0.286)		
eur			0.613***			0.614***
			(0.110)			(0.110)
usd	0.764***	0.838***	0.108	0.744***	0.761***	0.112
	(0.110)	(0.135)	(0.128)	(0.107)	(0.121)	(0.128)
jpy	0.055	0.127	-0.057	0.076	0.134*	-0.065
	(0.133)	(0.085)	(0.099)	(0.132)	(0.070)	(0.100)
emp	0.078	0.174***	0.048*	0.200**	0.306***	0.046*
	(0.055)	(0.054)	(0.025)	(0.079)	(0.079)	(0.024)
c	0.001	0.001	-0.001	0.001	0.001	-0.001
	(0.003)	(0.003)	(0.002)	(0.003)	(0.002)	(0.002)
R^2	0.517	0.562	0.270	0.545	0.642	0.270

Canada

	1.17			1.18		
	80.01-92.10	92.11-98.12	99.01-09.12	84.01-92.12	93.01-98.12	99.01-09.12
dem	-0.059	0.295		0.192**	0.097	
	(0.131)	(0.192)		(0.075)	(0.158)	
ffr	0.100	-0.379*		0.071	0.042	
	(0.151)	(0.201)		(0.052)	(0.169)	
eur			0208**			0.296***
			(0.082)			(0.027)
usd	0.921***	1.010***	0.659***	0.527***	0.606***	0.440***
	(0.039)	(0.048)	(0.089)	(0.056)	(0.065)	(0.021)
jpy	-0.027	-0.009	-0.018	0.106***	0.097***	0.137***
	(0.039)	(0.043)	(0.079)	(0.039)	(0.032)	(0.017)
emp	-0.026***	-0.060***	0.377***	0.663***	0.708***	0.986***
	(0.006)	(0.017)	(0.072)	(0.089)	(0.082)	(0.020)
c	0.000	0.003**	-0.003**	-0.001	0.000	-0.001**
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.000)
R^2	0.895	0.861	0.569	0.917	0.908	0.975

New Zealand

	1.17			1.18		
	85.04-92.10	92.11-98.12	99.01-09.12	85.04-92.10	92.11-98.12	99.01-09.12
dem	-1.082	-0.215		-1.011	-0.259	
	(0.976)	(0.285)		(0.981)	(0.272)	
ffr	0.906	0.290		0.852	0.336	
	(1.040)	(0.299)		(1.045)	(0.284)	
eur			0.580***			0.462***
		(0.131)			(0.117)	
usd	0.538***	0.759***	0.052	0.538***	0.751***	0.055
	(0.168)	(0.076)	(0.112)	(0.170)	(0.076)	(0.103)
jpy	0.211	0.188***	-0.037	0.208	0.192***	0.010
	(0.218)	(0.053)	(0.085)	(0.224)	(0.052)	(0.077)
emp	0.028	0.035	0.071**	0.053	0.098**	0.247***
	(0.041)	(0.023)	(0.035)	(0.052)	(0.041)	(0.079)
c	-0.004	0.001	-0.001	-0.004	0.001	-0.001
	(0.005)	(0.002)	(0.002)	(0.005)	(0.002)	(0.002)
R^2	0.282	0.655	0.246	0.291	0.670	0.363

Bulgaria

	1.17	1.18
	99.01-09.12	99.01-09.12
eur	1.026***	1.027***
	(0.035)	(0.035)
usd	-0.014	-0.015
	(0.017)	(0.017)
jpy	-0.007	-0.001
	(0.011)	(0.011)
emp	0.011	0.007
	(0.011)	(0.009)
c	0.000	-0.000
	(0.001)	(0.001)
R^2	0.952	0.952

Czech Republic

	1.17		1.18
	93.01-98.12	99.01-09.12	99.01-09.12
dem	0.847***		
	(0.217)		
ffr	-0.076		
	(0.221)		
eur		0.843***	0.910***
		(0.097)	(0.151)
usd	0.407***	-0.030	-0.143
	(0.093)	(0.096)	(0.087)
jpy	-0.079	-0.014	-0.048
	(0.119)	(0.051)	(0.076)
emp	-0.009	0.261**	0.050
	(0.021)	(0.113)	(0.044)
c	0.002	-0.004***	-0.004**
	(0.003)	(0.001)	(0.002)
R^2	0.677	0.693	0.598

Denmark

	1.17			1.18	
	80.01-92.10	92.11-98.12	99.01-09.12	92.11-98.12	99.01-09.12
dem	0.735***	0.351		0.329	
	(0.077)	(0.274)		(0.285)	
ffr	0.223***	0.593**		0.585**	
	(0.077)	(0.247)		(0.252)	
eur			1.035***		1.021***
			(0.024)		(0.028)
usd	0.021	0.017	-0.016	0.051*	-0.006
	(0.018)	(0.025)	(0.010)	(0.030)	(0.011)
jpy	0.010	0.022	0.004	0.031	0.009
	(0.018)	(0.023)	(0.011)	(0.026)	(0.010)
emp	-0.004	-0.008	0.002	0.020	0.037*
	(0.004)	(0.009)	(0.005)	(0.022)	(0.018)
c	0.001*	0.000	0.000	0.000	0.000
	(0.000)	(0.001)	(0.002)	(0.001)	(0.002)
R^2	0.952	0.901	0.985	0.858	0.986

Estonia

	1.17		1.18	
	93.01-98.12	99.01-09.12	93.01-98.12	99.01-09.12
dem	1.175***		1.172***	
	(0.150)		(0.149)	
ffr	-0.206		-0.204	
	(0.149)		(0.148)	
eur		1.025***		1.025***
		(0.016)		(0.016)
usd	-0.011	-0.023	-0.010	-0.024
	(0.046)	(0.016)	(0.046)	(0.016)
jpy	0.010	0.001	0.010	0.001
	(0.017)	(0.013)	(0.017)	(0.013)
emp	-0.017	0.001	-0.015	0.000
	(0.013)	(0.003)	(0.010)	(0.003)
c	0.000	0.000	0.000	0.000
	(0.001)	(0.000)	(0.001)	(0.000)
R^2	0.939	0.978	0.939	0.978

Hungary

	1.17			1.18	
	93.01-98.12	99.01-01.07	01.08-09.12	99.01-01.07	01.08-09.12
dem	0.169				
	(0.265)				
ffr	0.309				
	(0.302)				
eur		0.918***	1.215***	0.932***	1.264***
		(0.094)	(0.182)	(0.086)	(0.200)
usd	0.511***	0.214	-0.171*	0.137	-0.186*
	(0.113)	(0.148)	(0.095)	(0.154)	(0.099)
jpy	-0.056	-0.027	-0.134	-0.021	-0.162
	(0.072)	(0.115)	(0.092)	(0.118)	(0.099)
emp	0.094**	0.119	0.141***	0.016	0.078**
	(0.037)	(0.077)	(0.053)	(0.036)	(0.032)
c	0.010***	0.002	0.002	0.000	0.002
	(0.001)	(0.003)	(0.002)	(0.003)	(0.003)
R^2	0.600	0.779	0.618	0.757	0.590

Iceland

	1.17				
	83.07-86.08	86.09-92.10	92.11-98.12	99.01-01.03	01.04-08.09
dem	1.742*	0.630*	0.691***		
	(0.865)	(0.384)	(0.248)		
ffr	-1.441	-0.163	-0.053		
	(0.861)	(0.364)	(0.115)		
eur				0.448***	0.582*
				(0.075)	(0.336)
usd	0.572***	0.275***	0.213*	0.157	0.425**
	(0.103)	(0.058)	(0.120)	(0.120)	(0.207)
jpy	-0.115	-0.014	-0.024	0.222***	-0.613***
	(0.127)	(0.078)	(0.062)	(0.068)	(0.204)
emp	0.112	0.046	-0.005	0.008	0.083**
	(0.072)	(0.032)	(0.010)	(0.031)	(0.039)
c	0.011	0.006***	0.001	0.004	0.000
	(0.003)	(0.002)	(0.002)	(0.002)	(0.001)
R^2	0.681	0.560	0.581	0.739	0.225

Latvia

	1.17			1.18	
	94.01-98.12	01.99-04.12	05.01-09.12	01.07-04.12	05.01-09.12
dem	0.310***				
	(0.098)				
ffr	-0.037				
	(0.098)				
eur		0.212***	0.904***	0.267***	0.904***
		(0.024)	(0.045)	(0.043)	(0.044)
usd	0.446***	0.443***	-0.022	0.463***	-0.024
	(0.023)	(0.024)	(0.067)	(0.030)	(0.067)
jpy	0.168***	0.110***	0.115***	0.073***	-0.115***
	(0.015)	(0.022)	(0.042)	(0.033)	(0.042)
emp	0.010	0.003	-0.012	0.013	-0.011
	(0.010)	(0.008)	(0.020)	(0.011)	(0.010)
c	0.000	0.000	0.000	0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
R^2	0.951	0.910	0.894	0.889	0.895

Lithuania

	1.17		1.18		
	94.04-98.12	01.99-02.01	02.02-09.12	01.99-02.01	02.02-09.12
dem	-0.001				
	(0.008)				
ffr	0.002				
	(0.010)				
eur		0.003*	0.904***	0.003	0.866***
		(0.002)	(0.045)	(0.002)	(0.054)
usd	0.996***	1.004***	-0.022	1.005***	-0.015
	(0.003)	(0.002)	(0.067)	(0.002)	(0.047)
jpy	0.000	-0.002	0.115***	-0.002	0.079*
	(0.001)	(0.002)	(0.042)	(0.002)	(0.041)
emp	0.001	0.002**	-0.012	0.001**	0.006
	(0.001)	(0.001)	(0.020)	(0.000)	(0.011)
c	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.001)	(0.000)	(0.001)
R^2	0.999	0.999	0.877	0.999	0.878

Norway

	1.17			
	80.01-92.10	92.11-98.12	99.01-01.02	01.03-09.12
dem	0.403***	0.414**		
	(0.089)	(0.183)		
ffr	0.161*	0.516**		
	(0.082)	(0.206)		
eur			0.594***	0.721***
			(0.090)	(0.147)
usd	0.159***	0.152*	0.221	0.099
	(0.032)	(0.085)	(0.142)	(0.087)
jpy	0.048	-0.080	0.018	-0.089
	(0.033)	(0.038)	(0.086)	(0.081)
emp	0.023*	-0.018	0.083***	0.147***
	(0.012)	(0.020)	(0.019)	(0.031)
c	0.001	0.002	-0.001	-0.001
	(0.001)	(0.001)	(0.002)	(0.002)
R^2	0.756	0.723	0.782	0.465

Poland

	1.17		1.18	
	95.06-98.12	99.01-09.12	95.06-98.12	99.01-09.12
dem	0.508		0.237	
	(0.398)		(1.259)	
ffr	-0.016		0.212	
	(0.396)		(1.234)	
eur		0.563***		0.481***
		(0.144)		(0.105)
usd	0.531***	0.170	0.612**	0.246**
	(0.150)	(0.123)	(0.243)	(0.101)
jpy	0.017	-0.142	0.039	-0.074
	(0.088)	(0.092)	(0.017)	(0.070)
emp	0.192*	0.368***	0.256*	0.563***
	(0.094)	(0.063)	(0.144)	(0.064)
c	0.001	-0.002	0.000	-0.002
	(0.003)	(0.002)	(0.003)	(0.002)
R^2	0.612	0.593	0.565	0.665

Romania

	1.17		
	93.01-98.12	99.01-04.12	05.01-09.12
dem	0.922		
	(0.657)		
ffr	-0.209		
	(0.657)		
eur		0.436***	0.801***
		(0.182)	(0.214)
usd	0.062	0.361**	0.042
	(0.579)	(0.178)	(0.128)
jpy	-0.221	-0.008	-0.093
	(0.159)	(0.100)	(0.126)
emp	0.281***	0.014	0.344***
	(0.082)	(0.042)	(0.105)
c	0.026***	0.014***	-0.006**
	(0.006)	(0.003)	(0.003)
R^2	0.281	0.193	0.615

Slovak Republic

	1.17			1.18	
	93.01-98.12	99.01-05.11	05.12-08.12	00.03-05.11	05.12-08.12
dem	0.120				
	(0.307)				
ffr	0.619*				
	(0.368)				
eur		0.697***	0.959***	0.604***	0.864***
		(0.096)	(0.061)	(0.135)	(0.099)
usd	0.407***	-0.007	0.025	0.084	0.119
	(0.084)	(0.088)	(0.119)	(0.087)	(0.122)
jpy	-0.060	0.010	-0.016	-0.071	0.003
	(0.044)	(0.056)	(0.088)	(0.072)	(0.069)
emp	0.023	-0.000	0.050	0.125**	0.290
	(0.015)	(0.016)	(0.093)	(0.062)	(0.206)
c	0.002	-0.001	-0.007**	-0.003*	-0.005
	(0.001)	(0.002)	(0.003)	(0.002)	(0.002)
R^2	0.689	0.497	0.720	0.480	0.777

Sweden

	1.17				1.18	
	86.01-92.10	92.11-94.12	95.01-98.12	99.01-09.12	95.01-98.12	99.01-09.12
dem	0.283***	0.185	0.537		0.523	
	(0.099)	(0.648)		(0.452)	(0.444)	
ffr	0.289***	0.464	0.097		0.082	
	(0.103)	(0.715)	(0.462)		(0.453)	
eur				0.783***		1.166***
				(0.085)		(0.075)
usd	0.204***	-0.651	0.286*	-0.131	0.305*	-0.053
	(0.028)	(0.490)	(0.157)	(0.091)	(0.155)	(0.078)
jpy	-0.006	0.027	-0.016	0.074	-0.013	-0.068
	(0.027)	(0.210)	(0.063)	(0.081)	(0.063)	(0.054)
emp	0.004	-0.013	0.015	0.073***	-0.002	0.029*
	(0.007)	(0.119)	(0.027)	(0.027)	(0.018)	(0.016)
c	-0.000	0.009	0.001	0.001	0.001	0.001
	(0.001)	(0.007)	(0.003)	(0.001)	(0.003)	(0.001)
R^2	0.889	0.262	0.503	0.672	0.500	0.752

Switzerland

	1.17			1.18		
	80.01-92.10	92.11-98.12	00.01-09.12	80.01-92.10	92.11-98.12	00.01-09.12
dem	0.926***	0.679***		0.948***	0.694***	
	(0.119)	(0.197)		(0.120)	(0.201)	
ffr	-0.057	0.343		-0.056	0.343	
	(0.126)	(0.210)		(0.127)	(0.213)	
eur			0.908***			0.919***
			(0.078)			(0.080)
usd	-0.050	-0.096	0.012	-0.050	-0.110	-0.006
	(0.042)	(0.079)	(0.060)	(0.044)	(0.077)	(0.059)
jpy	0.145***	0.104***	0.176***	0.120**	0.102***	0.181***
	(0.049)	(0.036)	(0.057)	(0.048)	(0.036)	(0.058)
emp	0.019	0.049*	0.083*	0.024	0.029	0.058*
	(0.013)	(0.027)	(0.044)	(0.015)	(0.020)	(0.030)
c	0.000	-0.001	-0.001	0.000	0.001	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.003)	(0.001)
R^2	0.777	0.843	0.841	0.787	0.839	0.835

United Kingdom

	1.17				1.18		
	80.01-90.09	90.10-92.10	92.11-98.12	99.01-09.12	90.10-92.10	92.11-98.12	99.01-09.12
dem	0.022	0.809	0.146		0.788	0.143	
	(0.263)	(0.843)	(0.258)		(0.975)	(0.259)	
ffr	0.373*	0.504	0.385		0.572	0.370	
	(0.209)	(1.055)	(0.226)		(0.686)	(0.229)	
eur				0.650***			0.302**
				(0.220)			(0.134)
usd	0.218***	0.320	0.444***	0.487***	0.286	0.438***	0.413***
	(0.083)	(0.215)	(0.070)	(0.100)	(0.249)	(0.067)	(0.068)
jpy	0.188*	-0.069	0.017	0.030	-0.075	0.029	0.121*
	(0.109)	(0.257)	(0.052)	(0.071)	(0.198)	(0.051)	(0.067)
emp	0.080**	0.373*	0.271***	0.130***	0.309	0.308***	0.266***
	(0.040)	(0.216)	(0.068)	(0.040)	(0.248)	(0.067)	(0.078)
c	0.002	0.005	-0.000	0.001	0.006	-0.000	-0.001
	(0.002)	(0.006)	(0.002)	(0.002)	(0.005)	(0.001)	(0.001)
R^2	0.329	0.465	0.701	0.593	0.437	0.725	0.577

Chapter 2

Estimating Central Bank Preferences: Sweden 1995-2009

2.1 Introduction

Interest rate rules are often estimated as simple reaction functions à la Taylor (1993) rule linking the policy interest rate to variables such as future expected inflation and the output gap. However, it has been shown by Svensson (1997) that the coefficients estimated with this approach are convolutions of structural and preference parameters and thus are subject to the Lucas (1976) critique. In this chapter, I propose an approach to estimate Central Bank preferences starting from the Central Bank's optimization problem within a small open economy, extending previous work by Favero and Rovelli (2003). When we consider open economies that are in a regime of Inflation Targeting, the issue of the role of the exchange rate in the Monetary Policy rule becomes relevant. In particular, it is still widely debated whether Inflation Targeting Central Banks should, or do, limit exchange rate flexibility. During the last decade, a large body of empirical literature has investigated the tendency of Central Banks to adopt de facto policies which are in conflict with the official statements, in particular with respect to the exchange rate regime. While, on one hand, there has been a

tendency to move towards flexible exchange rates [1] , on the other hand it has been shown [2] that countries still engage in active exchange rate management. The literature on so-called "Fear of Floating", which we have discussed in Chapter 1, has documented on many countries, in particular, lower nominal exchange rate volatility and higher foreign exchange reserves volatility with respect to some benchmark floater.
Out of the 27 member states of the EU, only 16 have adopted the euro; six have floating exchange rates and an Inflation Targeting regime, while the remaining ones adopted some sort of exchange rate arrangement vis-à-vis the euro. Nevertheless, the bilateral exchange rates of inflation targeters with the euro have remained quite stable over the last decade, and this has raised the question of whether they have been - whether voluntarily or not - following the ECB policy with the aim of stabilizing the exchange rate [3].
When the country of interest has adopted an Inflation Targeting regime, the results obtained using exchange rate regime classification techniques might be misleading. Exchange rate smoothing can come as a side product when the Central Bank targets CPI inflation, and this will depend on the degree of exchange rate pass-through and the share of imported final goods. Moreover, exchange rate stabilization can come as the result of increased economic integration and business cycle synchronization, as suggested by the theory of endogenous optimum currency areas (see Frankel and Rose (1998)).

The objective of this chapter is therefore threefold. First of all, it aims at bridging the gap between the literature on exchange rate regime classification and that on monetary policy rules estimation. This, as it was stated above, is done by suggesting an approach for the estimation of Monetary Policy Rules and the identification of Central Bank preferences in a small open economy that builds on previous work by Favero and Rovelli (2003) and Collins and Siklos (2004). Rather than limiting ourselves to the estimation of Taylor rules, we take the Lucas (1976) critique seriously by identifying separately the parameters describing the structure of the economy and those describing Central Bank preferences, explicitly considering exchange

[1]See Reinhard and Rogoff (2001).
[2]See the discussion in Chapter 1 and, for example, Calvo and Reinhard (2002), Levy-Yeyati and Sturzenegger (2003), (2005) and (2007), Frankel and Wei (2008).
[3]See Van Dijk et al. (2005) and Reade and Volz (2009).

rate smoothing or "Fear of Floating" as one possible regime. The second objective is to show, through a simple and stylized theoretical model, how the speed at which the real exchange rate converges to the PPP can influence its role in the monetary policy rule, an aspect which has not been considered in the literature on monetary policy rules estimation, even when the exchange rate is included as a regressor. Third, by using Central Bank forecasts, I explicitly address the critique by Orphanides (2001) and Molodsova et al. (2008) who suggested that estimation of policy rules should be run on real time rather than revised data.

The subject of the empirical analysis is Sweden. While, officially, it has been on an Inflation Targeting regime since 1995, Sweden exhibited - at least until the economic crisis that started at the end of 2008, which put small currencies through a lot of stress - a remarkable stability of the bilateral exchange rate of its currency, the Krona, with the Euro. For these reasons, it is an obvious candidate to study how to discern between "honest" Inflation Targeting which has exchange rate stabilization as a side product, and "Fear of Floating".

The structure of the paper is the following. Section 2 describes the position of Sweden with respect to the Euro as well as some stylized facts on the Swedish and Euro Area economy during the last 15 years. Section 3 presents a brief review of the related literature. Section 4 introduces a simple model for the derivation of interest rate rules in an open economy. In Section 5, a parsimonious structural model of the Swedish economy is estimated, which is the empirical counterpart of the theoretical model in section 4. In Section 6 we estimate Central Bank preferences corresponding to alternative monetary policy rules, to see which one fits the behavior of the Swedish Riksbank best. Section 7 concludes.

