The Welfare Cost of the EMU
for Transition Countries

Alexandra Ferreira-Lopes

The Welfare Cost of the EMU for Transition Countries[*]

Alexandra Ferreira-Lopes[†]

Abstract

Czech Republic, Hungary, and Poland are set to join the European and Monetary Union (EMU) in the near future. This paper offers a framework for the quantitative evaluation of the economic costs of joining the EMU. Using an open economy dynamic general equilibrium model with sticky prices, we investigate the economic implications of the loss of monetary policy flexibility associated with EMU for each of these economies. The main benefit of this general equilibrium approach is that we can directly evaluate the effects of monetary policy in terms of welfare. Our findings suggest that the Czech Republic and Poland may experience sizable welfare costs as a result of joining the EMU. Results for Hungary are less striking as welfare costs in this country seem to be negligible in the benchmark economy. Nevertheless, costs of joining the EMU are higher if government shocks are important and when the trade share with the EMU is small.

[†]ISCTE (Lisbon University Institute), Economics Department, Economics Research Center (ERC)-UNIDE, and DINÂMIA. Avenida das Forças Armadas, 1649-026 Lisboa, Portugal. Tel.: +351 217903901; Fax: +351 217903933; E-mail: alexandra.ferreira.lopes@iscte.pt

1 Introduction

Should Poland, Hungary, and the Czech Republic adopt the euro? In this paper we construct a model to evaluate the economic costs of the loss of monetary policy due to joining the EMU, for each of these countries, the largest of the economies that joined the European Union (EU) in May of 2004.

Our focus is the loss of autonomy of monetary policy and its implications for business cycle synchronization. Business cycle synchronization is an important decision factor for joining the EMU. It is often argued that it is not a good decision to join the euro, if a country's economic cycle is not syncronized with that of other remaining members as a common monetary policy may actually accentuate economic fluctuations (for example Gros and Hefeker, 2002).

In this paper we develop a two country dynamic general equilibrium model with sticky prices, so that monetary policy can be used as a short run policy instrument of economic stabilization. We then investigate the economic implications of the loss of monetary policy flexibility associated with the EMU for each of the three countries. Specifically we consider two different scenarios: (1) one in which the country is currently inside the EMU and therefore the monetary policy rule is established by the European Central Bank, that follows a weighted Taylor Rule, designated *Common Monetary Policy*; (2) another where the country is outside the EMU and therefore the monetary policy is established by the country's National Central Bank, that follows a Taylor Rule, designated *Autonomous Monetary Policy*. We then examine the macroeconomic implications of these two policy arrangements and offer a detailed welfare analysis to formally assess which is prefered by domestic residents.

In order to do a welfare analysis to evaluate different monetary policy regimes, this work brings together two types of literature: the optimum currency areas literature with seminal work by Mundell (1961), McKinnon (1963), and Kenen (1969) and the dynamic stochastic general equilibrium (DSGE) models literature in the tradition of Obstfeld and Rogoff (1995) and Chari et al. (2002a).[1] We use this framework to study the decision to join European Monetary Union in terms of the loss of monetary policy flexibility for the Czech Republic, Hungary, and Poland, calibrating models specifically for each economy; a task we have never seen done in the literature and for the purpose stated above.

We also introduce a new interest rate rule for the ECB, that ponders the Eurozone countries's weights, since the countries do not have the same economic weight and hence its economic condition will enter in the interest rule of the ECB with different weights. This modification is important because a big country can influence the way the interest rate rule moves if it enters the Eurozone, but a small country does not have this type of influence, and business cycle synchronization becomes more important. For the countries at study in this paper, Holtemöller (2007) calculated an optimum currency area (OCA) index

---

[1] See Goodfriend and King (1997), Clarida et al. (1999), and Lane (2002) for surveys on models of monetary policy and new open economy macroeconomics.

to measure the economic consequences of joining the EMU and uses a Taylor Rule similar to the one we use here in one of the simulations, but in a different economic framework. The OCA index measures the relative loss in terms of output gap and inflation variability in the two regimes stated above. He concludes that both the Czech Republic and Hungary can reduce the volatility of inflation and output gap if they join the monetary union, but results for Poland are inconclusive.