2.2 Sweden and the euro

After the collapse of the Exchange Rate Mechanism at the end of 1992, Sweden entered a floating exchange rate regime and then formally adopted Inflation Targeting in January 1995. The introduction of the euro in 1999 created a huge debate in Sweden, concerning the adoption of the common currency; the Government decided that the country would not be part of the leading group of the Monetary Union, because of both political and economic considerations. The political considerations mainly dealt with the fact that Sweden had joined the EU only a few years earlier (in 1995) and the population was supposed not to be ”ready” to give up their national currency yet. The economic considerations were the result of the report of the Calmfors Commission, which had been appointed by the Government to evaluate the costs and benefits of joining the Monetary Union for Sweden. In the end, the government decided that a national referendum had to be held in order to let the people decide on the adoption of the euro. In September 2003 the referendum was held, where the 56% of voters rejected the proposal of joining the EMU, and since then it has not been clear what Sweden is going to do with the euro. In theory, it has to join the Monetary Union sooner or later. In fact, the Maastricht Treaty only considers the opt-out possibility for Denmark and the UK, while other countries and new member states have to join the EMU as soon as they fulfill the convergence criteria. In the last few years Sweden has fulfilled four of the five criteria, and manages to stay out by not joining ERM II [4]. One might ask to which extent the conduct of monetary policy in european countries that have not adopted the euro is constrained or influenced by shocks originating in the EMU, with which they are highly integrated, and whether they are actually setting their monetary policy in step with the ECB, regardless of official policy statements, i.e. whether there is some evidence of ”Fear of Floating” (Calvo and Reinhart, 2002). By looking at the graph of the exchange rate of the Swedish Krona vis à vis the Euro, one can notice that the latter has remained very stable since the adoption of inflation targeting in Sweden in 1995, and even more so between january 2002 and september 2008, that is, after the euro banknotes and coins were finally introduced [5] .

[4] The Maastricht Treaty requires that a country that wants to join the EMU has been a member of ERMII without realignments of the central parity of the last two years.

[5] During the last quarter of 2008 the bilateral exchange rate experienced a large increase in volatility, and the Krona suffered a depreciation of over 15%. The last months of 2008 were characterized by a sharp depreciation of minor currencies, and this was aknowledged also by the Riksbank in its Monetary Policy report of October 23rd 2008: *”The krona has weakened agains almost all of the largest currencies since September. It is unclear exactly what this weakening is due to, but in times of great anxiety, small countries' currencies are usually regarded as uncertain and they weaken. The krona weakened, for instance, after the crises in 1997-98 and* [...] *in September 2001. This is clear, for instance, from the krona's position against the euro* [...]. *The weakening of the trade-weighted krona , which is largely assumed to be due to the current crisis, is expected to persist for the remainder of the year* [...]. *After that, the krona will return to more normal levels.* [...] *A weakening*

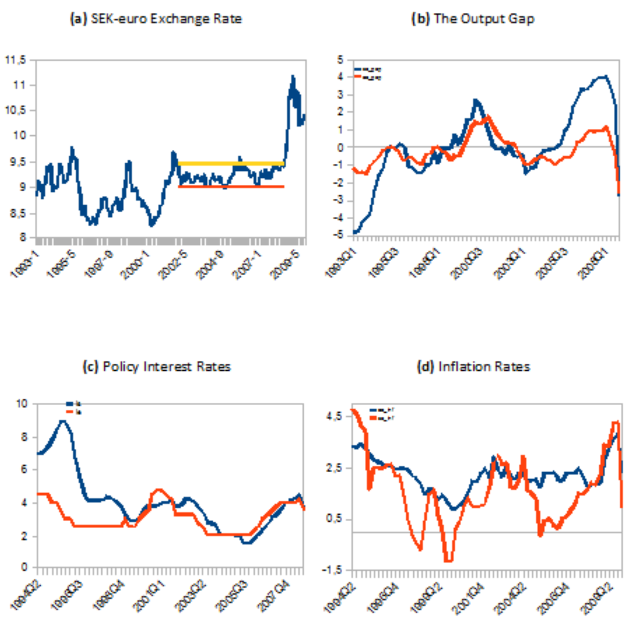

Figure 2.1: The business cycle in Sweden and the Euro Area

Not only has variability been low, but the bilateral exchange rate remained within a band of $\pm 2.50\%$ around a mean of 9.22 krona per euro (See Figure 2.1, panel (a)). It is also interesting to observe the evolution of the variables describing the Swedish and EMU business cycles, namely inflation, output and interest rates. Figure 2.1, panels (b)-(d) shows that, since the introduction of flexible exchange rates in 1993, the CPI inflation, output gap, and policy interest rates in Sweden and the EMU tended to move quite closely together. This is clear also from Table 2.1, which reports some correlations on the same variables and also shows how exchange rate volatility[6] has decreased in the last part of the period, while the other correlations have remained quite stable.

The natural question that arises is therefore the following: what was the source of the stabilization of the SEK/Euro exchange rate? Has the Riks-

of the exchange rate usually has a positive effect on exports in Sweden". The Riksbank's report highlights two elements: first, the krona is expected to appreciate when the crisis is over; second, the Riksbank is not going to intervene to defend the currency: in a situation of falling inflation and falling output, a depreciation of the currency is nothing but good in order to overcome the crisis.

[6] Defined as in prior 1.15 in Chapter 1.

bank actually been limiting the SEK/Euro exchange rate flexibility, despite its official claims of being an inflation targeter, or is such an exchange rate stabilization endogenous, i.e. the result of an increasing convergence of EMU and Swedish business cycles, so that "faced with similar data, the Riksbank and ECB tend to synchronize their interest rate decisions: this helps explaining why the exchange rate has been so stable" [7] ? Apart from alternative exchange rate regimes and arrangements, we can identify four possible sources of exchange rate stabilization: two are voluntary and two involuntary. Exchange rate volatility can be reduced through direct intervention using foreign exchange reserves or credit lines; alternatively, the central bank can stabilize the exchange rate through the policy interest rate, changing it in step with the anchor country (an example in this sense is Denmark). Alternatively, exchange rate stabilization can be the result of a synchronization of monetary policy interventions that is due to the convergence of business cycles, as suggested by Giavazzi and Mishkin (2005) for the case of Sweden. Finally, Reade and Volz (2009) suggest that Sweden might be unable to run a monetary policy that is independent from that of the EMU. The authors investigated this issue by looking at interbank interest rates in a Cointegrated VAR framework and concluded that the two interest rates are cointegrated with only the Swedish rate adjusting, and this indicates that the Riksbank is, "de facto, not a master in its house" [8]. In other words, since the two Central Banks behave similarly, it should not be costly for Sweden to give up its monetary policy independence.

	1993.01-1994.12	1995.01-1998.12	1999.01-2001.12	2002.01-2008.12
Output gaps correl.	0.69	0.84	0.81	0.88
Inflation rates correl.	-0.71	0.71	0.79	0.70
Policy rates correl.	0.94	0.82	0.87	0.84
Exchange rate stability	0.667	0.865	0.945	0.996

Table 2.1: The business cycle in Sweden and the EMU, 1993-2008.

[7] Giavazzi and Mishkin, 2007 p. 54.

[8] Reade and Volz (2009), p. 26.

2.3 Review of related literature

Since the seminal paper by Taylor (1993), which introduced the use of simple interest rate rules for the analysis of monetary policy, a lot of theoretical and empirical research has been developed on the issue. According to the "Taylor Rule", in each period the Central Bank sets the interest rate to respond to deviations of inflation from a pre−specified target (in his paper, 2%) and of output growth from the long−run growth rate of output. The original interest rate rule by Taylor has been modified in following empirical and theoretical works. In particular, it has been noticed (see, for example, Clarida et al.,1998) that Central Banks respond to forecasts of inflation rather than current inflation, due to time lags in the effectiveness of monetary policy. Moreover, interest rates show a high degree of persistence, and the fit of estimated interest rate rules can be improved a lot by augmenting the Taylor Rule with the lagged policy rate. In this sense, the observed interest rate can be interpreted as a weighted average of the target rate and the rate in the previous period; this behaviour has been termed *interest rate smoothing* and the theoretical justification would be that Central Banks change their policy rates gradually in order to avoid generating excessive macroeconomic volatility.

However, the role of the lagged interest rate in the monetary policy rule has been challenged in several works (see Cecchetti (2000), Rudebusch (2002), English (2003), Castelnuovo (2007)), suggesting that the persistence of the policy rate might be due to serially correlated errors rather than optimal partial adjustment. From a theoretical point of view, Cecchetti (2000) criticizes interest rate smoothing (as well as exchange rate smoothing) as an explicit objective of monetary policy, while it could be an instrument of the optimal policy. Recently, Consolo and Favero (2009) have shown that the observed inertia in monetary policy, resulting in very high (generally between 0.8 and 0.9) coefficients on the lagged policy rate, might be the consequence of a weak instrument problem in the GMM estimations performed.

The empirical literature has generally estimated monetary policy reaction functions (in the form of forward-looking Taylor (1993) rules) using a GMM approach (see, for example, Clarida et al., 1998 and 2000) [9]; however,

[9] To be precise, the GMM approach is used when official forecasts for the inflation rate are not available, and therefore least squares estimation of a forward-looking Taylor Rule setting $\pi_{t+k|t} = \pi_{t+k}$ would result in an endogenous error term. When the Central

as it was pointed out in Favero and Rovelli (2003), since Euler equations are the natural object of the GMM approach, it would be more natural to use first order conditions, derived from the Central Bank's optimization problem, to estimate the policy rule. Favero and Rovelli (2003) apply this approach for the estimation of Central Bank preferences to the U.S. A similar attempt was done by Collins and Siklos (2004) who estimate Central Bank preferences for Australia, New Zealand and Canada. However, their approach suffers from several limitations: first, their empirical analysis heavily relies on HP filters; second, they solve an infinite-horizon optimization problem which, although more realistic than the finite-horizon approach we adopt in sections 5 and 7, yields results which are less comparable to previous works that estimated simple interest rate rules. We believe that the finite-time approach adopted here is not an excessive simplification; moreover, it allows us to derive an analytical solution to the Central Bank's optimization problem which would not be possible otherwise. Finally, unlike them, we adopt an agnostic approach here estimating the structural model from a very general system, rather than relying on previously existing country-specific models as in Collins and Siklos, and is therefore this approach is more general for a small open economy. Cecchetti et al. (2002) estimate the Central Bank's preferences within a similar framework, but with a different methodological approach [10]. However, they do not attempt to estimate an optimal weight for interest rate smoothing and disregard exchange rate smoothing as well, which, however, is quite surprising given that the countries in their sample maintained a policy of limited exchange rate flexibility within (most of) the sample period.

An issue which is not solved is related to the role of the exchange rate in the monetary policy rule of inflation targeting Central Banks. According to Svensson (2003) there are no good reasons for separate - real or nominal - exchange rate objectives, under flexible inflation targeting, at least for advanced economies, while exchange rate smoothing would be more motivated for developing countries, which typically have foreign currency-denominated

Bank's inflation forecasts are available, however, nonlinear least squares are suited for the estimation of a forward-looking Taylor Rule with interest rate smoothing (see Castelnuovo, 2007, and De Aurelio, 2005).

[10] Given their model, they estimate the relative weights on output and inflation variability in the objective function that minimize the distance between estimated and optimal interest rate response to structural economic shocks; such structural shocks, in turn, are identified within a four- (or five- , depending on the country at hand) variable SVAR.

debt as well as other financial stability-related problems. At the same time, Svensson (1997) states that exchange rate targeting, as well as money growth targeting, would be better than inflation forecast targeting as a means to curb inflation only in the case they are sufficient statistics for future inflation; if they are not, as it generally happens, then exchange rate and money growth targeting lead to worse outcomes [11] with respect to inflation forecast targeting. The most widespread view in the literature is that the (real) exchange rate, therefore, would indeed play a role in the monetary policy rule when the central bank targets CPI inflation, but only indirectly, since it is a predictor of future inflation and it also affects the output gap; domestic inflation targeting presents worse outcomes in terms of output stabilization (see, for example, Gali and Monacelli (2005) and Svensson (2000)). Moreover, Taylor (2003) and Edwards (2006) discuss that if Central Banks responded directly to exchange rate changes by changing the policy interest rate, this would result in excessive interest rate volatility, which is not observed in practice. The model outlined in Section 5 will be on the same line, suggesting that, indeed, relatively high interest rate variability might be evidence of "fear of floating", in line with what suggested, in a different framework, by Levy-Yeyati and Sturzenegger (2005).

A country that is officially on a flexible exchange rate regime but actively intervenes to reduce the volatility of the exchange rate is said to have Fear of Floating (see Chapter 1). A large body of literature has recently introduced measures of exchange rate flexibility , but only one paper, namely Ball and Reyes (2008), has focused on the challenges for exchange rate classification schemes when they are applied to IT countries. However, Ball and Reyes (2008) present two main limits in the analysis of inflation targeting regimes: on the theoretical side, they only compare simple instrument rules rather than deriving the policy function from an optimizing behaviour of the Central Bank; this limited approach influences their empirical analysis, since they only focus on how the real interest rate responds differently to current and lagged inflation and changes in exchange rate under different official regimes, rather than estimating a policy rule.

[11] In particular, higher inflation and output variability.

2.4 Inflation Targeting in a Small Open Economy

Inflation Targeting (henceforth IT) is defined as a monetary policy regime characterized by: (i) an explicit inflation target (normally around 2%, with the possibility of some tolerance bands around the target); (ii) a framework for policy decisions called inflation-forecast targeting, which uses an inflation forecast produced by the Central Bank, and made public, as an intermediate target for Monetary Policy; and finally, (iii) a high degree of transparency and accountability (see Svensson, 1996). Starting from the end of the 1980s, an increasing number of countries , generally small open economies, have adopted IT as the official monetary policy regime [12]. Adopting IT does not rule out the possibility that additional objectives, other than inflation stabilization, be pursued by the Central Bank, as long as these do not jeopardize the achievement of the inflation target. The presence of such additional objectives - for example, output stabilization and interest rate smoothing - allows us to distinguish between strict and flexible IT. Official statements by the main IT Central Banks make it natural to regard IT, using Svensson's (2003) words, as a targeting rule. The Monetary Policy objective of the Bank of England is to

> [...] deliver price stability - low inflation - and, subject to that, to support the Government's economic objectives including those for growth and employment. Price stability is defined by the Government's inflation target of 2%. [...] The Monetary Policy Committee's aim is to set interest rates so that inflation can be brought back to target within a reasonable time period without creating undue instability in the economy.

Similarly, in Australia, which adopted inflation targeting in 1993, the Statement of Conduct of Monetary Policy established that

> [...] monetary policy's principal medium-term objective is to control inflation. [...] The appropriate target for monetary policy is to achieve an inflation rate of 2-3 per cent on average, over the cycle [...]. The inflation target is defined as a medium-term average rather than as a hard-edged target band within which inflation is to be held at all times. This formulation allows for the inevitable uncertainties that are

[12] To name a few, the United Kingdom, Canada, New Zealand, Australia, Sweden, Poland, the Czech Republic, Israel.

> involved in forecasting, and lags in the effects of monetary policy on the economy. [...] The inflation target is, necessarily, forward-looking, as evidenced by the operation of monetary policy since its introduction. This approach allows a role for monetary policy in dampening the fluctuations in output over the course of the business cycle.

Finally, the Swedish Riksbank, which is at the center of the present analysis [13], has stated that

> The Riksbank has specified an explicit inflation target whereby the annual change in the Consumer Price Index (CPI) is to be 2 per cent with a tolerance interval of plus/minus 1 per cent. Monetary Policy is also guided by various measures of "underlying inflation". There is no single measure of inflation that consistently indicates the appropriate stance of monetary policy. Monetary policy acts with a lag and is normally focused on achieving the inflation target within a two-year period. The two-year time horizon also provides scope for taking fluctuations in the real economy into consideration. The Riksbank routinely takes into consideration changes in asset prices and other variables [...].

As it was outlined by Svensson (2003), instrument rules like the Taylor (1993) rule are not appropriate to describe monetary policy for three main reasons: first, they are overly simple and mechanic, and therefore deny the necessary flexibility; second, they do not consider the fact that in reality, when setting the interest rate, central banks make use of a lot more information than just the inflation rate and the output gap; finally, the parameters of instrument rules estimated using for example the approach in Clarida et al. (1998) are not structural, in the sense that they are convolutions of structural and preference parameters, and estimation of a simple instrument rule would leave such parameters unidentified. For the reasons outlined so far, in order to compare the policy rules coming from alternative monetary policy frameworks, we will proceed to derive optimal monetary policy reaction functions using the approach introduced by Svensson (1997, 1999, 2000 and 2003) and also applied in Favero and Rovelli (2003) and extend it to the open economy, with a focus on fear of floating as an alternative to "honest" Inflation Targeting.

[13] The inflation target was formulated in January 1993, when the transition to the new monetary regime - after the collapse of ERM - began. However, it formally began to apply in January 1995 (see Giavazzi and Mishkin, 2007).

In this section we will therefore discuss and derive alternative monetary policy rules that are suitable for estimation, in order to find which one characterizes best the behavior of the Sveriges Riksbank. To this end, we sketch a stylized model of a small open economy similar to Svensson (2000), but with less complex dynamics, because the dynamics of each equation will be determined empirically in the next section. Let us assume that the aggregate demand in a small open economy is given by:

$$y_{t+1} = \beta_y y_t - \beta_r(i_t - \pi_t - \overline{r}) + \beta_q q_t + \nu_{t+1} \tag{2.1}$$

where q is the deviation of the real exchange rate, defined as domestic output per unit of foreign output, from PPP, so that when $q = 0$ the PPP holds and when q increases we have a real depreciation; therefore, the coefficient β_q is positive. For simplicity, unlike Svensson (2000), we have assumed that the foreign output gap does not influence the domestic business cycle. Finally, ν_{t+1} is a zero-mean i.i.d. demand shock. The Phillips curve is given by:

$$\pi_{t+1} = \pi_t + \alpha_y y_t + \alpha_q q_t + \xi_{t+1} \tag{2.2}$$

where $\alpha_q > 0$; a depreciation of the exchange rate has both a direct inflationary effect, since imported goods become more expensive, and an indirect effect through resource utilization which kicks with a two-period lag. ξ_{t+1} is a zero-mean i.i.d. cost-push shock. Since we are dealing with an open economy, with respect to the previous section we also have to define an equilibrium relation for the exchange rate. For a small open economy, with free capital mobility, uncovered interest parity should hold. We can write it for the nominal exchange rate as:

$$e_t = i_t^f - i_t + e_{t+1|t} + \phi_t \tag{2.3}$$[14]

[14]Notice that here we do not model the dynamics of foreign country variables, i.e. we do not specify a rule for the foreign interest rate. This, for example, implies that we disregard the impact of foreign monetary policy on foreign inflation. This choice is due to the need of keeping things simple so that we can analytically find the interest rate reaction functions, but the drawback is that it rules out one channel for the transmission of international shocks. This is evident in the Central Bank of Denmark's statement of Monetary Policy: "*The main objective of the monetary policy in the euro area is to maintain price stability, i.e. to avoid inflation. By keeping the krone stable vis-à-vis the euro, a basis for low inflation is also created in Denmark.*" (see Danmarks Nationalbank's Introduction to Monetary and Foreign Exchange Policy).

where ϕ is a stationary i.i.d. disturbance which we will label the risk premium. The exchange rate tends to be higher (i.e. weaker) when it is expected to increase in the next period and when foreign interest rates are higher than domestic interest rates. Notice that the real exchange rate is defined as:

$$Q_t = e_t + p_t^f - p_t$$

When the PPP holds, $Q_t = 1$, and thus the deviation from PPP is $q_t = Q_t - 1$. Plugging this in the UIP (2.3) above, we can rewrite it as:

$$q_t = q_{t+1|t} - i_t + i_t^f - \pi_t^f + \pi_t - \phi_t \tag{2.4}$$

which is the real interest parity, expressed in deviation from PPP. Finally, we make an assumption on the evolution of the real exchange rate. When PPP holds, the RER is stationary and therefore shocks to this variable do not have permanent effects. More generally, we can assume that qt gradually adjusts to the PPP, i.e. it gradually goes to zero, according to the following rule:

$$\Delta q_t = -\gamma_{t-1} + \omega_t$$

or, equivalently,

$$q_t = (1 - \gamma)q_{t-1} + \omega_t \tag{2.5}$$

which is a simple auto-regressive mechanism suggesting that, ceteris paribus, in each period qt converges to PPP (i.e. to its long-run constant value of 0) by γ, where $0 < \gamma < 1$ is the adjustment coefficient. ω_t is a zero-mean i.i.d. disturbance, representing temporary shocks affecting the exchange rate that disturb its convergence to the long-run equilibrium. The targeting rules analysis will be applied to four alternative scenarios: (i) exchange rate targeting; (ii) strict inflation targeting, (iii) flexible inflation targeting and (iv) "fear of floating", that in this case describes a country that is pursuing inflation targeting with some weight on exchange rate stabilization (here we do not care whether such exchange rate smoothing happens only de facto or also in official terms).