General equilibrium models with nominal rigidities have been used to study the problem of the loss of independence of monetary policy, usually using extensions of the Obstfeld and Rogoff (1995) model. The referred model is used to compare between an autonomous monetary regime (multiple currencies and different monetary policies) and a monetary union. The model, in a two country framework, has been used to assess the consequences on individual welfare of the loss of exchange rate flexibility, when facing asymmetric shocks. Some conclusions drawn for the French economy, find that in the presence of asymmetric permanent shocks to either technology or government expenditures, it is beneficial to households living in the country hit by an asymmetric shock to join a monetary union (Carré and Collard, 2003). Other conclusions state that entry is welfare improving the smaller the country, the smaller the correlation of technological shocks between countries, the higher the variance of real exchange rate shocks, the larger the difference between the volatility of technological shocks across member countries, and the larger the gain in potential output, compared with the gain in potential output of a flexible exchange rate regime (Ca'Zorzi et al. 2005).

When used to study the costs in terms of stabilization and welfare of joining a currency union, the class of models mentioned in the paragraph above, reveals that countries face a trade-off when joining a monetary union between higher instability in output and lower instability in inflation, and that this trade-off improves with the degree of cross-country symmetry of supply and demand shocks. These results lead to the conclusion that maintaining the monetary stabilization possibility proves to be always welfare improving, independently of the changes in the correlation and type of shocks (Monacelli, 2000). Corsetti (2008) studies the costs, in theoretical terms, of loosing monetary policy independence and exchange rate flexibility in the light of optimum currency area theory, using a micro-founded choice-theoretic model. The author states that a common monetary policy produces a level of economic activity which is lower than the optimum, but since exchanges rates do not present a stabilizing role as stated by the optimum currency area literature, monetary policy can be efficient, if the proportion of national goods in the consumption basket of the union is similar to the share of value added in total GDP across countries.

Sánchez (2007, 2008) studies the role of the nature of the shocks, aggregate and sectoral productivity shocks, in the performance of the common monetary policy in a simple macroeconomic model. The author focus particularly the case of catching-up member states, like the Central and Eastern European

Countries (CEECs). Common monetary policy performs better than an autonomous monetary policy when countries face an aggregate supply shock, especially when their preferences regarding price stability and also their economic size, are relatively similar. When a country faces sectoral productivity shocks an autonomous monetary policy is better to stabilize it, especially when it carries Balassa-Samuelson effects on relative prices and real exchange rates. When a given currency union can have as members transition countries, like the CEECs, which commonly have this last refered type of effect, the possibility of an asymmetric shock increases. He also finds a positive role of trade openness in diminishing the cost of adopting a common currency, since the influence of foreign prices are bigger, as well as a positive influence of the size of the country, since a bigger country can have a stronger impact on a common monetary policy.

Marcin (2008) calibrates a two-country DSGE model for the Polish economy and the Eurozone, to study the importance of heterogeneity and asymmetric shocks. The author finds differences in the volatility and synchronization of the shocks that occur in each of the two economies, which could potentially lead to the conclusion that euro adoption by Poland, would at this stage, be harmful. However, the degree of heterogeneity found in the shocks of the two economies, is similar to those found in some studies that address Eurozone member states. Bruha et al. (2007) calibrate a DSGE model for the Czech Republic and the EU and stress the importance of knowing the long run trajectories of a transition economy, especially in the case of Czech Republic, which has, somewhere in the future, to join the euro. The model replicates the macroeconomic events that happened in the Czech Republic in the last years.

The outline of the paper is as follows. Section 2 presents some initial evidence regarding the three economies under study. In section 3 we describe the model, while section 4 describes our methodology and calibration procedures. Section 5 contains our main results and section 6 examines their robustness. Section 7 concludes.

2   Empirical Evidence

In this section we analyze some of the most commonly used indicators of the optimum currency area literature, to assess the adequability of a country to join a currency union. Czech Republic, Hungary, and Poland are the largest countries to have joined the EU in May 2004 and they are scheduled to join the European Monetary Union at some time in the future, because, unlike the United Kingdom and Denmark, they do not have an opt-out clause.

Hungary currency is currently free floating and the country has not settle a date for euro adoption, although forecasters state that will be never before 2014. Poland plans to join the Euro never before 2012 and its currency is currently floating. The Czech Republic has not yet set a date for joining the Euro but aims to join the ERM (Exchange Rate Mechanism) II when convergence criteria are achieved. Its currency is on a managed float.

The economic conditions of these countries do not differ much from those of Portugal and Greece, the poorest of the European Union economies, at the time of their accession, as we can see in Table 1. GDP *per capita* in these economies resembles the levels, at the time of accession, for Portugal and Greece. These countries are also small open economies like Portugal and Greece, but much more open to trade. This makes them specially vulnerable to shocks and highly dependent on foreign trade partners. Degree of openness is calculated as *[(exports+imports)/2]/gdp*100*. The variables are in nominal terms. EU-15 is the European Union with the former fifteen member countries.

Table 1 - Comparison of GDP per capita and Degree of Openness in the Accession Year

Countries (Year of Accession)	GDP *per capita* in PPP (EU-15=100)	Degree of Openness (%)
Greece (1981)	63	27.2%
Portugal (1986)	53	28.7%
Czech Republic (2004)	65	71.3%
Hungary (2004)	56	65.1%
Poland (2004)	45	38.5%
Data Source: NewCronos		

Business cycle synchronization is also an important decision factor to join the EMU. If business cycles are not synchronized, the impact of a common monetary policy is different for each country and may hurt the economy of the country. The ECB considers only the average economic condition of the Eurozone when setting monetary policy. Table 2 shows results for the cross-country correlations between the countries at study and the Eurozone. In Appendix A we have details on empirical data and methodological issues for these calculations. The superscript $*$ identifies Eurozone variables. Results for Poland (POL) show that the country has a significative positive correlation with the Eurozone for output (Y) and investment (I) and a negative correlation with labor (l), and consumption (c). We can see that Hungary (HUN) is the country that exhibits more variables with a positive correlation with the Eurozone. Synchronization does not exist between the Czech Republic (CZE) and the Eurozone, with correlations for the variables being either vey small or negative. The analysis of business cycle for these countries must be done with caution since these economies are still on their transition paths.

Table 2 - Cross-Country Correlations between the Countries and the EMU

	CZE	HUN	POL
(Y, Y^*)	0.09	0.23	0.35
(c, c^*)	-0.44	0.02	-0.24
(I, I^*)	-0.33	0.26	0.51
(l, l^*)	-0.22	0.62	-0.12

Other studies also focused on business cycle synchronization between these countries and the Eurozone. Fidrmuc and Korhonen (2003) based on supply and demand shocks correlations between these countries and the Eurozone, conclude that EMU accession would be easy for Hungary, and have mixed results for Poland and Czech Republic. Furceri and Karras (2006) analyze some potential

macroeconomic costs and benefits of joining the EMU for the new member countries, and also for candidate countries. They also find, like Firdmuc and Korhonen (2003) that business cycle synchronization between Hungary and the Euro area is high, and also given other indicators, accession would be easy for this country. Accession would also be easy for Poland, but hard for the Czech Republic. Levasseur (2008) finds that using recent data to study business cycle synchronization leads to opposite results of those of Firdmuc and Korhonen (2003), namely that in recent years Poland seems more suitable for joining EMU and Hungary seems less.

Also important is the proportion of the economic cycle of each country that is explained by an idiosyncratic component *vis-a-vis* a common component with the Eurozone. If the idiosyncratic component is very high that could be a problem for EMU accession, because the lower the correlation between the economic cycle of a country and the Eurozone, the bigger could be the welfare loss of giving up monetary policy. For the sake of comparison we also present results regarding the common component with the USA. Results for the countries at study are presented in Table 3 below and details on the estimations are in Appendix B.

Table 3 - % of the variability of the specific component in the total variability of the cycle

	1991-2007	
	Eurozone	USA
Czech Republic	42%	47%
Hungary	29%	34%
Poland	36%	44%

As we can see, the weight of the specific component is less than 50% in the three transition countries and is lower in Hungary and Poland. The proportion of the specific component is higher when we calculate for the USA, meaning that the proportion of the economic cycle explained by the Eurozone economic cycle is higher. If we take in account these results, it seems, contrary to the other business cycle results, that entering the EMU would be easy to these countries, specially to Hungary and Poland.