2.4.1 Exchange-Rate Targeting

The simplest case is that of pure exchange rate targeting. We can describe exchange rate targeting in our framework as the central bank choosing the interest rate path that minimizes the loss function:

$$min_{i_t} E_t \sum_{\tau=0}^{\infty} \delta^{\tau} L_{t+\tau} \tag{2.6}$$

where L is the period loss function, which in this case is:

$$L_t = \frac{1}{2}[(e_t - \overline{e})^2] \tag{2.7}$$

subject to (2.3): we assume that the central bank manages to keep the exchange rate at the announced target and, at the same time, imposes no capital controls and therefore the UIP holds, up to a stationary risk premium. We can show that the monetary policy strategy is very straightforward and intuitive in this case. Since exchange rate stabilization is the only objective of monetary policy, and the central bank influences the exchange rate immediately by changing the interest rate, while current policy decisions do not affect future values of the exchange rate (because $e_{t+1|t}$ is equal to the exchange rate target), the first order condition is:

$$\frac{\partial L_t}{\partial i_t} = -(e_t - \overline{e}) = 0 \Rightarrow e_t = \overline{e}$$

i.e. in each period, the interest rate has to be set so that the exchange rate stays at the official target. Therefore, since the exchange rate is fixed, the expected rate of depreciation is zero and, from (2.1), the policy rule is simply:

$$i_t = i_t^f + \phi_t$$

i.e. the domestic repo rate has to be always equal to the foreign rate (plus the risk premium). This kind of rule currently characterizes, for example, the monetary policy of Danmarks Nationalbank:

> The monetary policy is designed to keep the krone stable vis-à-vis the euro, and other aspects than the exchange rate [. . .] are not considered in relation to monetary policy.[. . .] Danmarks Nationalbank can influence the krone rate by changing its monetary policy interest rates. When the exchange-rate market is stable, DNB normally changes its interest rates in step with the changes of the European Central Bank's minimum bid rate [. . .]. In a situation with upward or downward pressure on the krone or a sustained inflow or outflow of foreign currency,

DNB indipendently changes its interest rates in order to stabilize the krone. [15]

2.4.2 Strict Inflation Targeting

When the Central Bank pursues strict inflation targeting, its objective is to reach the target within a pre-specified period, generally 1-2 years. Assume that t in our model is equal to 3 quarters as in Svensson (2000). We know from equations (2.1)-(2.4) that, when it changes the interest rate at time t, the Central Bank immediately affects q; in $t+1$ it affects the output gap via the direct interest rate channel and the real exchange rate channel, and inflation via the exchange rate pass through (measured by α_q). In $t+2$, the interest rate intervention affects inflation via the output gap. When the central bank is pursuing strict inflation targeting, we can write the objective function as:

$$min_{i_t} E_t \sum_{j=0}^{\infty} \delta^j \frac{1}{2}[(\pi_{t+j} - \pi^*)^2] \tag{2.8}$$

In order to keep things simple and obtain an analytical solution for all alternative regimes, we will assume, as in Svennson (1999), that the Central Bank adopts a period-by-period optimization: the monetary authority takes last year's policy decision as given, but disregards the fact that today's instrument setting will affect next year's loss function. While this simplification is not free from drawbacks, it allows us to understand how alternative objective functions translate into different interest rate rules [16]. Moreover, if we want to describe the behavior of an IT central bank such as the Swedish Riksbank, this hypothesis is not overly restrictive: it is compatible, for example, with the Swedish Riksbank's policy statement that monetary policy is "normally focused on achieving the inflation target within two years". In sum, in this case the objective function simplifies to:

$$min_{i_t} \delta^2 \tfrac{1}{2}[(\pi_{t+2|t} - \pi^*)^2]$$

Since the target has to be reached within 2 years, and the Central Bank influences inflation via the repo rate, today's setting of the interest rate

[15] Danmarks Nationalbank (2003), Monetary Policy in Denmark, p. 22-24.

[16] The approach of period-by-period optimization is drawn from Svensson (1999) who applies it to interest rate smoothing. When the lagged interest rate enters the loss function, as he argues, the standard linear-quadratic optimal control problem requires a numerical solution since the number of state variables goes up to three; for the same reason, we will use this approach also for the anaysis of the other regimes.

is such that, given the Central Bank's models to forecast the inflation rate, constant-interest-rate two-years-ahead expected inflation is equal to the target, i.e. $\pi_{t+2|t} = \pi^*$. The FOC with respect to i_t is simply:

$$\frac{\partial L}{\partial i_t} = (\pi_{t+2|t} - \pi^*)\frac{\partial \pi_{t+2|t}}{\partial i_t} = 0$$

which becomes:

$$\pi_{t+2|t} = \pi^* \tag{2.9}$$

Rewrite the AS curve in $t + 2$ and after substituting we have:

$$\pi_{t+2|t} = \pi_t + \alpha_y(1+\beta_y)y_t + (\alpha_q + \alpha_y\beta_q)q_t - \alpha_y\beta_r(i_t - \pi_t - \overline{r}) + \alpha_q q_{t+1|t} \tag{2.10}$$

Plugging (2.5) in (2.10) and merging it with FOC (2.9), we obtain the interest rate rule when the central bank pursues strict inflation targeting[17]:

$$\begin{aligned} i_t =& \pi_t + \overline{r} + \frac{1}{\alpha_y\beta_r}(\pi_t - \pi^*) + \frac{1+\beta_y}{\beta_r}y_t + \\ & \frac{(\alpha_q(2-\gamma) + \alpha_y\beta_q)(1-\gamma)}{\alpha_y\beta_r}q_{t-1} \end{aligned} \tag{2.11}$$

Equation (2.11) is the policy rule in strict IT: the interest rate is raised when inflation is above target but, although the actual monetary policy strategy is strict inflation targeting, the policy rate is also influenced by the output gap and the real exchange rate deviation from PPP. Therefore, when the real exchange rate is weak, the central bank increases the repo rate to cool down the inflationary pressure and bring qt back to its long-run equilibrium faster than it would otherwise go. We can therefore see that an interest rate rule for inflation targeting in an open economy has the output gap and the real exchange rate in it even if the central bank is pursuing strict inflation targeting. The reason is that both qt and yt are predictors of future inflation, and therefore their role in the monetary policy rule is "indirect". The coefficient of the real exchange rate in the interest rate rule is higher the lower the adjustment factor γ, suggesting that when real exchange rate shocks are persistent the policy rate will exhibit higher variability. Interest rate rule (2.11) encompasses two extreme cases, that is when shocks to qt are not absorbed and there is no adjustment to the PPP (i.e. $\gamma = 0$ and

[17] In order to avoid the problem of the endogeneity of q due to its contemporaneity with i, I substitute q with (2.5)

$q_{t+1|t} = q_t$) and when shocks are immediately absorbed (i.e. $\gamma = 1$ and $q_{t+1|t} = 1$). In the former case, equation (2.11) becomes:

$$i_t = \pi_t + \overline{r} + \frac{1}{\alpha_y \beta_r}(\pi_t - \pi^*) + \frac{1+\beta_y}{\beta_r} y_t + \frac{(\alpha_q(2-\gamma) + \alpha_y \beta_q)}{\alpha_y \beta_r} q_{t-1} \quad (2.12)$$

while, when convergence to PPP occurs within one period, equation (2.11) becomes:

$$i_t = \pi_t + \overline{r} + \frac{1}{\alpha_y \beta_r}(\pi_t - \pi^*) + \frac{1+\beta_y}{\beta_r} y_t \quad (2.13)$$

The difference with respect to (2.13) is that the policy rate is not sensitive to exchange rate fluctuations; this result is intuitive: if qt rapidly goes back to equilibrium, shocks to it will have no effect on future inflation. Within the simple case of strict IT it is easy to consider the effect of the time horizion of the monetary authority on the interest rate rule. In particular, we ask ourselves: what happens if the target horizon of the central bank is longer? In this case, the more persistent real exchange rate fluctuations, the higher will be the weight of this variable in the interest rate rule. Let us assume that the Central Bank wants to reach the target in three periods. The objective function becomes:

$$min_{i_t} \delta^3 \frac{1}{2}(\pi_{t+3|t} - \pi^*)^2 \quad (2.14)$$

and therefore the FOC is the same as in the previous case, moved one period ahead:

$$\frac{\partial L}{\partial i_t} = (\pi_{t+3|t} - \pi^*) \frac{\partial \pi_{t+2|t}}{\partial i_t} = 0$$

which is simply: $\pi_{t+3|t} = \pi^*$. Three-periods-ahead expected inflation is:

$$\pi_{t+3|t} = \pi_{t+2|t} + \alpha_y y_{t+2|t} + \alpha_q q_{t+2|t}$$

If we assume that the RER adjusts to the PPP according to (2.5) and that forecasts of inflation and output gap are made at a constant interest rate , after some algebra we obtain the interest rate reaction function, which we write as:

$$\begin{aligned} i_t =& \overline{r} + \pi_t + \frac{1}{\alpha_y \beta_r (2+\beta_y)}(\pi_t - \pi^*) + \frac{1 + (1+\beta_y)\beta_y + \alpha_y \beta_r}{\beta_r(2+\beta_y)} y_t + \\ & \frac{a(1+\gamma)}{(\alpha_y \beta_r (2+\beta_y)} q_{t-1} \end{aligned} \quad (2.15)$$

Where $a = \alpha_q(\alpha_y\beta_r + 3 - \gamma + (1-\gamma)^2) + \alpha_y\beta_q(2 - \gamma + \beta_y)$. Notice that, with respect to equation (2.11), the coefficient on current inflation is lower, the coefficient on the output gap is lower and the coefficient on q_t is higher. The results stemming from this section are summarized in Proposition 1 below.

Proposition 1 *In an open economy, the interest rate rule of a Central Bank pursuing strict Inflation Targeting will have a role for y_t and q_t, other than for $(\pi_t - \pi^*)$. Other things equal, the interest rate reactivity to real exchange rate shocks will be larger when the target horizon is longer, when shocks to q_t are more persistent (i.e. $\gamma \rightarrow 0$) and when the exchange rate pass-through (captured by α_q) is larger.*

2.4.3 Flexible Inflation Targeting

We assume a quite general framework for flexible IT here: the flexibility comes both from a positive weight on output stabilization and a weight put on interest rate stabilization and smoothing , similar to Svensson (1999):

$$min_{i_t} \sum_{j=0}^{\infty} \delta^j \frac{1}{2} \left[\left(\pi_{t+j|t} - \pi^*\right)^2 + \lambda_i \left(i_t - i_{t-1}\right)^2 + \lambda_r (i_t - \pi_t - \overline{r})^2 + \lambda_y y^2_{t+j|t} \right] \tag{2.16}$$

subject to (2.1), (2.2), (2.4), where the weight on inflation is normalized to 1 and λ_i, λ_r, $\lambda_y > 0$are respectively the relative weight put on interest rate smoothing (i.e. the central bank wants to avoid excessive interest rate variability), on interest rate stabilization around the target real rate, and on output stabilization. Assuming a period-by-period optimization as in the previous case, the problem to be solved by the Central Bank becomes:

$$min_{i_t} \frac{1}{2} \delta^2 [(\pi_{t+2|t} - \pi^*)^2 + \lambda_i (i_t - i_{t-1})^2 + \lambda_r (i_t - \pi_t - \overline{r})^2 + \lambda_y y^2_{t+1|t}] \tag{2.17}$$

and thus the monetary authority takes last year's policy decision as given, but disregards the fact that today's instrument setting will affect next year's loss function. When $\lambda_i = \lambda_r = \lambda_y = 0$, this problem is equivalent to the intertemporal problem analysed for the case of strict inflation targeting. Notice that in objective function (2.17) the central bank sets the interest rate to minimize the two-period-ahead inflation gap and the one-period-ahead output gap. In principle, there is no fundamental reason why the time horizon for the output gap and inflation gap objectives should be the same; in (2.17) the difference is due to the fact that, given the dynamical structure of our simple model, the central bank can affect output via the policy rate after one period, while it takes two periods for inflation to be influenced by monetary policy. In any case, even if the output gap appeared in $t+2$, the results would qualitatively be the same. Minimizing (2.17) with respect to i_t yields the following FOC:

$$
\begin{aligned}
&-(\pi_t-\pi^*)(\alpha_q(2-\gamma)+\alpha_y(\beta_r+\beta_q))-\lambda_y(\beta_r+\beta_q)y_{t+1|t}+\\
&\lambda_i(i_t-i_{t-1})+\lambda_r(i_t-\pi_t-\overline{r})=0
\end{aligned}
\tag{2.18}
$$

This is the targeting rule of the central bank, showing that when the policy rule is flexible inflation targeting, with respect to strict IT, the adjustment towards the target will be slower due to interest rate smoothing. After some algebra, the interest rate rule is:

$$
\begin{aligned}
i_t=&\frac{\lambda_i}{\lambda_i+\lambda_r+b_2\beta_r}i_{t-1}+\frac{b_2\beta_r+\lambda_r+b_1\alpha_y\beta_r}{\lambda_i+\lambda_r+b_2\beta_r}(\pi_t+\overline{r})+\\
&+\frac{b_1}{\lambda_i+\lambda_r+b_2\beta_r}(\pi_t-\pi^*)+\frac{b_1\alpha_y(1+\beta_y+b_2\beta_y)}{\lambda_i+\lambda_r+b_2\beta_r}y_t+\\
&\frac{(b_2\beta_q+b_1(\alpha_q(2-\gamma)+\alpha_y\beta_q))(1-\gamma)}{\lambda_i+\lambda_r+b_2\beta_r}q_t
\end{aligned}
\tag{2.19}
$$

where $b_1=\alpha_q(2-\gamma)+\alpha_y(\beta_r+\beta_q)$ and $b_2=\lambda_y(\beta_r+\beta_q)$. Two things are worth noticing. First of all, as in the strict IT case, although the monetary authority does not have a target for the real exchange rate, it will respond to its fluctuations since it affects expected inflation and the expected output gap. The second result which is worth noticing is that the coefficients of the "Taylor Rule" (2.19) are convolutions of structural parameters and the preference parameters λ_i, λ_r, λ_y. When λ_i and λ_r are different from zero, interest rate variability is lower with respect to the case of strict IT.Finally, when $\lambda_y>0$, the monetary authority's reaction to output and real exchange rate fluctuations will be larger, and that to inflation smaller, than in strict IT. The results on flexible inflation targeting are summarized in Proposition 2.

Proposition 2 *The interest rate rule of a Central Bank pursuing flexible Inflation Targeting will have coefficients on* $(\pi_t-\pi^*)$, y_t *and* q_t *that are convolutions of structural parameters and the preference parameters* $\lambda_x=$

$[\lambda_y, \lambda_i, \lambda_r]$. If $lambda_x = 0$ we go back to the strict IT case. Other things equal, the larger any element in λ_x , the lower the response to inflation fluctuations, and the larger the response to fluctuations in y_t and q_t . As in strict IT, other things equal, the interest rate reactivity to shocks to q_t will be larger when $\gamma \to 0$.

2.4.4 Fear of Floating

Let us now move to the case of "Fear of Floating" or exchange rate smoothing. In order to concentrate on the role of the exchange rate, we will assume here that the weight on interest rate smoothing and output stabilization is zero, i.e. $\lambda_i = \lambda_i = \lambda_i = 0$. The period loss function will be:

$$L_t = \tfrac{1}{2}[(\pi_t - \pi^*)^2 + \lambda_e(e_t - e_{t-1})^2]$$

and thus we allow for a weight $\lambda_e > 0$ for exchange rate smoothing, that is, for a separate exchange rate objective in the monetary policy. In order to keep things simple, as it was stated above (see fn. 16) we will assume here that the Central Bank adopts a period-by-period optimization as we did above. This, other than being an acceptable restriction as we explained in section 2.4.1, will simplify matters and we will not have to resort to a numerical solution, while still being able to understand the consequences of fear of floating on the interest rate rule. The objective function of the Central Bank therefore becomes:

$$min_{i_t} \frac{1}{2}[(\pi_t - \pi^*)^2 + \lambda_e(e_t - e_{t-1})^2] \tag{2.20}$$

subject to: $\pi_{t+2} = \pi_{t+1} + \alpha_y y_{t+1} + \alpha_q q_{t+1} + \xi_{t+2}$. Recall that expected two-period-ahead inflation was written in (5.9) as:

$$\pi_{t+2|t} = \pi_t + \alpha_y(1 + \beta_y)y_t + (\alpha_q + \alpha_y\beta_q)q_t - \alpha_y\beta_r(i_t - \pi_t - \overline{r}) + \alpha_q q_{t+1|t}$$

The FOC for minimizing (2.20) with respect to the repo rate is:

$$\pi_t = \pi^* - \frac{\lambda_e}{\delta^2(\alpha_y\beta_y + \alpha_q(2 - \gamma) + \alpha_y\beta_r)}(e_t - e_{t-1}) \tag{2.21}$$

We can compare (2.21) with the FOC in the strict IT case: with fear of floating, expected inflation two periods ahead is equal to the target only if the exchange rate is stable. If the exchange rate in the current period is weak compared to the previous period, i.e. $e_t > e_{t-1}$, then the interest rate is kept at a level higher than what would ensure that the inflation target is reached in $t + 2$, and therefore $\pi_{t+2|t} < \pi^*$. The opposite holds when the exchange rate is falling. The deviation from the target will be higher the larger is γ, that is, the faster the real exchange rate tends to converge to PPP. In other words, when PPP holds it is harder to control the exchange rate via interest rate intervention and thus more costly in terms of deviation of inflation from the Central Bank's target. After some algebra, the interest rate rule in Fear of Floating is:

$$i_t = \pi_t + \bar{r} + \frac{1}{\alpha_y \beta_r}(\pi_t - \pi^*) + \frac{1 + \beta_y}{\beta_r} y_t + \frac{\alpha_q(2-\gamma) + \alpha_y \beta_q}{\alpha_y \beta_r} q_t + \frac{\lambda_e}{c_1 \alpha_y \beta_r}(e_t - e_{t-1}) \tag{2.22}$$

where $c_1 = \delta^2(\alpha_y \beta_q + \alpha_q(2-\gamma) + \alpha_y \beta_r)$.
Using the definition of real exchange rate in (2.22), we can rewrite it as:

$$i_t = \pi_t + \bar{r} + \frac{1}{\alpha_y \beta_r}(\pi_t - \pi^*) + 1 + \beta_y \beta_r y_t + \frac{c_2}{\alpha_y \beta_r}(\pi_t - \pi_t^f) + \frac{c_3}{\alpha_y \beta_r} q_{t-1} \tag{2.23}$$

where $c_2 = \frac{\lambda_e}{c_1}$;$c_3 = (\alpha_q(2-\gamma) + \alpha_y \beta_q)(1-\gamma) + \frac{\lambda_e \gamma}{c_1}$. Apart from the analytical complexity of the coefficients, we can see from (2.23) that, with fear of floating, the interest rate response to shocks to inflation and the real exchange rate will be stronger than in strict and flexible inflation targeting, since b_1 is positive. Moreover, as in the previous case, the lower the adjustment coefficient γ, the stronger its role in the interest rate rule. The results of the case of Fear of Floating are summarized in Proposition 3 below. The results obtained in sections $2.4.1 - 2.4.4$ are summarized in Table 2.2, which classifies the policy rules according to the interest rate reactivity to shocks of different nature.

Proposition 3 *The interest rate rule of a Central Bank with fear of floating and zero weight on output stabilization will feature larger reaction coefficients for shocks to* π_t *and* q_t *with respect to strict and flexible IT. Such coefficients are convolutions of structural parameters and the preference parameter* λ_e. *The interest rate response to exchange rate fluctuations will be larger when* $\gamma \to 0$. *All other conclusions drawn in Proposition 1 are confirmed.*

The definitions ”low”, ”medium” and ”high” should be interpreted as relative with respect to the other three regimes included in the analysis; in order to say anything on the magnitude of the coefficients, we need parameter values from the structural model.

	π	y	q	i^f
Exchange Rate Targeting	Nil	Nil	High	High
Strict Inflation Targeting	High	Low	Low	Low
Flexible Inflation Targeting	Low	Medium	Medium	Low
Fear of Floating	High	Medium	High	High

Table 2.2: Interest Rate reaction to different shocks.

2.5 A stylized model of the Swedish economy

The first step in the empirical analysis is the estimation of a small model for the Swedish economy. This will allow us to obtain the empirical counterparts of the theoretical model in Section 5. Depending on the chosen specification[18] , the literature seems to have reached a consensus on the minimal set of variables that should be present in an empirical model aimed at representing aggregate demand and supply in a small open economy; this includes domestic and foreign output (gap), price level (or inflation), short-term interest rates, the (nominal or real) exchange rate and possibly some commodity price index [19]. In our case, the ”rest of the world” is proxied by the euro area, and the exchange rate is therefore the bilateral rate. This assumption is not overly restrictive; almost 60% of Swedish international trade is with the euro area, and a similar assumption is quite common in the literature on small open economies[20]. As far as the sample period is concerned, we only consider data from the inflation targeting era, i.e. from 1995 on. This will help us to avoid the risk of including different regimes while maintaining a sufficient number of observations: in fact, Sweden was a member

[18]i.e., whether the one at hand is a model with stationary or cointegrated variables.

[19]See, for example, Eichembaum and Evans (1995), Jacobson et al. (2001); Kim and Roubini (1997) also include a commodity price index, while Betts et al. (1996) and Camarero et al. (2002) augment the system with a (domestic and foreign) monetary aggregate.