3   Model

We developed a dynamic equilibrium model in the tradition of Chari et al. (2002a), but modified to take into account an interest rate rule similar to that suggested by Taylor (1993) which also allows for forward looking behavior. This setting permits us to construct a detailed quantitative analysis for the behavior of the main macroeconomic variables and, more importantly, to quantify the welfare gain associated with the various policy choices. We provide a framework to evaluate the economic costs of joining the EMU, namely, to investigate the economic implications of the loss of the monetary policy flexibility associated with EMU and to assess the effects of monetary policy in terms of welfare.

There are two countries in the model with infinitely lived consumers and also competitive final goods producers, and monopolistically competitive intermediate goods producers. This last group of agents sells their products to the final goods producers; the latter type of goods is non-traded. Trade between economies is in intermediate goods, produced by monopolists who can charge different prices in two countries. Intermediate goods prices are set on local market currency, each producer having the right to sell his goods in the two countries. Once prices are set, each intermediate goods producer must satisfy his demand.

The following goods exist in the economy in each period; labor, capital, real money balances, and a continuum of intermediate goods indexed by $i \in [0,1]$ produced in the home country H, and a continuum of intermediate goods indexed by $i \in [0,1]$ produced in the foreign country F, which will be regarded as the Eurozone.

3.1 Consumers

In each period $t = 0, 1, ...$, consumers choose their allocations, facing the following budget constraints:

$$P_t c_t + M_t + E_{t+1} Q_t B_{t+1} \tag{1}$$
$$\leq P_t W_t l_t + M_{t-1} + T_t + Q_{t-1} B_t + \Pi_t$$

where c_t, l_t and, M_t are respectively, consumption, labor, and money, T_t are transfers of home currency, Π_t represents profits of the home country intermediate goods producers, P_t is the price of the final good and W_t represents real wages. The initial conditions M_{-1} and B_0 are given.

In this economy, markets are complete. The asset structure is represented by having a set of government bonds designated B_t, which represents a vector of state contingent securities. B_t^* is the foreign consumers' holdings of this bond. Q_t is the vector of state contingent prices for the bonds.

Consumers choose consumption, labor, real money balances, and bond holdings to maximize their utility:

$$E_0 \sum_{t=0}^{\infty} \beta^t U\left(c_t, l_t, M_t/P_t\right) \tag{2}$$

subject to the consumer budget constraints, where β is the discount factor. The first order conditions for the consumer can be written as:

$$-\frac{U_t^l}{U_t^c} = W_t$$

$$\frac{U_t^m}{P_t} - \frac{U_t^c}{P_t} + \beta E_{t+1} \frac{U_{t+1}^c}{P_{t+1}} = 0$$

$$Q_{t-1} = \beta E_{t-1} \frac{U_t^c}{U_{t-1}^c} \frac{P_{t-1}}{P_t}$$

where U_t^c, U_t^l, and U_t^m are the derivatives of the variables of the utility function. We can define the nominal interest rate, r^N, from the last first order condition:

$$\frac{1}{1+r^N} = \beta E_{t+1} \frac{U_{t+1}^c}{U_t^c} \frac{P_t}{P_{t+1}}$$

3.2 Final Goods Producers

In country H final goods are produced from intermediate goods through the following production function:

$$y_t = \left[a_1 \left(\int_0^1 (y_{i,t}^H)^\theta di \right)^{\frac{\rho}{\theta}} + a_2 \left(\int_0^1 (y_{i,t}^F)^\theta di \right)^{\frac{\rho}{\theta}} \right]^{1/\rho} \tag{3}$$

where y_t is the final good, $y_{i,t}^H$ and $y_{i,t}^F$ are intermediate goods produced in H and F, respectively. Parameter θ determines the mark-up of price over marginal cost (θ is the elasticity of substitution between goods produced in the same country, representing the market power of producers), ρ along with θ, determine the elasticity of substitution between home and foreign goods. Parameters a_1 and a_2, combined with θ and ρ, determine the ratio of imports to output.

Final goods producers behave in a competitive way, in each period t, choosing inputs $y_{i,t}^H$ for $i \in [0,1]$ and $y_{i,t}^F$ for $i \in [0,1]$, and y_t to maximize profits subject to (3). Prices are expressed in units of the domestic currency. Price of intermediate goods can at most depend on $t-1$, because producers set prices before period t. Factor demand functions are calculated by the resolution of the maximization problem and have the following expressions:

$$y_{i,t}^H = \frac{[a_1 P_t]^{\frac{1}{1-\rho}} \overline{P}_{t-1}^{H \frac{\rho-\theta}{(1-\rho)(\theta-1)}}}{P_{i,t-1}^{H \frac{1}{1-\theta}}} y_t \tag{4}$$

$$y_{i,t}^F = \frac{[a_2 P_t]^{\frac{1}{1-\rho}} \overline{P}_{t-1}^{F \frac{\rho-\theta}{(1-\rho)(\theta-1)}}}{P_{i,t-1}^{F \frac{1}{1-\theta}}} y_t \tag{5}$$

where $\overline{P}_{t-1}^H$ is the average price of inputs and is equal to:

$$\overline{P}_{t-1}^H = \left(\int_0^1 P_{i,t-1}^{H \frac{1}{1-\theta}} di \right)^{\frac{\theta-1}{\theta}}$$

and $\overline{P}_{t-1}^F$ is equal to:

$$\overline{P}_{t-1}^{F} = \left(\int\limits_{0}^{1} P_{i,t-1}^{F}{}^{\frac{1}{1-\theta}} di \right)^{\frac{\theta-1}{\theta}}$$

since all producers behave competitively, their economic profit is zero, and the final good price is given by:

$$P_t = \left(a_1^{\frac{1}{1-\rho}} \overline{P}_{t-1}^{H}{}^{\frac{\rho}{\rho-1}} + a_2^{\frac{1}{1-\rho}} \overline{P}_{t-1}^{F}{}^{\frac{\rho}{\rho-1}} \right)^{\frac{\rho}{\rho-1}} \tag{6}$$

which is independent of period t shocks.

3.3 Intermediate Goods Producers

Each intermediate good i, is produced according to a standard constant returns to scale production function:

$$y_{i,t}^{H} + y_{i,t}^{H^*} = F\left(k_{i,t-1}, A_t l_{i,t} \right) \tag{7}$$

where $k_{i,t-1}$ and A_t are respectively capital and technology used in the production of the good, $y_{i,t}^{H}$ and $y_{i,t}^{H^*}$ are the quantities of the intermediate good produced in H, used in the production of the final good in country H and F, respectively. The law of motion for capital is given by:

$$k_{i,t} = (1-\delta) k_{i,t-1} + I_{i,t} - \phi\left(\frac{I_{i,t}}{k_{i,t-1}} \right) k_{i,t-1} \tag{8}$$

where $I_{i,t}$ is investment, function $\phi(.)$ represents adjustment costs, and δ is the depreciation rate. The initial capital stock $k_{i,-1}$ is given and is the same for all producers in this group.

Intermediate producers behave as imperfect competitors, setting their prices in a staggered way. As usual this monopolistic setting ensures that output is determined by demand, at least in the short term when prices are fixed. Specifically, at the beginning of each period t, a fraction $1/N$ of producers in H choose a home currency price $P_{i,t-1}^{H}$ for the home market and a price for the foreign market. As these prices are set for N periods, for this group of intermediate goods producers: $P_{i,t+\tau-1}^{H} = P_{i,t-1}^{H}$ and $P_{i,t+\tau-1}^{H^*} = P_{i,t-1}^{H^*}$ for $\tau = 0, ..., N-1$. Intermediate goods producers are indexed so that those with $i \in [0, 1/N]$ set prices in $0, N, 2N$, and so on, while those with $i \in [1/N, 2/N]$ set prices in $1, N+1, 2N+1$, and so on, for the N groups of intermediate producers.