[20]Betts et al. (1996), for example, in a Cointegration analysis for Canada, use the U.S. as a proxy for the rest of the world.

of the ERM from 1986 to 1992, then abandoned it because of speculative attacks to the Krona. Between 1992:4 and 1994:4, Sweden suffered from a severe economic downturn and financial crisis, while on the other hand, the inflation targeting regime, coupled with a flexible exchange rate, was being put in place. Inflation targeting was not, however, adopted officially until January 1995; moreover, Sweden entered the European Union in the same month and, although its economy was already well integrated with the rest of Europe, it is plausible that this fostered further economic integration. For this reason, we will restrict ourselves to the period from 1995 to 2008, using quarterly data. There are several alternative empirical strategies to identify a set of equations that could be interpreted as a small structural model for the Swedish economy. Two alternative approaches are VAR (Vector Autoregressive) models and structural econometric models. VAR models are the most general, a-theoretical models to describe the macroeconomy. Once the choice on the set of variables and the number of lags (on the basis of information criteria and likelihood ratio tests) is made, the researcher "lets the data speak" and, given an empirically congruent representation of the DGP, imposes restrictions to identify long-run (in Cointegrated VARs, CVARs) relations among the variables or structural shocks (in Structural VARs - SVARs). The main drawback of VARs, however, is that they are very demanding in terms of data needed. As the number of variables and lags increases, the number of parameters increases quickly, raising the so-called problem of "vanishing degrees of freedom" of VARs, not to mention the fact that, in the case of CVARs, tables for the rank test have been developed only for models with up to 11 variables [21]. On the other hand, structural econometric models are identified by imposing restrictions on the parameters of the models; they are more parsimonious than VARs and therefore more reliable when the number of observations is limited; finally, all restrictions imposed on the system are testable, while the same is not true for SVARs, identified using recursive and/or sign restrictions. For these reasons, we will stick to structural econometric models. Since we do not know what the "true" data generating process (DGP) is, we will start from specifying a statistical model which should be general enough to deliver a congruent representation of the true DGP. In other words, in the first stage we will estimate regression equations similar to (2.1) - (2.4) specified as general

[21] For a discussion, see Johnston, DiNardo (1997), Chp. 9.

polynomial lags models [22]:

$$y_t = d_0 + d_1(L)y_{t-1} - d_2(L)(i_{t-1} - \pi_{t|t-1}) + d_3(L)q_{t-1} + d_4(L)\Delta w_t + \epsilon_t^y \quad (2.24)$$

$$\pi_t = f_0 + f_1(L)\pi_{t-1} + f_2(L)y_{t-1} + f_3(L)\pi_t^f + f_4(L)q_{t-1} + f_5(L)\Delta C_t + \epsilon_t^\pi \quad (2.25)$$

$$q_t = g_0 + g_1(L)q_{t-1} + \epsilon_t^q \quad (2.26)$$

Equations (2.24) − (2.26) represent our empirical model; the identification assumptions embodied in this model are quite standard in the literature and resemble the (simpler) theoretical model in section 5: first, Monetary Policy cannot affect output and prices immediately; the setting of interest rates affects the real exchange rate immediately and output with some lag; this will, in turn, affect inflation. Second, the foreign (i.e. "large") economy variables and commodity inflation are exogenous; thus, shocks originating in the domestic economy (Sweden) have no impact on Europe and on commodity prices. Equation (2.24) is an Aggregate Demand equation normalized on the domestic output gap; output depends on its past values, on the real interest rate, the growth in world demand (proxied by euro area output growth, Δw) and the real exchange rate. The presence of the contemporaneous foreign growth rate allows for synchronized shocks to output. Equation (2.25) is an aggregate supply equation, where inflation is determined by past inflation, imported inflation (i.e. the euro area inflation rate), resource utilization (the past output gap), convergence to the purchasing power parity and commodity price inflation, ΔC_4. Equation (2.26) is just a more general representation of (2.5) and shows how the real exchange rate corrects to the PPP; when $\sum_{l=1}^{L} g_{1l} < 1$the real exchange rate is stationary. We will further test the validity of the real interest parity, that was included in the theoretical model of section 5. The RIP shows how q is immediately affected by monetary policy shocks (i.e. changes in the interest rate). The first step will be to estimate the model equation by equation, in order to impose restrictions on the dynamics of each regression. Equations (2.24) to (2.26) are thus estimated by OLS . Once each equation is estimated and passes all specification tests, we simplify the dynamic structure by dropping the parameters which are not significant at 5%, following a limited information approach and mak-

[22]The empirical model here is similar to Golinelli and Rovelli (2005), although unlike them we do not include a Taylor Rule, since it will be estimated separately in the next section.

ing sure that the parsimonious model residuals are white noise. Finally, we re-estimate the simultaneous equations model, with further restrictions, by Constrained Full Information Maximum Likelihood (CFIML). Inflation is measured as the annual change in the CPI ; the real exchange rate is defined as: $q_t = e_t + p_t^f - p_t$ where p is the (log) swedish price level and p^f is the european CPI; e is the nominal bilateral SEK/Euro exchange rate; commodity prices are measured using the IMF index for all commodities; finally, the output gap is taken from the OECD Economic Outlook[23]. Data are seasonally and working day adjusted. As a starting point, we chose $L = 3$ lags for each equation (2.24) - (2.26). Table 2.3 shows specification tests for the three equations; notice that the restricted regression equations are well specified as the residuals are white noise[24]. Moreover, even when the variables included in the system are nonstationary, regression is valid as long as the regressors are cointegrated (see Hsiao, 1997). Nonstationarity of interest rates and inflation is an issue in the present dataset; the fact that these variables have a unit root might be disturbing from a theoretical point of view but it has been widely discussed in the empirical literature [25].

		ϵ^y	ϵ^π	ϵ^q
Normality		0.783	0.589	0.320
Autocorr.	Ljung−Box(4)	0.504	0.111	0.246
ARCH	LM(4)	0.995	0.501	0.330
		output gap	*inflation*	*Real E.R.*
R^2		0.939	0.848	0.999

Table 2.3: Specification tests.

$q_t = q_{t+1\|t} - i_t + i_t^f - \pi_t^f + \pi_t + \phi_t$	where	$\phi_t = 0.003 + ?0.645^a \phi_{t-1} + \epsilon_t^\phi$
ADF test on ϕ		τ = -2.01 ; p-value 0.04

Table 2.4: Real interest parity.

[23]The OECD measures the output gap using the production function approach. The estimation was robust to the use of a different measure of output gap (obtained using the HP filter), although the coefficient on y was larger.

[24]Further single-equation tests were performed which are not reported here and show that the model is well-specified and no parameter instability seems to be present.

[25]The argument that inflation is I(1) and therefore prices are I(2), which leads to the empirical finding of the failure of the PPP and the UIP to hold, has been thoroughly investigated and discussed, for example, by Juselius (2006) and Johansen et a. (2009).

The AD curve shows that the real interest rate affects output with three lags; output also responds to real exchange rate changes and foreign output growth[26]:

$$\begin{aligned} y_t = & -0.002^b + 0.803^a y_{t-1} - 0.079^b (i_{t-3} - \pi_{t-2|t-3}) + \\ & + 0.043^b (q_{t-2} - q_{t-3}) + 0.215^b \Delta w_t + \epsilon_t^y \end{aligned} \tag{2.27}$$

The negative (and significant) constant is in line with Hjelm and Jönsson (2010) who state that an estimation of the Swedish output gap starting in the beginning of the 1990s necessarily yields an output gap which is negative on average due to the consequences of the financial crisis of the '90s. Moreover, the same authors state that when prices, as well as wages, react more to positive gaps than to negative gaps, as it is the case for Sweden [27], the output gap will be negative on average. The Aggregate Supply curve shows that the inflation rate is positively affected by past inflation, the output gap two periods before, commodity price inflation and the real exchange rate:

$$\pi_t = \pi_{t-1} + 0.112^a y_{t-2} + 0.085^a (q_{t-1} - q_{t-3}) + 0.018^a (\Delta C_t - \Delta C_{t-1}) + \epsilon_t^\pi \tag{2.28}$$

The coefficient on inflation was restricted to 1, and this restriction, together with the restrictions on the coefficients on q and ΔC could not be rejected with a p-value of 0.104. The restriction on past inflation is also present in theoretical macro models that have been cited in the present work such as Svensson (1997). This is equivalent to finding that expectations are backward-looking and therefore, in the Phillips Curve, $\pi^e_{t|t-1} = \pi_{t-1}$[28]; thus we can re-write (2.28) as:

$$\Delta\pi_t = 0.112^a y_{t-2} + 0.085^a (q_{t-1} - q_{t-3}) + 0.018^a (\Delta C_t - \Delta C_{t-1}) + \epsilon_t^\pi \tag{2.29}$$

Finally, the real exchange rate is represented here as an AR(1) process: if the real exchange rate is stationary, as it should occur if purchasing power parity holds, then it should be mean-reverting and its coefficient significantly lower than one. In our case, we have:

$$q_t = 1.00 q_{t-1} + \epsilon_t^q \tag{2.30}$$

[26] a= significant at 1%, b = significant at 5%.
[27] See also Eliasson (2001).
[28] See Bagliano et al. (2001), Taylor (1999) and Rudebusch and Svensson (1999).

The real exchange rate was found to be nonstationary, i.e. purchasing power parity does not hold The restriction that $g_1 = 1$ could not be rejected with a p-value of 0.510. While this might sound puzzling from a theoretical point of view, the fact that the PPP does not hold (if not over very long time horizons) has been documented in many empirical works[29]. In other words, since the coefficient on q_{t-1} is exactly equal to 1, $\gamma = 0$ in (2.5) and the real exchange rate exhibits a unit root. We have also checked for possible level shifts at significant dates which might have determined the nonstationarity of q_t but no significant break was found. Apparently, q_t has been steadily depreciating over the sample period, since Sweden had a lower average inflation rate than the Euro Area, with the nominal exchange rate not correcting for the imbalance. The overidentified structure of the system could not be rejected, with a p-value of 0.065[30]. Table 6.2 shows the real interest parity equation, which was estimated by 2SLS, and the risk premium. As it is clear from the table, the risk premium is stationary, with a positive but insignificant contant term. Summing up, monetary policy affects inflation indirectly, through different channels: the real exchange rate channel, with a lag of 1 quarter, and the interest rate channel via the output gap, after 5 quarters, i.e. 1 year and three months.

2.6 The identification of Central Bank Preferences

We can identify Central Bank preferences by assigning the Central Bank a loss function to be minimized, as we did in the theoretical model of Section 4, subject to the constraint given by the structure of the economy that was estimated in Section 5. Once the relevant first order conditions have been derived, we will estimate them and compare the results we obtain under alternative policy regimes like those we outlined in Section 4 with the actual policy adopted by the Riksbank. The general problem is the following. The

[29] See for example Juselius and McDonald (2004 and 2007) and Juselius (2006) who have thoroughly investigated the so-called PPP puzzle using a Cointegrated VAR approach. The failure of PPP to hold has instead been challenged by Rey et al. (2005) who estimate the half life of PPP to be between 7 and 11 months, using an intersectoral price dataset issued by Eurostat.

[30] The complete statistics as well as vector specification tests are available on request.

Central bank chooses it to minimize the loss function:

$$E_t \sum_{k=0}^{\tau} \delta^k [\lambda_\pi (\pi_{t+k} - \pi^*)^2 + \lambda_y y_{t+k}^2 + \lambda_i (i_{t+k} - i_{t+k-1})^2 + \\ + \lambda_r (i_{t+k} - \pi_{t+k} - \overline{r})^2 + \lambda_e (e_t - e_{t-1})^2] \tag{2.31}$$

Where λ_x, $x = [\pi, y, i, r, e]$ are the weights attached to the various goals of monetary policy in the present setup; the terms $(i_t - i_{t-1})$ and $(i_t - \pi_t - \overline{r})$ as in Section 4 allow for the case of interest rate stabilization and smoothing [31]. The loss function is minimized with respect to it subject to the structure of the economy:

$$\pi_t = \pi_{t-1} + \alpha_1 y_{t-2} + \alpha_2 q_{t-1} - \alpha_3 q_{t-3} + \alpha_4 \Delta C_t - \alpha_5 \Delta C_{t-1} + \epsilon_t^\pi \tag{2.32}$$

$$y_t = \beta_0 + \beta_1 y_{t-2} - \beta_2 (i_{t-3} - \pi_{t-3}) + \beta_3 (q_{t-2} - q_{t-3}) + \beta_4 \Delta w_t + \epsilon_t^y \tag{2.33}$$

$$q_t = q_{t+1|t} - i_t + i_t^f - \pi_t^f + \pi_t + \phi_t \tag{2.34}$$

$$q_{t+1|t} = (1 - \gamma) q_t + \epsilon_{t+1}^q \tag{2.35}$$

The structure defined in equations (2.32) - (2.35) is derived from the empirical model estimated in Section 5; the estimated α_i and β_i coefficients are reported in table 2.5. Notice that, given the model in Section 5, real interest parity holds, up to a stationary risk premium; q_t is a random walk, since $\gamma = 0$. The five alternative monetary policy strategies are defined by different weights λ_x as described in table 2.6: these are precisely the coefficients we want to estimate within out framework. To this end, we also set a numerical value for the discount factor. In particular, we set $\delta = 0.984$ which corresponds to a discount rate of around 1.6%; this figure is equal to the average real interest rate in Sweden over the period we are considering. The cited works of Favero and Rovelli (2003) and Collins and Siklos (2004) adopted different approaches to defining δ. The former sets $\delta = 0.975$, while the latter chooses, for each country, a level of δ consistent with the average interest rate over the sample period. We therefore follow Collins and Siklos; however, our results are robust to a (marginally) different choice of δ. As in Section 4, rather than assuming a "timeless perspective" for the central bank, we consider a finite-time horizon, so that we are able to derive

[31] See also Svensson (1997).

analytically the first order conditions for all regimes. As far as the length of the horizon k is concerned, that depends on the monetary policy regime. In the case of exchange rate targeting, we know from Section 5 that it is optimal for the Central Bank to passively follow foreign monetary policy, so the horizon is one period. Within strict inflation targeting, the Central Bank only has the concern of stabilizing inflation at its target; since, in the present case, we have seen that the interest rate channel kicks in after 5 quarters, then $k = 5$. The remaining three regimes are extensions of strict inflation targeting where the Central Bank wants to minimize fluctuations in output, the interest rate and/or the exchange rate. Here we set $k = 8$ to be consistent with the monetary policy statement of the Riksbank :

> [...] Monetary Policy is normally focused on achieving the inflation target within two years. One reason for that is that the effects of monetary policy appear with a lag. Another reason is that the Riksbank, by aiming at this horizon, can contribute to dampening fluctuations in the real economy [...].

It has been discussed (see Svensson, 1999) that by smoothing the interest rate, the Central Bank might also stabilize output, as a side product. In other words, when forecasted inflation is above target, rather than immediately setting i to the level that brings inflation back to target as soon as possible given policy lags, the Central Bank gradually changes the interest rate, and in this way it minimizes output fluctuations. For this reason, the time horizon in regimes 3 to 5 is equal to 8 quarters, consistent with the Riksbank's official statements. With a horizon of 8 periods and the dynamics given in (2.32) − (2.35), the first order conditions for regimes 2 to 5 of Table 2.6 would be particularly complicated, with many collinear terms; this collinearity is an increasing function of the length of the horizon [32].

To obtain a manageable solution we consider for those regimes a period-by-period optimization, as discussed in Section 5. This, however, is not an overly strong simplifying assumption as it appears consistent with official Central Bank statements. Moreover, this approach has the advantage, on the empirical side, that it allows us to estimate policy rules relying only on official forecasts of inflation [33] . The availability of official forecasts is

[32] See Favero and Rovelli (2003).

[33] Over the whole sample, only forecasts at t, $t+4$ and $t+8$ are available. If we adopted a finite-time horizon, also $\pi_{t+1|t}, \cdots, \pi_{t+7|t}$ and $y_{t+1|t}, \ldots, y_{t+7|t}$ would appear in the FOC and they would need to be instrumented.

a serious advantage of the present analysis. Real-time forecasts are very attractive because they can be considered predetermined variables in period t, and consistent parameter estimates can be computed running least squares regression. In fact, since the actual forecast rather than a proxy is available, the former can be used as a regressor, and one does not need to revert to instrumental variable estimation. Empirical Taylor rules generally put a very high coefficient on monetary policy inertia and this appears to be due to a weak instrument problem (see Consolo and Favero, 2009). By using real-time forecasts we can circumvent this limitation of monetary policy rules estimation, and this is another strength of the present empirical analysis.

α_0	1.000	α_4	0.018	β_2	0.079
α_1	0.112	α_5	0.018	β_3	0.043
α_2	0.085	β_0	-0.002	β_4	0.215
α_3	0.085	β_1	0.803	γ	0

Table 2.5: Estimated structural coefficients

Regimes	weights λ_π	λ_y	λ_i	λ_r	λ_e
1. Exchange Rate Targ.	0	0	0	0	1
2. Strict Inflation Targ.	1	0	0	0	0
3. Interest Rate Smoothing	1	0	> 0	> 0	0
4. Flexible Inflation Targ.	1	> 0	≥ 0	≥ 0	0
5. Fear of Floating	1	$\geq$	≥ 0	≥ 0	> 0

Table 2.6: Preference parameters and monetary policy regimes.

2.6.1 Exchange Rate Targeting

In the case of Exchange Rate Targeting, the policy rule to be estimated is:

$$i_t = \kappa_1 i_t^f + \psi_t \tag{2.36}$$

where we should have $\kappa_1 = 1$ and ψ_t should be stationary. The results are presented in Table 2.7. The restriction to 1 is rejected at all significance levels, and residuals are nonstationary; thus, while the two interest rates have been moving closely, a "strict exchange rate targeting" policy cannot well mirror swedish monetary policy in the last 14 years. This is not a surprise: while there is a doubt that the Riksbank might have put some weight on exchange rate stabilization, it is clear from both official statements and its actions that in several occasions it actually pursued an interest rate policy that did not always follow that of the ECB.

	Coefficient	Std. Error	t-Stat.	P-Value
κ_1	1.262	0.071	17.70	0.000
Restriction: $\kappa_1 = 1$ $F(1,55) = 13.506$ $p - value : 0.001$				
$R^2 = 0.851$ S.E. Of Regression:0.0166 Mean of Dep. Var.: 0.0391				
ψ	ADF (with const): τ = -1.526 p-val:0.119 $\psi_t = -0.001 + 0.941\psi^a_{t-1}$			
Estimation method: OLS. Standard Errors are HAC. a = significant at 1%.				

Table 2.7: Exchange rate targeting estimation results.

2.6.2 Strict Inflation Targeting

As anticipated above, in order to have a manageable solution we will assume a period-by-period optimization as discussed in Section 4. We know from Section 5 that, in Sweden, it takes 5 quarters for monetary policy to affect the inflation rate via the interest rate channel. Minimizing equation (2.31) setting $k = 5$ and λ_i, λ_y, λ_e and λ_r equal to zero we obtain the empirical counterpart of (2.11):

$$i_t = \frac{\beta_0}{\beta_2} + \overline{r} + \pi_t + \frac{1}{\alpha_1\beta_2}(\pi_{t+4|t} - \pi^*) + \frac{\beta_1}{\beta_2}y_{t+2|t} + \frac{\beta_4}{\beta_2}\Delta w_{t+5|t} \tag{2.37}$$

The corresponding unrestricted equation is:

$$i_t = k_0 + \overline{r} + k_1\pi_t + k_2(\pi_{t+4|t} - \pi^*) + k_3 y_{t+2|t} + k_4\Delta w_{t+5|t} \tag{2.38}$$

Notice from (2.37) that, due to the structure of the economy, the real exchange rate and the commodity price index are cancelled from the interest rate rule, since $\alpha_2 = \alpha_3$ and $\alpha_4 = \alpha_5$. In the present case, with strict inflation targeting, when the central bank is responding to forecasted inflation and output gap, the coefficients on q and commodity price inflation should thus be zero, as q and ΔC only have a role as predictors of future inflation. If the Riksbank has indeed been following strict inflation targeting, the actual and optimal interest rate reaction functions should not be too different from each other; by imposing the appropriate restrictions we should therefore reconcile (2.37) with (2.38). That is, the following restrictions should not be rejected:$k_1 = 1$;$k_2 = \frac{1}{\alpha_1\beta_2}$;$k_3 = \frac{\beta_1}{\beta_2}$;$k_4 = \frac{\beta_4}{\beta_2}$.

Table 2.8, column 3 reports the results of the strict IT case. A Wald Test on the above restrictions rejected them at all significance levels. The estimated interest rate rule would imply a higher interest rate variability than what is observed in practice, but still it can capture the behaviour of the Swedish policy interest rates moderately well; a strict inflation targeting rule with optimal coefficients as derived from our structural model estimated in the previous section, instead, does not predict correctly the magnitude of the coefficients. Indeed, the optimal coefficients if the Riksbank had actually been pursuing strict IT would have been much larger, and the interest rate variability extremely high. This result is in line with those in Favero and Rovelli (2003) and Collins and Siklos (2004) and the prediction of the theoretical model by Svensson (2000).

2.6.3 Interest rate stabilization and smoothing

In the case of interest rate stabilization and smoothing, we set λ_y and λ_e equal to zero in (2.31) and $k = 8$; minimizing the loss function with respect to it we obtain the following first order condition:

$$\delta^8(\pi_{t+8|t} - \pi^*)\left((-2\alpha_2 - \alpha_1\beta_2)(1 + \beta_1 + \beta_1^2 + \beta_1^3)\right) + \lambda_i(i_t - i_{t-1}) + \lambda_r(i_t - \pi_t - \overline{r}) = 0$$

For the purpose of estimation, we can rewrite it as:

$$i_t = \frac{\lambda_r}{\lambda_i + \lambda_r}\overline{r} + \frac{\lambda_r}{\lambda_i + \lambda_r}\pi_t + \frac{\lambda_i}{\lambda_i + \lambda_r}i_{t-1} + \delta^8\frac{k_5}{\lambda_i + \lambda_r}(\pi_{t+8|t} - \pi^*) \quad (2.39)$$

where $k_1 = 2\alpha_2 + \alpha_1(\beta_2 + \beta_3\beta_1)(1 + \beta_1 + \beta_1^2 + \beta_1^3)$. Two things are worth noticing: first, output does not appear in the first order condition, i.e. the central bank responds to output only as an indicator of forecasted inflation. In other words, they are included in the forecast $\pi_{t+8|t}$ produced by the Central Bank. The problem with (2.39) is that the coefficients are not uniquely identified. In order to achieve identification, we have to impose further restrictions, either on the target real interest rate, that we have assumed to be constant [34], or on k_1. We choose the latter option, imposing

[34] Collins and Siklos (2004), within a different macroeconomic framework - do not assume a constant target real interest rate and take it to be given by the trend from an HP filter

the restriction $k_1 = 2\alpha_2+\alpha_1(\beta_2+\beta_3\beta_1)(1+\beta_1+\beta_1^2+\beta_1^3)$, where α_1, α_2, β_1 and β_2 are those given in Table 2.6, while leaving the constant r unrestricted and then check if the estimated equation is meaningful and able to replicate the observed path of policy interest rates. We estimated equation (2.39) by NLS and the estimated coefficients are reported in Table 2.8. The results suggest that the Riksbank might have been pursuing interest rate stabilization and smoothing. Given that the weight on expected inflation is normalized to 1, we estimate that the relative weight on interest rate smoothing was over 41% and the weight on interest rate stabilization close to 8%. The target real rate over the sample period was 1.46. With respect to the previous case, the fit of the regression has largely improved, with the adjusted R^2 going from 0.35 to 0.97.