Consider, for example, producers in a group, namely $i \in [0, 1/N]$, who choose prices $P_{i,t-1}^{H}$ and $P_{i,t-1}^{H^*}$, production factors $l_{i,t}$, $k_{i,t}$ and $I_{i,t}$ to solve the following problem:

$$\max E_0 \sum_{t=0}^{\infty} Q_t [P_{i,t-1}^{H} y_{i,t-1}^{H} +$$
$$+ e_t P_{i,t-1}^{H^*} y_{i,t}^{H^*} - P_t W_t l_{i,t} - P_t I_{i,t}] \tag{9}$$

9

subject to (7), (8), and the constraints that their supplies to home and foreign markets, $y_{i,t-1}^H$ and $y_{i,t-1}^{H^*}$, must equal the amount demanded by home and foreign final goods producers, from equation (4) and analogue for F (equation (5)). Another constraint implies that prices are set for N periods. e_t is the nominal exchange rate. Optimal prices for $t = 0, N, 2N$ and so on, are:

$$P_{i,t-1}^H = \frac{\sum_{\tau=t}^{t+N-1} E_\tau Q_\tau P_\tau v_{i,\tau} \Lambda_\tau^H}{\theta \sum_{\tau=t}^{t+N-1} E_\tau Q_\tau \Lambda_\tau^H}$$

$$P_{i,t-1}^{H^*} = \frac{\sum_{\tau=t}^{t+N-1} E_\tau Q_\tau P_\tau v_{i,\tau} \Lambda_\tau^{H^*}}{\theta \sum_{\tau=t}^{t+N-1} E_\tau Q_\tau e_\tau \Lambda_\tau^{H^*}}$$

where $v_{i,t}$ is the real unit cost which is equal to the wage rate divided by the marginal product of labor, $W_t / F_{i,t}^l A_t$ and:

$$\Lambda_t^H = [a_1 P_t]^{\frac{1}{1-\rho}} \overline{P}_{t-1}^H \frac{\rho-\theta}{(1-\rho)(\theta-1)} y_t$$

$$\Lambda_t^{H^*} = [a_2 P_t^*]^{\frac{1}{1-\rho}} \overline{P}_{t-1}^{H^*} \frac{\rho-\theta}{(1-\rho)(\theta-1)} y_t^*$$

in a symmetric steady-state real unit costs are equal across firms, hence, in this steady state these formulas reduce to $P_i^H = P_i^{H^*} = Pv/\theta$, so that the law of one price holds for each good, and prices are set as a mark-up $(1/\theta)$ over marginal costs Pv.

3.4 Government

New money balances of the home currency are distributed to consumers in the home country in a lump-sum fashion by having transfers satisfy:

$$P_t * g_t + T_t = M_t - M_{(t-1)} \tag{10}$$

this equation represents the home government budget constraint, where g_t is government consumption.

Several empirical papers have shown that the Taylor rule seems to replicate in an accurate way the monetary policy rule of central Banks throughout the world, namely Taylor (1993). For our benchmark case we assume that the Central Bank of country H uses a forward looking Taylor type interest rate rule formulated by Clarida, Gali, and Gertler (2000), represented by:

$$r_t^N = \rho^r r_{t-1}^N + (1 - \rho^r)[\rho^\pi E_t \pi_{t+1} + \rho^o O_t] + \varepsilon_t^{r^N} \tag{11}$$

where r_t^N is the nominal interest rate in period t for the domestic economy, $(\pi_{t+1} = \frac{P_{t+1}}{P_t} - 1)$ is the inflation rate between period t and $t+1$ for the domestic economy, and O_t is the real gross domestic product at t of the domestic economy.

$\varepsilon_t^{r^N}$ are shocks with a normal distribution, zero average, σ^{r^N} standard deviation, and positive cross-country correlation. If $\rho^r > 0$ the rule exhibits some degree of inertia, as the Central Bank does not fully adjust to current changes in the economy.

Interest rates in country F, the Eurozone, are set according to the rule:

$$
\begin{aligned}
r_t^{N^*} = & \ \rho^r r_{t-1}^{N^*} + (1 - \rho^r)[\varpi \rho^\pi E_t \pi_{t+1} + (1 - \varpi)\rho^\pi E_t \pi_{t+1}^* + \\
& + \varpi \rho^o O_t + (1 - \varpi)\rho^o O_t^*] + \varepsilon_t^{r^{N^*}}
\end{aligned}
\tag{12}
$$