2.6.4 Flexible Inflation Targeting

In the empirical counterpart of Section 2.4.3 we minimize (2.31) with respect to i_t setting $\lambda_e = 0$ and k = 8. The interest rate rule resulting when we rearrange the FOC is:

$$i_t = \frac{\lambda_r}{\lambda_i+\lambda_r}\overline{r}+\frac{\lambda_r}{\lambda_i+\lambda_r}\pi_t+\frac{\lambda_i}{\lambda_i+\lambda_r}i_{t-1}+\delta^8\frac{k_5}{\lambda_i+\lambda_r}(\pi_{t+8|t}-\pi^*)+\frac{\delta^8\lambda_y k_6}{\lambda_i+\lambda_r}y_{t+8|t} \tag{2.40}$$

Where $k_5 = 2\alpha_2 + \alpha_1\beta_2(1+\beta_1+\beta_1^2+\beta_1^3)$;$k_6 = \beta_1^5(\beta_1\beta_3+\beta_2)$. Again, the real exchange rate as well as foreign output and commodity inflation do not play a direct role in the Euler Equation but, being themselves predictors of inflation and, in particular, the output gap (which is endogenous in (2.40)), they should be included as instruments. As in the previous case, in order to achieve identification, we restrict k_1 and k_2 using the parameters estimated in the structural model, and limit ourselves to the estimation of the λ's and the target real rate. Column 5 in Table 2.8 shows the results for flexible inflation targeting. According to our estimates, the Riksbank has not been following flexible IT. The coefficient on the expected output gap is positive but not significant and this result was robust to a different choice of the time horizon for output (in particular, setting the target for the output gap

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of the observed real rate. In this case, we would have to impose the restriction that the coefficients on the (time−varying) r and on current inflation are equal. We have already discussed in Section 6 the pitfalls related to the use of HP filters; moreover, it is not unreasonable to imagine that, when there are no regime shifts or major policy or structural changes, the target real interest rate is constant.

to be one year). The estimated target real interest rate is up to 2This result suggests that the objective of "dampening fluctuations in the real economy" as stated in the Riksbank's monetary policy statement has probably been fulfilled by smoothing the interest rate and, at the same time, choosing a horizon for the inflation target which is longer than necessary, rather than by directly responding to the output gap. Moreover, this result is consistent to what was obtained by Favero and Rovelli (2003) on the U.S. and Collins and Siklos (2004) on Australia, Canada and New Zealand. Finally, interestingly this confirms the results in Cecchetti et al. (2002). In fact, in their model the loss function of the Central Bank features only inflation and output and, in the case of Sweden (although within a different time period) and the dynamic estimate suggests a 97% weight on inflation and 3% on output.

2.6.5 Fear of Floating

The case of Fear of Floating is analyzed minimizing (2.31) with respect to i_t while leaving all λ_x unrestricted and setting $k = 8$. Rearranging, and using (2.35) to get rid of the endogenous contemporaneous nominal exchange rate, the equation to be estimated by GMM is:

$$\begin{aligned} i_t = & \frac{\lambda_r}{\lambda_i + \lambda_r}\overline{r} + \frac{\lambda_r}{\lambda_i + \lambda_r}\pi_t + \frac{\lambda_i}{\lambda_i + \lambda_r}i_{t-1} + \delta^8 \frac{k_5}{\lambda_i + \lambda_r}(\pi_{t+8|t} - \pi^*) + \\ & + \frac{\delta^8 \lambda_y k_6}{\lambda_i + \lambda_r} y_{t+8|t} + \frac{\lambda_e}{\lambda_i + \lambda_r}\Delta e_{t-1} \end{aligned} \tag{2.41}$$

where k_5 and k_6 are the same as in (2.40). Column 7 in Table 2.8 shows the results of the GMM estimation of (2.41) when we assume that the objective function of the Central Bank is (2.31); since, in the previous section, we estimated λ_y to be insignificant, we also estimated (2.41) with $\lambda_y = 0$ and Column 8 shows the results for this alternative rule. The GMM estimation suggests that the Riksbank might indeed have put some weight on exchange rate stabilization; the relative weight in the objective function is quite small (2.6%) but significant at all levels. However, this result is not robust to the specification of the interest rate rule with $\lambda_y = 0$, since λ_e becomes insignificant. We can therefore conclude that "Fear of Floating" (at least *via* the policy interest rate) cannot describe the preferences of the Riksbank between 1995 and 2008 well, and thus the sources of the SEK/euro exchange rate stabilization have to be found somewhere else.

	Optimal Coeff.	2.6.2	2.6.3	2.6.4	2.6.5 (1)	2.6.5 (2)
k_0	n.a.	-0.2860				
		(0.002)				
k_1	1.000	1.5720^a				
		(0.1109)				
k_2	91.11	1.0172^a				
		(0.1067)				
k_3	8.041	0.1147^b				
		(0.0558)				
k_4	2.255	0.6255^a				
		(0.0520)				
k_5			0.208	0.208	0.208	0.208
			(−)	(−)	(−)	(−)
k_6				0.038	0.038	
				(−)	(−)	
$\overline{r}$			1.462^a	1.996^a	2.865^a	1.464^a
			(0.309)	(0.106)	(0.186)	(0.315)
λ_i			0.415^a	0.268^a	0.493^a	0.415^a
			(0.090)	(0.028)	(0.051)	(0.091)
λ_r			0.078^a	0.077^a	0.070^a	0.078^a
			(0.019)	(0.005)	(0.006)	(0.019)
λ_y				0.220	0.124	0
				(0.150)	(0.220)	(-)
λ_e					0.026^a	0.000
					(0.005)	(0.010)
δ			0.984	0.984	0.984	0.984
			(−)	(−)	(−)	(−)
R^2		0.385	0.967	0.958	0.953	0.953
Reg. SE		1.3847	0.325	0.361	0.382	0.382
D.W.Stat.			1.065			1.063
J-stat.		0.1642		0.201	0.238	
		GMM	NLS	GMM	GMM	NLS

HAC S.E. in Parenthesis. Instruments in GMM: first four lags of π, y,i, Δw, ΔC, Δe

Table 2.8: Estimation of Central Bank Preferences: Results.

2.7 Conclusion

In this chapter, I have proposed an approach to estimate Central Bank preferences within a small open economy starting from the monetary authority's optimization problem. When the official regime is Inflation Targeting, the issue of the role played by the exchange rate in the policy rule becomes relevant, and yet it has not received a definite answer so far. On one hand, the literature on inflation targeting suggests that the exchange rate can only play an indirect role in the interest rate rule as a predictor of inflation, because responding directly to exchange rate fluctuations would result in excessive interest rate fluctuations. On the other hand, the literature on exchange rate regimes classification has shown that as far as the exchange rate policy is concerned, (small open economies) Central Banks' de facto policies often deviate from the de jure regime, and this ends up in a situation, for many countries with flexible exchange rates, of implicit exchange rate smoothing, that has been termed by Calvo and Reinhart (2002) "Fear of Floating". A CPI Inflation targeting regime can, as a side product, contribute to the stabilization of the exchange rate and therefore it can be hard to distinguish it from a Fear of Floating regime just using the techniques suggested by the literature on exchange rate classification.
By estimating Central Bank preferences using the approach suggested by Favero and Rovelli (2003) and Collins and Siklos (2004), we were able to bridge the gap between exchange rate regime classification schemes and the literature on the estimation of monetary policy rules including explicitly exchange rate smoothing in the Central Bank's objective function. At the same time, we could overcome a well-known critique on Taylor rule coefficients: since they are a convolution of structural and preference parameters, they cannot be given a structural interpretation.
Sweden was the object of the empirical analysis for two main reasons: it has a history of 15 years of Inflation Targeting and the exchange rate of its currency with the euro has shown a substantial stability in the recent years, raising the doubt that some sort of exchange rate smoothing could have been in place. The results suggest that the Riksbank has been following a policy of Inflation Targeting with interest rate stabilization and smoothing, but not Fear of Floating.
The stabilization of the Krona/euro exchange rate, therefore, does not seem

to have come through interest rate setting. This result does not conflict with Edwards (2006) who states that direct stabilization of the exchange rate via the policy interest rate, in a regime of inflation targeting, would result in excessive interest rate volatility, which is not observed in practice. Therefore, the decrease in the SEK/euro exchange rate volatility might have come only through the reserves channel, as suggested in Chapter 1, or be the result of the convergence of the business cycles in the two regions, which made sure that the ECB and the Riksbank have been synchronizing their interest rate decisions, and this can be the object of further research on exchange rate stabilization.

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Chapter 3

Wage spillovers across sectors in Eastern Europe

3.1 Introduction

The aim of this chapter is to study the interactions and spillovers in wage determination across different macro sectors. In particular, we analyze this interplay in three broad sectors: the open (internationally traded) sector, the closed or sheltered sector, which can also be called the market non-traded sector, and the public sector, also called the non-market, non-traded sector. The focus of this work is on Central and Eastern European Countries (CEEC) that have joined the European Union during the last decade.

This issue is relevant for several reasons. First, public sector employment is large and relevant: in the OECD, around 25% of the work force is employed in the public sector. Second, wage spillovers across sectors may lead to wage costs growing faster than productivity and this may affect the international cost competitiveness of the country's tradable goods sector. In particular, theoretical models generally assume that the traded sector is leader in wage determination and there is free mobility of labor across sectors which, in turn, ensures wage equalization. This is assumed, for example, by the Froot and Rogoff (1995) model of the Balassa-Samuelson (henceforth B-S) effect, and the so-called Scandinavian Model of wage determination (Aukrust (1970), see Section 3). If these assumptions hold, during the process of catching-up excess inflation will be witnessed and the real exchange rate will appreciate, but, on the other hand, only wages in the non-traded sector should grow faster than productivity, and therefore competitiveness should not be harmed. However, it can also happen that wage bargaining in the non-traded sector, which is not subject to international competition, and/or in the public sector, which is influenced by political rather than productivity considerations, may lead to higher outcomes and, in turn, push traded sector wages up. A large strand of empirical literature that has tried to measure the B-S effect has found that it can only account for a small part of the excess inflation observed in Central and Eastern European Countries [1], while other factors like the switch to consumption of higher quality goods might be at play [2]. This paper, by rigorously testing whether the hypothesis of wage leadership of the traded sector is valid, studies an additional potential source of fallacy of the B-S hypothesis [3]. Further, testing wage leadership in the case of Central and Eastern European transition Countries is important because they are in the process of catching up: entry in the EU, which also fostered international labor mobility, may have influenced wage determination in these countries, so that prices and wages converge to the western European level faster than productivity, thus leaving room for competitiveness loss. As long as the leader in wage setting is the traded sector, the problem is not relevant. But if this is not the case, increased labor mobility together with union pressures might lead to a decoupling of real and nominal convergence, i.e. price convergence occurring faster than productivity convergence. From a policy perspective, this would be worrying since we would expect catching-up to occur at the cost of large international imbalances. The contribution of this paper is twofold: first, while there is limited existing literature on public/private wage spillovers, no empirical work to date, to our knowledge, studies the issue from the three-sector perspective that is adopted here. Second, this is the first work on the topic which focuses on transition countries.

The paper is organized as follows. Section 2 reviews the literature on wage spillovers across the public and private sector. Section 3 presents three alternative models of wage determination and causality. Section 4 outlines

[1]See, for example, Mihaljek and Klau (2003), Egert (2003,2007).

[2]See Egert (2010).

[3]Empirical models testing the size of the B-S effect in CEECs often estimate a regression equation having CPI inflation differential as dependent variable and dual productivity growth differential (productivity growth in tradeables vs. non-tradeables) as explanatory variable. This is the result of assuming that wages in T grow in step with productivity.

the empirical model, a Cointegrated VAR; section 5 describes the data set and presents the results of the empirical analysis. Section 6 concludes.

3.2 Related literature on wage spillovers

While this is not a paper on wage setting models, the literature on wage setting is indeed relevant for the topic. In particular, since we are dealing with the issue of externalities in wage determination, we are interested in models studying the impact of centralization of wage setting and its impact on the overall macroeconomic performance. In principle, we can imagine different degrees of centralization in wage setting, ranging from firm-level bargaining (no centralization) to national bargaining. The outcome of the bargaining process will therefore depend, among other things, on how much wage setting is centralized. According to the Calmfors - Driffill hypothesis (Calmfors and Driffil, 1988) both firm-level bargaining and national bargaining are likely to produce wage moderation, while industry-level bargaining tends to produce higher real wages. In other words, the relationship between the real wage and the extent of centralization is a hump-shaped curve (see Figure 3.1). The reason for this is that in the case of no centralization, with perfect competition, firms will not increase wages above productivity because they are price takers, and thus cannot increase prices when the real consumption wage is raised by the firm and not elsewhere in the sector. However, such wage moderation is restrained if firms have market power. On the other hand, with national bargaining, firms and unions internalize the negative externalities produced by aggregate real wage increases [4] and thus the outcome will be a lower wage level. Other things equal, however, when the economy is open the employment and profit losses due to real wage increases are dampened in centralized systems (which therefore tend to have higher wages), but this will in any case depend on the degree of competition between domestic and foreign producers (Calmfors, 1993).

[4] There are several kinds of externalities in this sense: Consumer price externalities, since prices will increase (Layard et al. [1991]); Input price externalities, since the price of inputs will go up; fiscal externalities due to higher unemployment benefits that have to be paid since higher wages reduce employment (Blanchard and Summers (1987), Calmfors and Driffill (1988); envy externalities, if the welfare of an agent depends on the wage of other agents, and thus we have forms of social comparisons (Oswald (1979) and others). For a broader discussion, see Calmfors (1993).

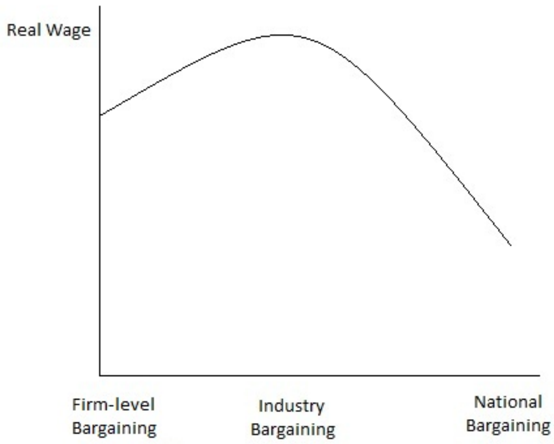

Figure 3.1: The relationship between centralization and the aggregate real wage.

The literature on inter-sectoral wage spillovers, in particular private and public wages, is quite scarce. Theoretical models generally assume that public wages are exogenous or follow the same pattern as private wages (Quadrini and Trigari (2007), Ardagna (2007)). Demekas and Kontolemis (2000), instead, in a static model show that public wages can affect private sector wages through the labor supply channel: when public wages increase, workers move to that sector, and private firms are forced to increase wages too. As far as the direction of causality is concerned, the main theoretical reference is the so-called Scandinavian model of wage determination (Aukrust, 1970). This model assumes that the sector that is open to international competition is the leader in wage setting, since productivity should increase faster in the traded goods sector and firms there cannot increase wages above productivity, because they would otherwise become less competitive [5]. In this sense, also public sector wages should be led by private sector wages. Evidence in favor the Scandinavian Model was found by Aukrust for Norway, the U.S. and France, while Bemmels and Zaidi (1990) successfully applied it to Canada. However, this model has been found to be at odds with more recent data. Ultimately, the results seem to be country-dependent. Demekas and Kontolemis (2000) find weak exogeneity of government wages over private wages. Jacobsson and Ohlsson (1994), in

[5] An outline of this model is presented in the next section.

a Vector Error Correction Model for Sweden, find long-run wage leadership of the private sector, thus confirming the predictions of the Scandinavian model, but Friberg (2007), using a broader sectoral decomposition [6] does not find evidence of the Scandinavian model for Sweden. Christou et al. (2007) show a bidirectional causality relationship between private and public sector wages in Romania using monthly wages over the period 1993-2006. Lamo et al. (2008) used several empirical methods to study the co-movement and causality relationship between private and public wages using annual data for 18 OECD countries (plus the Euro Area as a whole), finding that private and public wages generally do not decouple and the former seem to exert a stronger influence on the latter than the reverse; moreover, they find that prices seem to play an important role in the transmission of wage leadership. None of the cited works is applied to transition countries (with the exception of Christou et al.), and, more importantly, none decomposes the private sector into a traded and non-traded sector, which is relevant when we want to understand the role of wage spillovers in affecting competitiveness. In fact, as we will see in the next section, not only a leading role of public sector wages but also of non-traded goods sector wages can lead to traded sector wages growing faster than productivity and thus harm the country's international competitiveness.

3.3 Three competing theories of wage determination

When dealing with inter-sectoral wage spillovers, theoretical models generally assume that the leader in wage determination is the sector that is exposed to international competition, i.e. the traded sector. However, as it was outlined in the previous section, the results obtained by the empirical literature are often at odds with this hypothesis. Alternative models of inter-sectoral wage linkages can therefore be imagined.
In this section we will outline three alternative theories of wage determination and inter-sectoral wage spillovers. This will allow us to come up with testable hypotheses that will be taken to the data. The first model is the

[6] In particular, he distinguishes between private sector, manufacturing sector, construction, wholesale and retail trade, financial sector, central government and county/municipal government.

main theoretical reference as far as inter-sectoral wage linkages and expected causality is concerned, and it is the so-called "Scandinavian Model" of inflation, which was first developed by Aukrust (1970) [7]. The Scandinavian Model rests on three fundamental assumptions: (1) the different sectors in the economy can be classified as either traded (exposed) sectors or non-traded (sheltered) sectors; (2) wage increases in the traded sectors can be expected to be transmitted to wage increases in the non-traded sectors of the economy, and therefore wage decisions are not taken simultaneously; (3) the exchange rate is fixed. In the original model we have two sectors (traded, T, and nontraded, N) and two countries (home, H, and foreign, F). We add the public sector as a non-traded, non-market sector and label it P. The timing structure of the model is pictured in figure 3.2, panel (a).

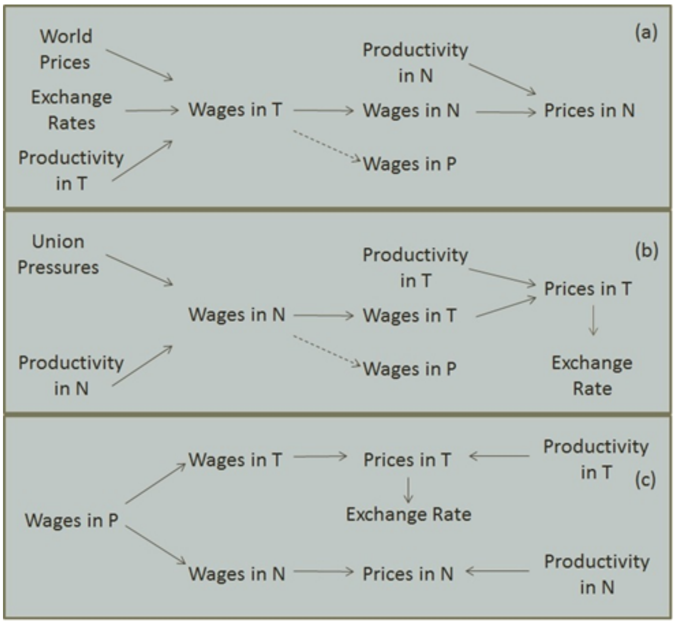

Figure 3.2: Three models of wage spillovers.

In this highly stylized model, nominal wages in the traded sector are determined by the productivity in that sector and the prices obtainable

[7] Aukrust (1970) first developed this model to describe price dynamics in Norway, and tested it on that country. However, Aukrust's model was applied to other countries' data to test for inter-sectoral wage linkages: France, USA and Australia (Aukrust, 1977), Canada (Bemmels and Zaidi, 1990), Sweden (Friberg et al. (2004), Friberg (2007), Jacobson and Ohlsson (1994)).

internationally for the output of those firms [8]:

$$w_{T,t} = p_{T,t} + c_{T,t} + \eta_{T,t} \tag{3.1}$$

where $c_{T,t}$ is productivity, p_T are prices and η_T represents stationary deviations from this long-run equilibrium relation. Labor is mobile across sectors; for this reason wage equalization occurs:

$$w_{N,t} = \mu_{N.1} + \theta_{N.1} \cdot w_{T,t} + \eta_{N,t} \tag{3.2}$$

$$w_{P,t} = \mu_{P.1} + \theta_{P.1} \cdot w_{T,t} + \eta_{P,t} \tag{3.3}$$

where $\theta_{i.1} \geq 0$, $i = N, P$ are parameters describing the degree of wage adaptability across sectors. The Scandinavian model concludes that not only should wages in different sectors co-move, but the transmission of wage shocks should be one to one, a testable hypothesis that we will term "full wage adaptability". In other words, according to the Scandinavian Model the deviations from equilibrium, η_j, $j = N, P, T$ should be stationary, $\mu_{N.1} = \mu_{P.1} = 0$ and $\theta_{N.1} = \theta_{P.1} = 1$. Finally, firms in the non-traded sector set the prices for their goods and services accordingly, in order to avoid losses [9], so that

$$p_{N,t} = w_{N,t} - c_{N,t} + \eta_{P_N,t} \tag{3.4}$$

As a result, non-traded goods prices will increase more than traded goods prices, a result which is in line with the so-called "internal version" of the Balassa-Samuelson hypothesis. A peculiar argument may be relevant for transition countries that have entered the European Union. The catching up process of transition countries, in terms of productivity and price level, has been documented in many studies on the Balassa-Samuelson effect [10]. However, when a country joins the European Union, the liberalization of labor mobility across countries could itself foster wage convergence with the

[8] The model outlined here heavily draws on Aukrust (1977).

[9] One additional assumption that we have left implicit is that productivity growth is higher in the traded sector than in the non-traded sector. This assumption, which is empirically sound, is also at the basis of the so-called Baumol-Bowen effect that the price wedge between non-tradables and tradables should be co-moving with productivity. If this assumption did not hold, then we could either have p_N growing more than p_T (if firms in N set prices under mark-up pricing) or less than p_T (if there is pricing-to-market in N).

[10] A small subset includes Mihaljek and Klau (2001), Egert (2002a, 2002b, 2002c, 2007), Fischer (2004), Dobrinsky (2006) and Staher (2010).

Union. This, in turn, can be due to convergence in productivity, but also to migration of labor to countries with higher wage levels or increased union pressures for wage raises. In the latter two cases, wage increases can harm the competitiveness of the country if they are above productivity growth. In the B-S hypothesis, instead, labor is assumed to be internationally immobile.

As long as the traded sector is the leader in wage determination, pressures due to international competition will avoid wage increases in excess of productivity. However, alternative models of inter-sectoral wage spillovers might be in place, and the empirical analysis in the next section will prove that this is indeed the case. As it was pointed out by Friberg (2007), non-traded sector firms operate in a less competitive environment, since they are not subject to international competition: therefore, wage bargaining in non-traded sectors may lead to higher outcomes, ceteris paribus. This is not the only issue, since in the present paper we further distinguish, within non-traded sector wages, market non-traded and from non-market non-traded (public) sector wages. Theoretical models of public sector wage setting generally assume that wages for public employees are set exogenously or, as in Demekas and Kontolemis (2000), that the government maximizes an objective function in public goods provision and public wages (a form of political patronage). In this sense, also wage bargaining in the public sector may lead to higher outcomes, depending on the political pressure that public employees are able to exert on the government. If the mobility of labor across sectors is high and therefore wages tend to equalize, a leading role in wage setting of either the public sector or the non-traded sector can harm international competitiveness. We can sketch models of wage determination which are parallel to the Scandinavian model for these two cases.

A model with the non-traded sector leading is pictured in figure 3.2, panel (b). For practical reasons, we will call it the "wage mark-up model". Nominal wages in the non-traded sector are set according to productivity in that sector, the prices that firms can obtain on the internal market, and the mark-up on productivity that unions are able to extract from employers, m:

$$w_{N,t} = p_{N,t} + c_{N,t} + m_{N,t} + \eta_{N,t} \tag{3.5}$$

Pressures for wage equalization across sectors due to free intersectoral labor mobility, as in the previous case, will make sure that wages in T and

P adjust to wN:

$$w_{T,t} = \mu_{T.2} + \theta_{T.2} \cdot w_{N,t} + \eta_{T,t} \quad (3.6)$$

$$w_{P,t} = \mu_{P.2} + \theta_{P.2} \cdot w_{N,t} + \eta_{P,t} \quad (3.7)$$

where again $\mu_{T.2} = \mu_{P.2} = 0$ and $\theta_{T.2} = \theta_{P.2} = 1$ if full wage adaptability holds and $\eta_j,\ j = N, P, T$ are stationary i.i.d. disturbances. The firms in the traded sector, then, will set the prices of their goods according to the level of wages and the productivity in the sector:

$$p_{T,t} = w_{T,t} - c_{T,t} + \eta_{p_T,t}$$ [11]

and this in turn causes real appreciation. Thus, unless a nominal exchange rate depreciation occurs, it will lead to the country's firms becoming less competitive on the international markets [12]. In this case, the presence of low wage adaptability ($\theta_{T.2} < 1$) might offset (at least partially) the negative effect of public sector wages on competitiveness. Finally, Figure 3.2, panel (c) pictures the case of the public sector leading the other two. We will call this the "envy-effect model" (Friberg (2007), Strom (1995)).In this case, we assume (following Ardagna (2007) and Quadrini and Trigari (2007)) that the public sector wages are predetermined:

$$w_{P,t} = \overline{w} \quad (3.8)$$

where $\overline{w} > c_{i,t},\ i = N, T$, i.e. public wages lead wage determination and they also grow faster than productivity in the other sectors. In fact, while in the private sector the argument of competition between different production units (either different firms in the same sector, or domestic vs. foreign firms) producing wage restraint holds, this is not true for the public sector. Fiscal discipline itself may not be sufficient to produce wage restraint in the public sector, in particular under centralized wage bargaining, because in that case the (central) government would be bargaining with a large share of the

[11] The implicit assumption here is that $c_{N,t} + m_{N,t} > c_{T,t}$.

[12] In order to avoid losing market share, firms in T might keep prices unchanged for some time, but this strategy would not be sustainable since it will generate losses. Alternatively, they might reduce employment and/or try to push productivity up, for example by eliminating previous slack in the work process (see, for example, Juselius and Ordonez (2009)). However, in order to be able to account for this we would need a more general theoretical and empirical model which is beyond the scope of this paper.

electorate (Calmfors et al., 1985 and 1988). As in the previous cases, wage equalization occurs due to free inter-sectoral labor mobility and/or envy externalities:

$$w_{T,t} = \mu_{T.3} + \theta_{T.3} \cdot w_{P,t} + \eta_{T,t} \tag{3.9}$$

$$w_{N,t} = \mu_{N.3} + \theta_{N.3} \cdot w_{P,t} + \eta_{N,t} \tag{3.10}$$

Again, full wage adaptability holds if $\theta_{i.3} = 1$, $i = N, T$. As in the previous case, the consequences for the domestic firms' international competitiveness might be serious due to traded goods prices growing faster than productivity. Moreover, since wages in both market sectors (N and T) will be growing ahead of productivity, in this latter case the impact on CPI inflation will be larger than in the previous cases. The envy-effect framework, thus, introduces an additional negative fiscal externality of wage increases: when the public sector is the leader in wage setting, the overall level of the real wage will be higher, resulting in higher prices and/or lower employment.

Albeit highly stylized, these models give us an idea of the scenarios we are likely to find in an empirical analysis of wage spillovers and leave us with clear testable hypotheses to find out which model fits best in describing the spillovers in wage determination in a specific country.

3.4 The empirical model

The ideal empirical model to test the assumptions embedded in the theoretical models sketched in the previous section, for reasons that will be clarified shortly, is a Cointegrated VAR (Johansen 1988, 1995). The main advantage of the CVAR is that it is a data-driven approach, and can therefore challenge - as it has been proved in several recent works[13] - theoretical macro models which have often been proved to fail to explain many empirical facts. Instead of pre-specifying the correct economic model from the outset, by using the CVAR we "let the data speak". One drawback of VAR models is that they are quite data-demanding, which can be a problem when we deal with transition countries, given the limited data availability. However, in this specific case, the dimension of the VAR (three variables) and the characteristics of the series (see next section) make this problem less relevant. In particular, the cointegration should occur much faster than within

[13]See, for example, Juselius and Franchi (2007).

other business cycle models, and this is confirmed by the Impulse-Response analysis. Moreover, in order to save on degrees of freedom, each model was re-estimated gradually restricting to zero all insignificant coefficients in the short-run matrices, starting from the one with the highest p-value, following a general-to-specific approach (Juselius, 2006). This left us with parsimonious models where the problem of the overparameterization of VARs was greatly reduced. Suppose we have a vector of p variables in time series. When the p variables, in levels, are nonstationary and integrated of order 1, I(1), their first difference will be I(0). Moreover, if two or more variables are I(1) but their linear combination is I(0), they are said to be cointegrated (CI(1,0)). The CVAR, as we will see, has the variables in first differences as dependent variables but is simply a reparametrization of the VAR (see Juselius, 2006, Chp.2). Therefore, the value of the likelihood is the same and there is no information loss in moving from the VAR to the Cointegrated (or Vector Error Correction) counterpart. A Cointegrated VAR model of order n with p variables is defined as:

$$\Delta x_t = \Pi \widetilde{x}_{t-1} + \Gamma_1 \Delta x_{t-1} + \cdots + \Gamma_n \Delta x_{t-n} + \phi D_t + \mu + \epsilon_t; \epsilon_t \sim Niid(0, \Omega) \tag{3.11}$$

where D is a vector of dummy variables (seasonals and other unrestricted dummies), μ is a vector of constant terms and Ω is the $(p \times p)$ covariance matrix of (white noise) residuals. Γ_j, $j = 1, \ldots, n$ are the matrices of the short-run coefficients. When variables are I(1) and cointegrated, the matrix Π will be of rank $r < p$, where r is the number of (long-run) cointegration relations. Therefore, Π can be decomposed as:

$$\Pi = \alpha \widetilde{\beta}'; \widetilde{\beta} = \begin{bmatrix} \beta & 1 & \beta_d & t \end{bmatrix}; \widetilde{x_{t-1}} = \begin{bmatrix} x_{t-1} & 1 & Ds & t \end{bmatrix};$$
$$x'_{t-1} = \begin{bmatrix} w_{T,t-1} & w_{N,t-1} & w_{P,t-1} \end{bmatrix}.$$

where the elements in $\widetilde{\beta}$ are $r \times 1$ vectors, 1 represents a constant restricted to lie in the cointegration relation, D_s are dummies capturing shocks that do not cancel in the cointegration relations and t is a linear trend. The $\widetilde{\beta}$'s are called the cointegration relations while the α's are the loadings. In other terms, the long run (stationary) relations that characterize the variables are the $\widetilde{\beta}$'s, while the α's show how each variable adjusts to disequilibria in the corresponding long-run relation. When we decompose Π, the coefficients in the α and $\widetilde{\beta}$ matrices will not be, in general, identified (i.e. we have an infinite number of matrices α and $\widetilde{\beta}$ that, if multiplied, are equal to Π); therefore, in order to achieve identification, we will need to impose restrictions on $\widetilde{\beta}$: a necessary (but not sufficient) condition for a Cointegrated VAR model to be empirically identified is that $r-1$ restrictions are imposed on each long-run relation. If the number of restrictions is larger, the model is overidentified and such restrictions are testable. Including a linear term (the time trend t) in the cointegration relations is useful when variables in the system are trending and trends do not cancel in the cointegrating relations; the constant, instead, allows for a non-zero mean in the relations. The CVAR (3.11), in sum, says that the changes in the variables in each period are explained by adjustments to equilibrium relations and the effect of past changes in the variables of the system, plus some deterministics; all contemporaneous effects are in the covariance matrix, i.e. it is a reduced form model. Moreover, the CVAR classifies the variables in r long-run relations by which the system is pulled and p-r common stochastic trends, by which the system is pushed. In other words, when the rank is r, the shocks in the equations of the VAR can be rewritten as r transitory shocks (i.e. shocks that cause disequilibria which are gradually absorbed through adjustment to the long-run relations) and $p-r$ permanent shocks. We can therefore re-write the CVAR in the so-called common trends representation:

$$x_t = C\sum_{i=1}^{t}(\epsilon_i + \mu_0 + \phi_1 Dp_i) + C^{\circ}(L)(\nu_t + \mu_0 + \mu_1 t) + \widetilde{X}_0 \tag{3.12}$$

where Dp are permanent (shift) dummies, ν are the transitory shocks, $\widetilde{X}_0$ the initial values and

$$C = \beta_\perp(\alpha_\perp \Gamma \beta_\perp)^{-1}\alpha'_\perp = \widetilde{\beta}_\perp \alpha'_\perp$$

where $\alpha_\perp$ and $\beta_\perp$ are the $p \times (p-r)$ orthogonal complements of α and β describing the common stochastic trends, $\alpha_\perp \sum \epsilon$, and their loadings. If a variable is found to be weakly exogenous, i.e. it does not adjust to any cointegrating relation[14] , then shocks to that variable are identified as one of the common stochastic trends of the system. In other words, the weakly exogenous variable "causes" movements in the other variables.

It should now be clear why the Cointegrated VAR model is a natural candidate to test empirically the predictions of the theoretical model

[14] This amounts to testing that the corresponding row in the matrix is zero.

sketched in the previous section. Theoretical models of wage determination make precise statements on the long-run relations as well as the causal links between wages in different sectors. The Scandinavian Model and the Froot and Rogoff (1995) model of the Balassa-Samuelson effect state that the open sector should be the driving force of the system, since on one hand productivity grows faster in this sector (as it has been empirically observed), and on the other hand it faces international competitiveness and therefore wages should increase in step with productivity to make sure that prices to not grow and there is no competitiveness loss. Free mobility of labor across sectors, then, makes sure that wages are equalized. The hypothesis of wage equalization (or, more precisely, constancy of the wage ratio)[15] implies that in a model including wages in the three sectors (industry, services and public administration) we should be able to find two cointegrating (long-run) relations and one common trend[16] and the coefficients in the cointegration relations should satisfy long-run homogeneity, (i.e. we should find one-to-one long-run relations and the constant in the cointegration vectors should be zero). Finally, in the Scandinavian Model, the common trend should be identified with shocks to industry wages, i.e. industry wages should be weakly exogenous. On the other hand, if the hypothesis of one-to-one relations (coefficients in the β - vector equal to 1) is rejected, this is interpreted as low wage adaptability between the sectors considered (see Friberg, 2007). If less than two cointegration relations are found, this means that there is more than one common trend affecting the wages: in other words, a weaker form of our three theoretical models holds. For example, if both N and T are found to be weakly exogenous, with public sector wages adjusting, this would imply that the (market) traded and non-traded sector wages are subject to different kinds of shocks (i.e. bargaining processes), and also a lower mobility of labour across sectors is present. By classifying the model into pulling and pushing forces, we will be able to identify how the wage shocks load into the three sectors. If the weak exogeneity of traded sector wages does not hold, the empirical model suggests that the Scandinavian model is

[15]Since we have wage indexes, when testing the hypothesis of wage adaptability we will actually test the constancy of the wage ratio, rather than equality of wages, which a weaker hypothesis but it is more realistic and, on the other hand, it is the assumption actually made by the empirical literature on the Balassa-Samuelson effect.

[16]Moreover, the model should be specified with an unrestricted constant and and no trend, since the presence of a trend in the cointegrating relation would imply that one sector has been gaining purchasing power with respect to the others.

not a good approximation of wage dynamics in the country under analysis, and the hypotheses at the basis of the Balassa-Samuelson effect do not hold. Put it another way, absence of weak exogeneity of w_T would imply that the traded sector has not been a driving force in wage determination, and rather it has been influenced by shocks to the other sectors, leaving room for competitiveness loss if wages have grown more than productivity. Equation (3.11), where we omitted, for simplicity, the trend and the constant from the cointegration relations, before any restrictions are imposed and making the matrices explicit, can be written as:

$$\begin{bmatrix} \Delta w_{T,t} \\ \Delta w_{N,t} \\ \Delta w_{P,t} \end{bmatrix} = \begin{bmatrix} \alpha_{1T} & \alpha_{2T} & \alpha_{3T} \\ \alpha_{1N} & \alpha_{2N} & \alpha_{3N} \\ \alpha_{1P} & \alpha_{2P} & \alpha_{3P} \end{bmatrix} \begin{bmatrix} \beta_{1T} & \beta_{1N} & \beta_{1P} \\ \beta_{2T} & \beta_{2N} & \beta_{2P} \\ \beta_{3T} & \beta_{3N} & \beta_{3P} \end{bmatrix} \begin{bmatrix} \Delta w_{T,t-1} \\ \Delta w_{N,t-1} \\ \Delta w_{P,t-1} \end{bmatrix} + \sum_{i=1}^{n} \Gamma_i \Delta x_{t-i} + \phi D_t + \mu + \epsilon_t \tag{3.13}$$

Table 3.1 summarizes the hypotheses embedded in the theoretical models outlined in Section 3 and the corresponding testable restrictions within the Cointegrated VAR framework.

Model	Rank	Leader	Identifying Restrictions	Weak Exog.	Full Wage adaptability
(a)	2	w_T	$\begin{bmatrix} \beta_{1T} & 1 & 0 \\ \beta_{2T} & 0 & 1 \end{bmatrix}$	$\alpha_{iT} = 0$	$\beta_{1T} = \beta_{2T} = -1$
(b)	2	w_N	$\begin{bmatrix} 1 & \beta_{1N} & 0 \\ 0 & \beta_{2N} & 1 \end{bmatrix}$	$\alpha_{iN} = 0$	$\beta_{1N} = \beta_{2N} = -1$
(c)	2	w_P	$\begin{bmatrix} 1 & 0 & \beta_{1P} \\ 0 & 1 & \beta_{2P} \end{bmatrix}$	$\alpha_{iP} = 0$	$\beta_{1P} = \beta_{2P} = -1$

Table 3.1: Testable assumptions on wage spillovers.

3.5 The data and empirical results

Our dataset contains quarterly data from 2000Q1 until 2010Q3 for ten Central and Eastern European Countries that have joined the European Union in either of the two waves of 2004 and 2007 (Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovak Republic, Slovenia). The time sample was chosen in order to make sure we had data for all countries, as well as excluding data from the very first years after the fall of Communism which might be less reliable or, for what concerns the consumer price index, depend heavily on price administration.

There are three wage series for each country: Industry (proxying the traded sector), Services (proxying the market non-traded sector) and Public Administration (the non-market, non-traded sector)[17]. While the definition of the Public Sector (wages in public administration, defence and compulsory social security) is not really debatable, some assumptions had to be done in order to define the traded and non-traded sector. To this end, we have followed a common practice in the literature on the Balassa-Samuelson effect by identifying the traded sector with industry (excluding construction, which is not unanimously treated in the literature) and the market non-traded sector with "Services of the business economy"[18]. Agriculture is excluded from the sample as agricultural prices heavily rely on state support and price administration, and are influenced by policies as the CAP in the EU. Finally, the wage indexes are deflated using the Harmonized CPI index. This is done in order to concentrate on the relationship between real wages, excluding price shocks from the model. Most of the empirical works on this issue define wages as compensation per employee in the corresponding sector, calculated as compensation of employees divided by the number of workers in that sector; however, these data are only available on an annual basis and the available time series for transition countries are too short to use annual data[19]. The dimension of the VARs estimated in this paper makes the use of quarterly data suitable; moreover, unlike other long-run equilibrium relations, deviations from a long-run equilibrium of wage series should be less persistent, and therefore 11 years represent a long enough time span to detect cointegration. Finally, we prefer using quarterly data to annual data because the latter can be misleading - or at least less informative - if intersectoral wage spillovers occur within the year, i.e. with a frequency which is higher than that of the sample. As we will show through impulse response

[17]The exact definition of the series and the sources is given in Appendix 1.

[18]The literature generally identifies the open sector with industry and the sheltered sector with services or "all the rest". For example, Egert (2002, 2003a, 2003b) and Golinelli and Orsi (2002) define Industry as the Open sector and the rest as the closed sector. Halpern and Wyplosz (2001) include respectively Industry and Services, and exclude construction from the latter. Agriculture is excluded in Coricelli and Jazbec (2004). Nenovsky and Dimitrova (2002) include also construction in the open sector.

[19]For example, Lamo et al. (2008) and Demekas and Kontolemis (2000). Friberg (2007) uses average monthly wages.

analysis, indeed, disequilibria in the wage relations are generally absorbed within the year. As already stated, the empirical model is a Vector Error Correction Model in three variables: (real) wages in Industry, w_T , Services, w_N, and Public Administration, w_P. Since the wage series, from a graphical inspection, seem to exhibit a deterministic trend, we also include a linear term in the baseline VAR. As a result, the corresponding VECM can either have an unrestricted constant and no trend (if the trend cancels out in the cointegrating relations), or an unrestricted constant and a restricted trend, in the case the latter does not cancel out in the cointegration relations[20] [21]. Table 3.2 shows the results of the cointegration rank tests. As it is common in the literature, we do not limit ourselves to looking at the results of the trace test but combine it with information on the largest unrestricted root of the characteristic polynomial, the significance of the adjustment coefficients in the corresponding row of the α-matrix, and a graphical inspection of the cointegration relations. We do this in order to make sure that, by excluding a cointegration relation, albeit persistent, we are not throwing away potentially important information. These criteria need not (and in general, do not) suggest the same rank, as it is the case in Table 3.2, and in this sense some room for judgment is left. Table 3.2 reports the results of the trace test and the modulus of the largest unrestricted root of the characteristic polynomial. As a rule of thumb, when using quarterly data the chosen rank should not leave out roots larger than 0.83-0.84 (Juselius [2006], chp. 8). The trace test suggested no cointegration in the case of Lithuania and Slovenia, but this was not supported by the other criteria we have listed above, and therefore we opted for r = 1. Only for three countries out of ten (Estonia, Romania and Slovakia) we could not reject the null of r = 2. In the other cases, the rank is 1. This might suggest low intersectoral mobility across sectors, so that the wage series do not share a single common trend but two different trends.