where ϖ is the weight of the home country's GDP in the Eurozone (in simulation *Common Monetary Policy*), considering that the country is already a member. For the benchmark case, which we will explain in section 5, when the home country is outside the Eurozone (simulation *Autonomous Monetary Policy*), we set $\varpi = 0$. $r_t^{N^*}$ is the nominal interest rate in period t for the foreign economy, $(\pi_{t+1}^* = \frac{P_{t+1}^*}{P_t} - 1)$ is the inflation rate between period t and $t + 1$ for the Eurozone, and O_t^* is the real gross domestic product at t of the Eurozone. As usual we allow for monetary policy shocks $\varepsilon_t^{r^{N^*}}$ with a normal distribution, zero average, $\sigma^{r^{N^*}}$ standard deviation, and no cross-country correlation. When we use the Taylor rule of the ECB as the policy rule, the domestic economy has no monetary policy shock; we therefore imposed the following restriction on the nominal interest rate:

$$
r_t^N = r_t^{N^*}
\tag{13}
$$

3.5 Equilibrium Conditions

All maximization problems for country F are analogous to those of country H. An equilibrium requires several market-clearing conditions. The resource constraint in the home country is given by:

$$
y_t = c_t + g_t + \int_0^1 I_{i,t} di
\tag{14}
$$

The labor market-clearing condition is:

$$
l_t = \int l_{i,t} di
\tag{15}
$$

similar conditions hold for the foreign country. The market-clearing condition for contingent bonds is:

$$
B_t + B_t^* = 0
\tag{16}
$$

The state of the economy when monopolists make their pricing decisions (previously of period t) must record the capital stocks for a representative monopolist in each group in the two countries, the prices set by the other $N - 1$ groups in both countries, and the period $t - 1$ monetary shock but not period t monetary shock, and period t and $t - 1$ technological and government consumption shocks. Period $t - 1$ shocks help forecast the shocks in period t and current

shocks are included in the state of the economy when the remaining decisions are taken. Consumers and final good producers know current and past realizations of shocks. Monopolists know the past and current realizations of technological and government consumption shocks, but only know past realizations of monetary shocks.

We use the Blanchard and Kahn (1980) approach to solve the model. Several procedures are necessary: First, to make economies stationary we deflate all first order conditions for the nominal variables by the growth rate of prices mu; second, we derive the steady state equations and conditions for some stationary variables; third, we apply logs and linearize the first order conditions around the steady state, and finally we solve the system of equations.[2]

4 Calibration and Data

The calibration for the models is made in order to reproduce the long term properties of the Czech, Hungarian, and Polish economies. In this case where the economies under study are transition countries, calibration is a rough exercise. We use the calibration methodology suggested by Prescott (1986) and Cooley (1995). When needed, X12-ARIMA was used to remove seasonality and the Hodrick-Prescott filter to detrend the data. Results for the parameters for each of the three economies are reported in Table 4, at the end of this section.

4.1 Preferences

The functional form of the utility function is:

$$U\left(c, l, \frac{M}{P}\right) = \frac{\left[\frac{c^{(1-\kappa)}}{(1-\kappa)} + \frac{w\left(\frac{M}{P}\right)^{\frac{\eta-1}{\eta}}}{\frac{\eta-1}{\eta}} + \varphi\frac{(1-l)^{(1-\gamma)}}{1-\gamma}\right]^{1-\sigma}}{1-\sigma} \qquad (17)$$

whose arguments are real consumption (c), labor (l), and a real money aggregate (M/P). The discount factor β is calculated using annual data, 1999-2007 for Poland and Hungary and 2000-2007 for the Czech Republic, later turned into quarterly values, from AMECO, a European Commission annual database for $\beta = \frac{1}{(1+r^{LT})}$, where r^{LT} is the real long term interest rate for government bond yields, which was deflated using the consumer price index. The value for σ is 0.0001 for all countries and κ is the relative risk aversion coefficient. In order to have a balanced growth we impose $\gamma = \sigma$. The weight on leisure, φ, is calculated in order to make the time that families dedicate to work equal to a value that matches estimates from the Labour Force Survey of EUROSTAT, for the period between 1997 and 2007.