We can now move to testing restrictions on the cointegration vectors, i.e. the β matrices, in order to find out the degree of wage adaptability; on the other hand, by testing restrictions on α (i.e. testing for weak exogene-

[20]See Juselius [2006], Chp. 6. A linear term in the cointegration vector here would imply that wages one sector have been gaining purchasing power with respect to wages in the other sector(s)

[21]The exact specification of the deterministic part and the order of the underlying VARs is given in Appendix 2.

ity) we will be able to classify the variables in the system in pushing and pulling forces, i.e. variables that drove the system out of equilibrium and variables which brought the system back to equilibrium, adjusting to the cointegration relations. Then, we will employ Granger non-causality tests (Granger, 1969) to test for wage leadership. The process of adjustment of the variables after a shock to other sectors will be investigated by means of impulse response analysis.

Tables 3.3−3.5 report the results of the empirical model. Table 3.3 provides the null hypothesis, the imposed restrictions and normalization on the β-vectors and the likelihood ratio test results. If we have, for example, two cointegration relations and the null hypothesis of one-to-one relations (i.e. long-run homogeneity) can be rejected at the 10% level, then we interpret this as a signal of low wage adaptability (see Friberg, 2007). In order to achieve economic identification, i.e. making the cointegration vectors interpretable as equilibrium relations, the vectors in Table 3.3 were normalized to the variable which is significantly adjusting to the corresponding cointegration relation.

Table 3.4 reports the results of the weak exogeneity tests and Table 3.5 shows the common trends representation of the model, where the coefficients to the stochastic trends of the system are reported. We can now comment on the results by country.

Bulgaria shows only one cointegration relation and Industry and Services are weakly exogenous. The joint hypothesis of weak exogeneity could not be rejected with a fairly high p-value, and since there is only one cointegration vector, the model is identified without having to impose restrictions on β. Looking at the common trends representation, we see that shocks to industry wages had a significant permanent effect only on the industry sector, while shocks to the services sector significantly affected the services and public sector. In other words, we can label the two permanent shocks a "traded sector wage shock" and a "sheltered sector shock". Overall, a weak version of the Scandinavian Model therefore holds for Bulgaria.
The Czech Republic exhibits one cointegration vector; the two closed sector wages, w_N and w_P, are found to be weakly exogenous and the joint weak exogeneity could not be rejected with a p-value of 0.170. Wages in T, therefore, have been adjusting, and table 3.4 shows that the sector that

Country	Null	Trace p-value	Largest characteristic root	Choice
	r=0	0.030	$r = 1$ 0.748	
Bulgaria	$r \leq 1$	0.433	$r = 2$ 0.911	r=1
	$r \leq 2$	0.898	$r = 3$ 1.045	
	r=0	0.021	$r = 1$ 0.428	
Czech Republic	$r \leq 1$	0.060	$r = 2$ 0.935	r=1
	$r \leq 2$	0.204	$r = 3$ 0.916	
	r=0	0.025	$r = 1$ 0.712	
Estonia	$r \leq 1$	0.061	$r = 2$ 0.789	r=2
	$r \leq 2$	0.201	$r = 3$ 0.959	
	r=0	0.001	$r = 1$ 0.689	
Hungary	$r \leq 1$	0.027	$r = 2$ 0.956	r=1
	$r \leq 2$	0.767	$r = 3$ 0.960	
	r=0	0.005	$r = 1$ 0.654	
Latvia	$r \leq 1$	0.066	$r = 2$ 0.847	r=1
	$r \leq 2$	0.077	$r = 3$ 1.005	
	r=0	0.278	$r = 1$ 0.844	
Lithuania	$r \leq 1$	0.497	$r = 2$ 0.919	r=1
	$r \leq 2$	0.177	$r = 3$ 0.971	
	r=0	0.022	$r = 1$ 0.720	
Poland	$r \leq 1$	0.496	$r = 2$ 0.973	r=1
	$r \leq 2$	0.916	$r = 3$ 0.985	
	r=0	0.017	$r = 1$ 0.436	
Romania	$r \leq 1$	0.535	$r = 2$ 0.735	r=2
	$r \leq 2$	0.890	$r = 3$ 0.822	
	r=0	0.001	$r = 1$ 0.326	
Slovak Rep.	$r \leq 1$	0.018	$r = 2$ 0.650	r=2
	$r \leq 2$	0.159	$r = 3$ 0.954	
	r=0	0.665	$r = 1$ 0.712	
Slovenia	$r \leq 1$	0.692	$r = 2$ 0.728	r=1
	$r \leq 2$	0.933	$r = 3$ 0.997	

Table 3.2: The choice of the cointegration rank.

has been leading on T was the public sector. Wages in N were found to be long-run excludable, and full wage adaptability between T and P was rejected. This structure of wage spillovers is consistent with a weak version of our "Envy-effect model" and shows a potential for wage costs increasing more than productivity and competitiveness loss in the Czech Republic.

Estonia has two cointegration relations; however, there is not full wage adaptability since the hypothesis of long-run homogeneity is rejected at all significance levels. On the other hand, industry wages are weakly exogenous (though only at 1%) and shocks to this sectors load significantly on the other sectors.

In the case of Hungary only one cointegration vector was found; wP and w_N are weakly exogenous and w_T is adjusting to a cointegration relation with non-traded sector wages. In other terms, w_P is long-run excludable and therefore public wages have been following a separate pattern. The wage mark-up model is therefore a good approximation of inter-sectoral wage spillovers in Hungary.

Latvia has one cointegration relation with the Traded sector adjusting, while the Public and Non-traded sector are weakly exogenous. Moreover, public sector wages are long-run excludable but shocks to w_P are the only ones that significantly affected the three variables in the system in the long run.

Lithuania presents one cointegration relation; w_P and w_N are weakly exogenous and w_T is adjusting. Moreover, from the common trends representation we can see that shocks to N had a significant long-run effect on that sector and T, while shocks to the P significantly affected only public sector wages in the long run.

Poland shows one cointegration relation; wages in T and P are weakly exogenous but only shocks to w_T significantly affect w_N in the long run.

Romania presents two cointegration vectors with wages P being weakly exogenous. Full wage adaptability was rejected.

The Slovak Republic is the only country for which all hypotheses in the Scandinavian model and were found to hold. There are two cointegration vectors, full wage adaptability and w_T is weakly exogenous and significantly affects the other sectors in the long run.

Finally, Slovenia has one cointegration relation, where the public sector wages adjust to a linear combination of Industry and the Services, and the latter two sectors being jointly weakly exogenous and shocks to these variables significantly affecting public sector wages.

Country	Restriction [22]	LR stat.[23]	P-value
Bulgaria	$\widehat{\beta}' = [\beta_{1T}\ \beta_{1N}\ 1]$	N.A.	N.A.
Czech Republic	$\widehat{\beta}' = [1\ 0\ \beta_{1P}]$	5.874	0.118
Estonia	$\widehat{\beta}' = \begin{bmatrix} \beta_{1T} & 1 & 0 \\ 0 & \beta_{2N} & 1 \end{bmatrix}$	N.A.	N.A.
Hungary	$\widehat{\beta}' = [\beta_{1T}\ 1\ 0]$	2.896	0.089
Latvia	$\widehat{\beta}' = [1\ \beta_{1N}\ 0]$	0.243	0.622
Lithuania	$\widehat{\beta}' = [1\ \beta_{1N}\beta_{1P}]$	N.A.	N.A.
Poland	$\widehat{\beta}' = [\beta_{1T}1\ \beta_{1P}]$	N.A.	N.A.
Romania	$\widehat{\beta}' = \begin{bmatrix} 0 & 1 & \beta_{1P} \\ 1 & 0 & \beta_{2P} \end{bmatrix}$	4.465	0.347
Slovak Republic	$\widehat{\beta}' = \begin{bmatrix} -1 & 1 & 0 \\ 0 & -1 & 1 \end{bmatrix}$	7.538	0.110
Slovenia	$\widehat{\beta}' = [\beta_{1T}1 - \beta_{1T}\ 1]$	1.811	0.612

Table 3.3: Cointegration Vectors and wage adaptability.

In order to test for wage leadership, we follow Tagtström [2000] and Friberg [2007] and employ Granger non-causality tests on our VECM model (3.11). Testing for wage leadership in (3.11) with two cointegration vectors therefore implies the following null hypotheses:

$$\alpha_{1T}\beta_{1P} = \alpha_{2T}\beta_{2P} = \Gamma_i T = 0 : w_P \overset{not}{\rightarrow} w_T \tag{3.14}$$

$$\alpha_{1T}\beta_{1N} = \alpha_{2T}\beta_{2N} = \Gamma_i T = 0 : w_N \overset{not}{\rightarrow} w_T \tag{3.15}$$

$$\alpha_{1N}\beta_{1P} = \alpha_{2N}\beta_{2P} = \Gamma_i N = 0 : w_P \overset{not}{\rightarrow} w_N \tag{3.16}$$

$$\alpha_{1N}\beta_{1T} = \alpha_{2N}\beta_{2T} = \Gamma_i N = 0 : w_T \overset{not}{\rightarrow} w_N \tag{3.17}$$

$$\alpha_{1P}\beta_{1T} = \alpha_{2P}\beta_{2T} = \Gamma_i P = 0 : w_T \overset{not}{\rightarrow} w_P \tag{3.18}$$

$$\alpha_{1P}\beta_{1N} = \alpha_{2P}\beta_{2N} = \Gamma_i P = 0 : w_N \overset{not}{\rightarrow} w_P \tag{3.19}$$

Where $\Gamma_{ij}, i = 1, \ldots, n;\ j = P, N, T$ is the row of the Γ matrix (the matrix of coefficients of the lagged differences) corresponding to sector j for lag i. In other words, if (3.14) and (3.15) cannot be rejected, then the traded sector is wage leader and the Scandinavian model holds. A similar reasoning can be done for the non-traded and public sector. We have ten countries here, and

Country	Industry	Services	Public	Joint w.e. test
Bulgaria	0.014	0.489	38.788	w_T, w_N:1.166 [0.558]
	[0.906]	[0.484]	[0.000]	
	1.510	0.339	0.159	w_N, w_P: 3.539 [0.170]
Czech Republic	[0.219]	[0.560]	[0.690]	w_N, w_T: 3.116[0.213]
				w_T, w_P: 12.469 [0.002]
Estonia	5.991	7.306	13.394	
	[0.030]	[0.026]	[0.001]	
Hungary	6.056	0.612	1.765	w_N, w_P:0.711 [0.339]
	[0.014]	[0.434]	[0.184]	
	2.606	0.006	3.119	w_T, w_N:12.194 [0.002]
Latvia	[0.106]	[0.939]	[0.077]	w_T, w_P:3.359 [0.186]
				w_N, w_P: 1.745 [0.418]
Lithuania	2.524	0.388	2.038	w_T, w_N:7.012 [0.030]
	[0.112]	[0.533]	[0.153]	w_T, w_P:4.471 [0.107]
				w_P, w_N:2.862 [0.239]
Poland	0.068	12.877	2.937	w_T, w_P:4.712 [0.095]
	[0.795]	[0.000]	[0.087]	
Romania	30.275	15.914	3.439	
	[0.000]	[0.000]	[0.179]	
Slovak Republic	2.664	6.451	12.555	
	[0.264]	[0.040]	[0.002]	
Slovenia	1.367	0.066	4.192	w_T, w_N: 3.946 [0.139]
	[0.242]	[0.798]	[0.041]	

Table 3.4: Weak Exogeneity.

Country	Equation	ϵ_T	ϵ_N	ϵ_P	Det. Trend
Bulgaria	$w_{T,t}$	**1.124 (2.717)**	0.370 (0.697)	0.000 (N.A.)	0.009
	$w_{N,t}$	0.066 (0.155)	**1.360 (2.314)**	0.000 (N.A.)	0.013
	$w_{P,t}$	-0.456 (-1.068)	**1.750 (3.191)**	0.000 (N.A.)	0.014
Czech R.	$w_{T,t}$	0.000 (N.A.)	0.048 (0.337)	**0.645 (2.073)**	0.012
	$w_{N,t}$	0.000 (N.A.)	**0.894 (4.060)**	0.251 (0.517)	0.011
	$w_{P,t}$	0.000 (N.A.)	0.099 (0.337)	**1.346 (2.073)**	0.011
Estonia	$w_{T,t}$	**1.316 (1.874)**	0.000 (N.A.)	0.000 (N.A.)	0.014
	$w_{N,t}$	**1.316 (1.874)**	0.000 (N.A.)	0.000 (N.A.)	0.011
	$w_{P,t}$	**1.316 (1.874)**	0.000 (N.A.)	0.000 (N.A.)	0.013
Hungary	$w_{T,t}$	0.000 (N.A.)	**1.557 (2.314)**	-0.000 (-0.004)	0.011
	$w_{N,t}$	0.000 (N.A.)	**1.750 (2.314)**	-0.000 (-0.004)	0.012
	$w_{P,t}$	0.000 (N.A.)	2.055 (1.272)	**0.783 (5.636)**	0.010
Latvia	$w_{T,t}$	0.000 (N.A.)	0.378 (0.920)	**0.412 (2.408)**	0.012
	$w_{N,t}$	0.000 (N.A.)	0.445 (0.920)	**0.484 (2.408)**	0.014
	$w_{P,t}$	0.000 (N.A.)	-1.202 (-0.980)	**1.961 (3.840)**	0.005
Lithuania	$w_{T,t}$	0.000 (N.A.)	**1.881 (2.054)**	-0.467 (-1.848)	0.005
	$w_{N,t}$	0.000 (N.A.)	**1.915 (2.083)**	-0.261 (-1.029)	0.005
	$w_{P,t}$	0.000 (N.A.)	1.080 (1.274)	**0.447 (1.909)**	0.004
Poland	$w_{T,t}$	**0.827 (2.419)**	0.000 (N.A.)	-0.049 (-0.179)	0.008
	$w_{N,t}$	**0.961 (2.623)**	0.000 (N.A.)	-0.305 (-1.043)	0.007
	$w_{P,t}$	0.009 (0.032)	0.000 (N.A.)	**1.025 (4.801)**	0.010
Romania	$w_{T,t}$	0.000 (N.A.)	0.000 (N.A)	**0.304 (2.489)**	0.022
	$w_{N,t}$	0.000 (N.A.)	0.000 (N.A)	**0.505 (2.489)**	0.021
	$w_{P,t}$	0.000 (N.A.)	0.000 (N.A.)	**0.860 (2.489)**	0.036
Slovak Republic	$w_{T,t}$	**0.810 (3.086)**	0.000 (N.A)	0.000 (N.A)	0.022
	$w_{N,t}$	**0.810 (3.086)**	0.000 (N.A)	0.000 (N.A)	0.021
	$w_{P,t}$	**0.810 (3.086)**	0.000 (N.A.)	0.000 (N.A)	0.036
Slovenia	$w_{T,t}$	**0.431 (2.067)**	0.299 (0.777)	0.000 (N.A.)	0.008
	$w_{N,t}$	-0.199 (-0.963)	**0.938 (2.463)**	0.000 (N.A.)	0.005
	$w_{P,t}$	**-0.760 (-2.943)**	**1.508 (3.164)**	0.000 (N.A.)	0.003

Table 3.5: Common Trends representation.

	Null	Wald test (p-value)
Bulgaria		
	$w_N \overset{not}{\rightarrow} w_T$	3.31(0.050)
	$w_P \overset{not}{\rightarrow} w_T$	4.27 (0.024)
Czech Republic		
	$w_N \overset{not}{\rightarrow} w_T$	3.54 (0.068)
	$w_P \overset{not}{\rightarrow} w_T$	4.63 (0.039)
Estonia		
	$w_N \overset{not}{\rightarrow} w_T$	3.67 (0.037)
	$w_P \overset{not}{\rightarrow} w_T$	2.02 (0.150)
Hungary		
	$w_N \overset{not}{\rightarrow} w_T$	1.09 (0.348)
	$w_P \overset{not}{\rightarrow} w_T$	2.47 (0.100)
Latvia		
	$w_N \overset{not}{\rightarrow} w_T$	1.57 (0.225)
	$w_P \overset{not}{\rightarrow} w_T$	5.61 (0.008)
Lithuania		
	$w_N \overset{not}{\rightarrow} w_T$	0.77 (0.520)
	$w_P \overset{not}{\rightarrow} w_T$	1.40 (0.264)
Poland		
	$w_N \overset{not}{\rightarrow} w_T$	1.42 (0.257)
	$w_P \overset{not}{\rightarrow} w_T$	0.77 (0.469)
Romania		
	$w_N \overset{not}{\rightarrow} w_T$	2.45 (0.103)
	$w_P \overset{not}{\rightarrow} w_T$	5.19 (0.011)
Slovak Republic		
	$w_N \overset{not}{\rightarrow} w_T$	0.90 (0.349)
	$w_P \overset{not}{\rightarrow} w_T$	0.05 (0.830)
Slovenia		
	$w_N \overset{not}{\rightarrow} w_T$	2.04 (0.162)
	$w_P \overset{not}{\rightarrow} w_T$	2.96 (0.094)

Table 3.6: Granger Causality.

thus the number of tests to be performed is quite high; however, since we are mainly interested in discussing the role of the Balassa-Samuelson assumption of traded sector wage leadership in the process of convergence as well as for brevity, we only report the results of (3.14) and (3.15)[24]. The leadership of the Traded sector wages vis à vis the Public sector (i.e. null hypotheses (3.14)) is rejected at 5% significance in the case of Bulgaria, Czech Republic, Latvia and Romania and at 10% for Slovenia. The null (3.15) is rejected at 5% for Estonia and Bulgaria, and 10% for Hungary. Therefore, in Bulgaria and Estonia, while w_T was found to be weakly exogenous, the traded sector was not wage leader, meaning that w_P and w_N affected it at least in the short run. In other words, there was bidirectional (Granger) causality.

	BG	CZ	EE	HU	LV	LT	PL	RO	SK	SI
Model	(a)	(c)	(a)	(b)	(c)	(b)	(a)	(c)	(a)	(a)

Table 3.7: Models of wage spillovers.

In order to analyze the adjustment dynamics of the system, in Appendix 3 I plotted the Impulse Response functions for each country. The graphs of the responses up to 20 quarters ahead confirm the results reported in Table 3.5; moreover, we notice that, in general, the adjustment to the new long-run value after a permanent shock is pretty quick, taking in general at most one year and a half. In the case of Poland, Bulgaria and Estonia the adjustment requires less than one year. This is interesting since, if most of the adjustment occurs within the year, previous works on wage spillovers that use yearly data (for example, Lamo et al. (2008)) might not be able to capture these feedback effects.

3.6 Conclusion

This paper analyzed spillovers in wage determination across macro sectors in ten european transition countries that joined the European Union within the last decade. Several previous studies have shown, either with a descriptive approach or using econometric techniques, that wages in different sectors generally equalize or, more generally, that the wage ratio tends to be constant.

[24]Test results of the other tests are available on request.

However, as it was discussed in Section 3, different frameworks of leads and lags in wage determination may have different impacts as regards the international cost competitiveness of a country's firms. When wages in sectors that are not exposed to international competition lead the process of wage setting, inter-sectoral labor mobility as well as union pressure may cause the traded sector wages to grow more than productivity, thus harming competitiveness. In this case, the catching up process will be characterized by wages converging faster than productivity.

The main results of the paper are the following: first of all, in transition countries (with the exception of Slovakia) we do not find support for full wage adaptability, and in most cases two common trends are present, meaning that shocks to wages in the sectors that are found to be leaders in wage determination are not fully transmitted to the other sectors. Thus, pushes to wage equalization coming from inter-sectoral labor mobility might have been low. Moreover, the fact that we have two common trends may imply separate bargaining processes. Second, the "right" model to describe wage interactions is different across countries. In Section 3, we have outlined three alternative models of wage spillovers and derived the hypotheses they implied. Table 3.7 shows which model best describes wage spillovers in each of the sample countries; in general, we found support for a weaker form of those models, with the exception of the Slovak Republic, for which the strict version of the Scandinavian Model holds. In Romania, the Czech Republic and Latvia public sector wages were found to be weakly exogenous, "causing" movements in traded and non-traded sector wages. In the case of Hungary and Lithuania, the non-traded sector has been leading wage determination. Thus, for these five countries, the process of convergence may be accompanied by the creation of large international imbalances due to competitiveness loss.

As far as the remaining countries are concerned, while traded sector wages were weakly exogenous, with the exception of Estonia we found shocks to wages in N to significantly affect public sector wages in the long run. Thus, we could find what we called a traded sector wage shock and a non-traded sector wage shock. In the case of Estonia, Bulgaria and (only at 10% significance) Slovenia, while model 1 appears to hold, the traded sector was not wage leader and actually we could observe bidirectional causality.

Finally, Granger "causality" tests and Impulse Response analysis have shown that, in some cases, even when the traded sector is weakly exogenous, there is bidirectional causality (Bulgaria and Estonia); adjustment after a shock to wages in the leading sector occurs quite quickly, taking in general less than six quarters.

As it was stated in the introduction, in principle, when wage setting in sectors that are not subject to international competition leads that in the traded sector, there is room for competitiveness loss since wage costs will grow faster than productivity. At a micro level, firms in the export sector will either have to increase prices or, to avoid losing market share, reduce profits. At a country level, excess inflation may be balanced by a depreciation of the nominal exchange rate to re-establish (relative) purchasing power parity. When the nominal exchange rate is fixed, however, due to an exchange rate arrangement or entry in a monetary union, nominal depreciation is not an option. For this reason, in principle, empirical support for the wage mark-up or the envy-effect model in central and eastern European countries, as it was found in the present paper, may suggest the potential for accumulating large current account imbalances when these countries will finally have to adopt the euro, and this may be the subject of further research.

3.7 References

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3.8 Appendix 1. Data Sources

Variable	Source and Definition
Industry Wages	Eurostat, LCI (Labor Cost Index) - Wages and Salaries. Seasonally adjusted and adjusted data by working days - B-E ("Industry except construction"). Nominal value.
Services Wages	Eurostat, LCI (Labor Cost Index) - Wages and Salaries. Seasonally adjusted and adjusted data by working days - G-N ("Services of the business economy"). Nominal value.
Public Wages	Eurostat, LCI (Labor Cost Index) - Wages and Salaries. Seasonally adjusted and adjusted data by working days - O ("Public administration and Defence, compulsory social security"). Nominal value.
Price Adjustment	Eurostat, HICP Overall Index - Seasonally and Working day adjusted

3.9 Appendix 2. Specification of the empirical model

Country	Order	Specification	Rank
Bulgaria	2	UC, transitory dummies (2001Q4, 2009Q4)	1
Czech Republic	1	UCRT, shift in 2004Q3	1
Estonia	2	UC	2
Hungary	2	UC	1
Latvia	2	UC, Shift at 2006Q4	1
Lithuania	3	UC	1
Poland	2	UC, blip dummy 2004Q2 restricted in the CV.	1
Romania	2	UCRT. Trend break at 2007Q1 (entrance to EU)	2
Slovak Republic	1	UC	2
Slovenia	1	UC	1

Note: UC = unrestricted constant, no trend; UCRT=unrestricted constant, restricted trend. Residuals in all models are white noise [25]

3.10 Appendix 3. Impulse Response Functions

[25]Specification tests results are available on request.

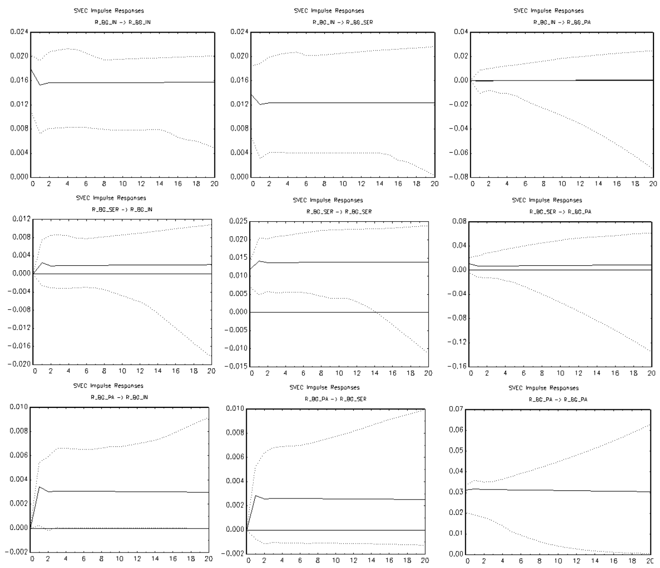

Figure 3.3: Bulgaria.

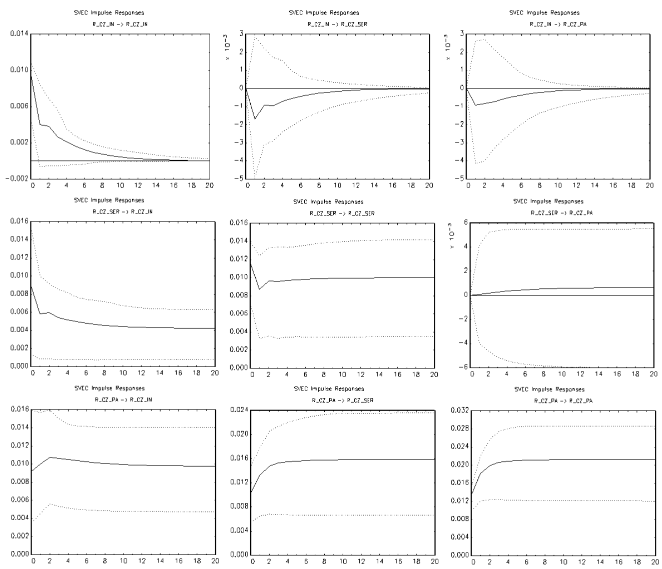

Figure 3.4: Czech Republic

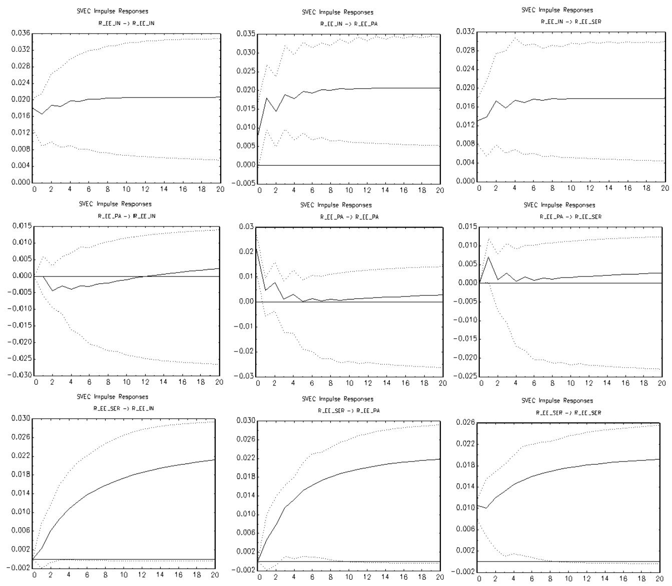

Figure 3.5: Estonia

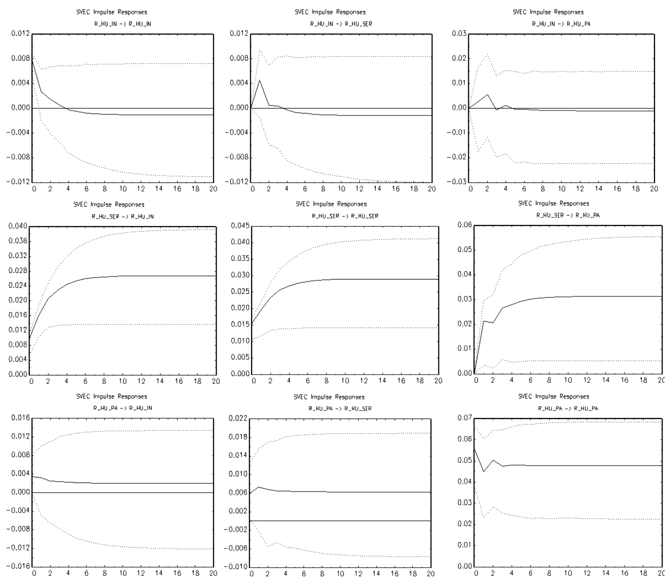

Figure 3.6: Hungary

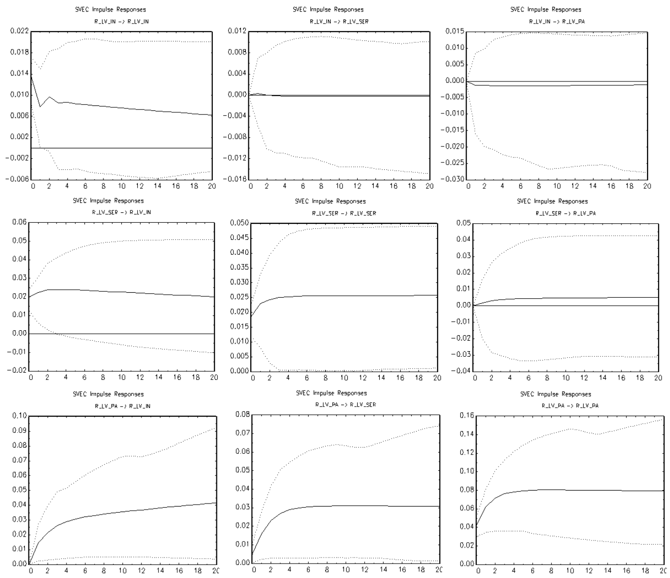

Figure 3.7: Latvia

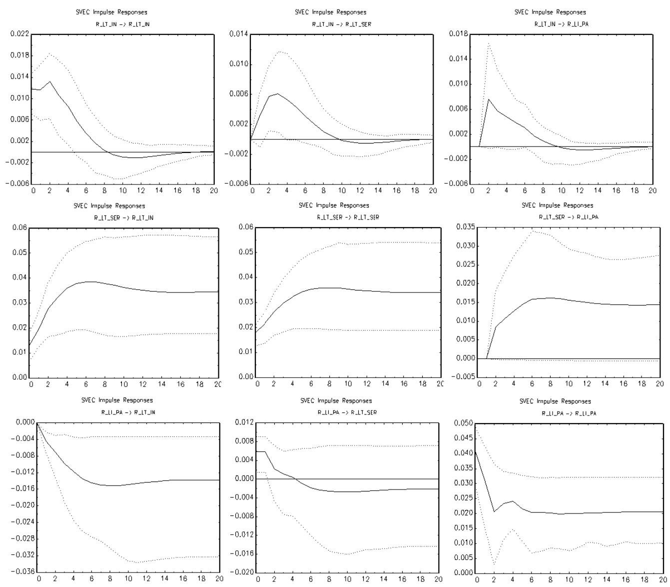

Figure 3.8: Lithuania

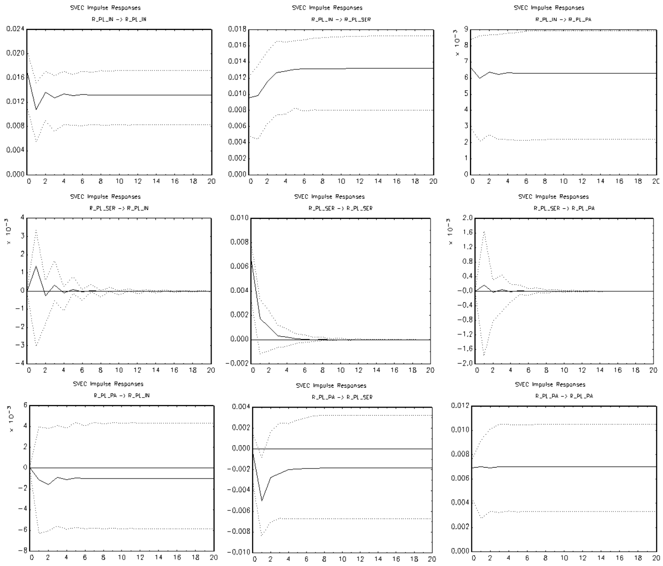

Figure 3.9: Poland

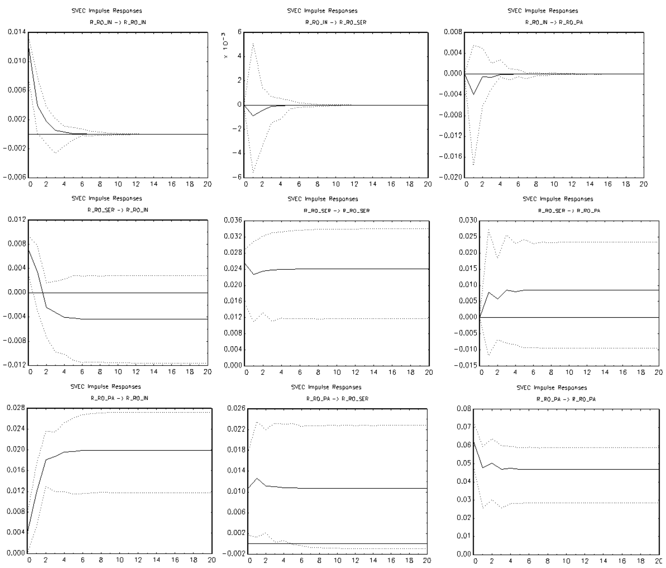

Figure 3.10: Romania

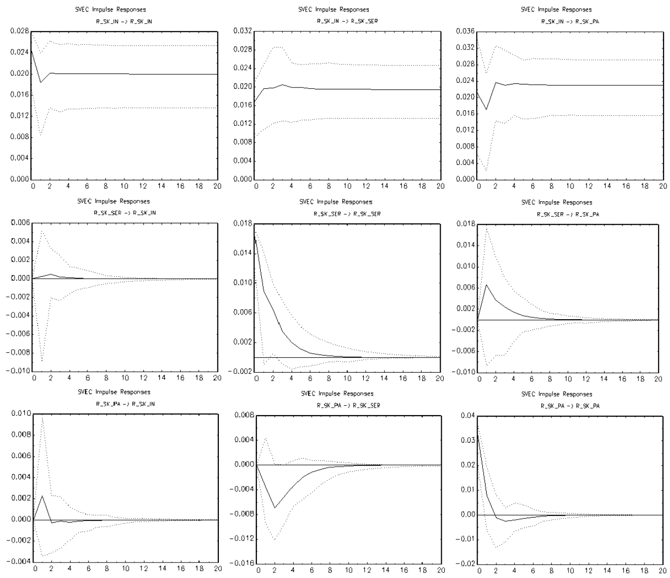

Figure 3.11: Slovak Republic

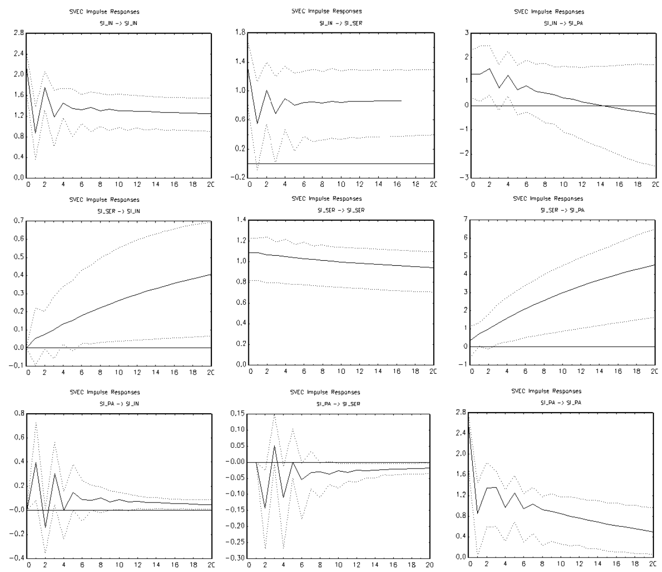

Figure 3.12: Slovenia

Chapter 4

Conclusion

The research developed within this doctoral thesis deals with several aspects of european economic and monetary integration. Each chapter was self-contained and strongly policy-related.

The recent literature on *Fear of Floating* has shown how many countries that are, officially, in a floating exchange rate regime actually tend to manage the exchange rate in disguise. On the other hand, countries within some forms of official exchange rate arrangement with one foreign currency actually tend to reduce the volatility *vis à vis* some other currencies.

When the country we are considering is in a regime of inflation targeting, the economic literature suggests that it should not directly target the exchange rate, but only respond to its fluctuations as long as they affect (expected) inflation. For countries that are in the European Union, or strongly integrated with the EMU, the rationale for having a managed float may be given by the high economic and financial integration with the euro area. In particular for developing countries, the fact that a large portion of domestic credit is denominated in a foreign currency reduces the scope for domestic monetary policy, on one hand, and on the other hand makes the exchange rate channel stronger. Interest rate pass-through, moreover, may occur from the foreign money market rate to the domestic one, rather than through the traditional channel involving the home policy rate. The strong connection between domestic (of the small open economy) and foreign (the large economy's) market interest rate is not, however, an issue that only involves developing countries. Reade and Volz (2009), for example, have shown that the Swedish interbank rate, the Stibor, is cointegrated with the Euribor and the latter is weakly exogenous. This discussion shows why, in principle, in EU Countries that have not adopted the euro yet Central Banks might have been placing some weight in their monetary policy on exchange rate stabilization.

In Chapter 1 I reviewed two approaches recently developed by the literature to detect the *de facto* exchange rate regimes and weights in currency baskets, the Calvo and Reinhart (2002) approach and the Frankel and Wei (2008) approach, and applied those techniques to a group of 14 european countries: 3 non-EU countries (Switzerland, Iceland and Norway), two countries that recently adopted the euro (Slovakia and Estonia) and nine EU members. The results obtained from these ountries were compared to those of five *benchmark* floaters.

This Chapter, therefore, attempted to merge the technique to detect the *de facto* exchange rate regime by Calvo and Reinhart with the Farnkel and Wei approach for estimating weights in currency baskets, and it was also, to my knowledge, the first attempt to study systematically the evolution of *de facto* exchange rate regimes in Europe comparing the pre-euro and the post-euro era.

The results of these approaches were interesting on several grounds. First of all, with no surprise, official regimes of pegging and limited flexibility have remained fairly stable through the last decade and consistent with the official policy.

Second, the introduction of inflation targeting has brought about higher exchange rate and lower reserves volatility, but up to a level that is not comparable to benchmark floaters. All Inflation Targeters appear to intervene actively in the foreign exchange market, a fact that is not justified by their official monetary policy regime. Surprisingly enough, this was the case for advanced economies with credible central banks like Sweden and Switzerland, as well as Australia, to a lower extent, rather than for "youger" Inflation Targeters like Poland and the Czech Republic, while it is pretty much common knowledge the Central Bank of Hungary has been pursuing a mixed approach.

Third, the euro seems to have gained a relevant role as a reference currency since its introduction, even outside Europe, as its weight in the informal basket of European and non-european countries included in our sample was significantly larger than that of its main constituent currencies. Moreover, even for the most committed floaters in Europe, the euro has been the most important (in some cases the only) informal reference currency.

In general, the euro era was characterized by higher exchange rate stability than the previous periods. Finally, Limited Flexibility (ERM membership) seems to be a more credible commitment to exchange rate management than managed floating, since - at least in this sample - it was characterized by both lower foreign exchange intervention and exchange rate volatility.

Chapter 2 was dedicated to the analysis of the Monetary Policy of the Swedish Central Bank, the Riksbank, by estimating its policy preferences. Since the introduction of the euro, and in particular between 2002 and 2008, the exchange rate of Swedish Krona with the euro exhibited a remarkable stability, and we wanted to understand whether that came through direct interest rate intervention, i.e. whether the Riksbank put some weight on exchange rate stabilization in its policy rule. A Taylor Rule would not be a good approach to that end, since the coefficients in this rule are convolutions of structural and preference parameters. By means of a stylized theoretical model, we showed how an observational equivalence between Inflation Targeting and a form of Fear of Floating may arise if we do not take that into account. For this reason, rather than estimating a Taylor rule augmented to include the exchange rate, we have derived alternative interest rate rules from the Central Bank's optimization problem and estimated separately the parameters describing the structure of the economy and those representing the Central Bank preferences under alternative monetry policy rules, namely Strict Inflation Targeting, Flexible Inflation Targeting, Interest Rate Stabilization and Smoothing, Fear of Floating and Exchange Rate targeting. The results show that Inflation Targeting with Interest Rate Stabilization and Smoothing can describe the Swedish Monetary Policy of the last 16 years pretty well, and therefore exchange rate stabilization was not coming through the interest rate.

Chapter 3 discussed the issue of real and nominal convergence in Central and Eastern European Countries (CEECs) from the point of view of the labor market. The Balassa-Samuelson hypothesis states that, during the process of catching up, if labor is freely mobile across sectors, since productivity grows faster in the traded goods sector, the resulting aggregate real wage increases will push the price of tradable goods up. This, in turn, generates structural inflation and a real exchange rate appreciation which, however, as long as relative PPP holds for tradable goods, should not harm competitiveness. During the last decade a number of papers has investigated the importance of the Balassa-Samuelson hypothesis in explaining the real appreciation experienced by CEECs. However, empirical support for this theory was limited. The limit of this literature is that one fundamental assumption of the Balassa-Samuelson hypothesis, namely that the traded goods sector drives wage determination while the other sectors (the non-traded and the public sector) are following.

In Chapter 3, I first sketched three alternative models of spillovers in wage determination where the leader is, alternatively, the traded sector (as in the Balassa-Samuelson hypothesis and the so-called Scandinavian Model), the non-traded sector (which holds if unions in that sector have a higher bargaining power and can thus extract a mark-up over productivity), and the public sector (where wage setting is driven by political rather than productivity considerations). In each case, the other two sectors adjust to the higher wage set in the leading one. Then I tested the assumptions embedded in these three models within a Cointegrated VAR framework for each country.

The results showed that a large heterogeneity across countries is present. We did not find support for full wage adaptability, and in most cases two common trends are present, meaning that shocks to wages in the sectors that are found to be leaders in wage determination are not fully transmitted to the other sectors, which may be due to low inter-sectoral labor mobility. Only in Slovakia full wage adaptability as well as a leading role of the traded sector (i.e. the assumptions of the B-S hypothesis) were found. In Romania, the Czech Republic and Latvia public sector wages were found to be weakly exogenous, "causing" movements in traded and non-traded sector wages. In the case of Hungary and Lithuania, the non-traded sector has been leading wage determination. Thus, for these five countries, the process of convergence may be accompanied by the creation of large international imbalances due to competitiveness loss.

As far as the remaining countries are concerned, while traded sector wages were weakly exogenous, with the exception of Estonia we found shocks to wages in N to significantly affect public sector wages in the long run. Thus, we could find what we called a traded sector wage shock and a non-traded sector wage shock. In the case of Estonia, Bulgaria and (only at 10% significance) Slovenia, while model 1 appears to hold, the traded sector was not wage leader (i.e. it did not Granger-cause the other variables) and actually we could observe bidirectional causality.

These results suggest one potential source of the failure of the Balassa-Samuelson hypothesis, that was documented by a large strand of literature cited in Chapter 3, in explaining excess inflation and real appreciation in Central and Eastern Europe.