Parameters concerning money demand are estimated according to the first order condition for a nominal bond, which costs one euro at t and pays $(1 + r^N)$

---

[2] The growth rate of prices mu is calculated in order to respect the observed inflation rates of the countries at study.

euros in $t+1$:

$$\log \frac{M_t}{P_t} = -\eta \log \frac{w}{1-w} + \log c_t - \eta \log \left(\frac{r^N}{1+r^N} \right) \qquad (18)$$

we estimated regressions with quarterly data for the period 1995:01-2005:03, where $M1$ is used for money, the GDP deflator for P, private consumption at real prices for c, and the three month interest rate of the money market for r^N. In the estimation we obtained the value for η, the interest elasticity of real money demand, and the value for w is residual, which we set equal for all countries.

4.2 Technology

4.2.1 Final Goods Producers

The elasticity of substitution between home and foreign goods is defined as $\frac{1}{(1-\rho)}$. Some studies, like that of Whalley (1985), found this elasticity to have a range between 1 and 2, and was lower for Japan and Europe than for the USA. We found the value for this elasticity by calculating the following regression, based on the first order condition of the demand functions for the intermediate goods:

$$\log \frac{IMP}{D} = b_0 + b_1 \log \frac{PD}{PIMP} + b_2 \log Y \qquad (19)$$

where IMP, D, and Y are respectively imports, national production subtracted from exports, and national income, all at constant prices, $PIMP$ is the imports deflator, PD is the deflator for D. We use annual National Accounts data for 1990-2007, 1991-2007, and 1992-2007, respectively for the Czech Republic, Hungary, and Poland.

For the a_1 and a_2 parameters, representing respectively the weights of domestic and imported goods, we used annual bilateral trade data from the CHELEM data base for 1990-2006, except for the Czech Republic, where data begins in 1993. Shares for each country are calculated assuming that there are only two countries in the world, each of the transition countries and the Eurozone. y_h and y_f represent the share of imports from the Eurozone as a percentage of GDP and the share of national production as a percentage of GDP, respectively. To calculate a_1 and a_2 in their steady state values, the following relation is used: $y_h/y_f = [a_1/a_2]^{\frac{1}{1-\rho}}$.

4.2.2 Intermediate Goods Producers

The production function for intermediate producers is a Cobb-Douglas with constant returns to scale:

$$F(k, Al) = k^\alpha (Al)^{1-\alpha} \qquad (20)$$

We calculated the share of capital, α, using OECD statistics for the capital income share of the private sector for the Czech Republic. We assume that

Hungary has the same capital share that Czech Republic, because we did not find available data for the former country. For Poland the value was taken from Zienkowski (2000).

For the mark-up parameter we used data between 1992 and 2006, 1991 and 2005, and 1995 and 2006, respectively for the Czech Republic, Hungary, and Poland, taken from the NewCronos data base. In order to calculate the value for the markup parameter, we need to define several variables. First, we define the markup of price to marginal cost as $P_H/P_v = 1/\theta$. Then we need to define profit as $\Pi = y - vy$, where v is the unit cost. In steady state $v = \theta$, so $\Pi/y = 1 - \theta$. To obtain a estimate of Π/y we follow Domowitz et al. (1986) and define the price-cost margin as $(value\ added - payroll)/(value\ added + cost\ of\ materials)$. In the steady state of the model the numerator of the former equation equals $\Pi + (r + \delta)k$. We calculate the denominator as Jorgenson et al. (1987), assuming that the value for the cost of materials is similar to the value added. We then calculate the steady state values for $r + \delta$ and k/y. The previous calculations imply the value for Π/y. Using the last value, we find the markup, which implies the value for θ.

We choose the number of periods that prices stay fixed for each group of producers, based on Gali et al. (2001) estimates that the number of quarters that price stay fixed in Europe to be about six, so we use this value for all countries.

Capital Accumulation   We could not find data for the capital stock of these countries, so we use data for the Eurozone taken from AMECO, for the 1991-2007 period, and we assume that the steady-states for these economies will be close to the Eurozone value. The depreciation rate for capital, δ, was calculated implicitly by the following formula:

$$k_t = (1 - \delta)k_{t-1} + I_t \tag{21}$$

We use data for the capital stock and gross fixed capital formation (GFCF).

Adjustment Costs   The adjustment cost function has the following expression:

$$\phi\left(\frac{I}{k}\right) = b\left(\frac{I}{k} - \delta\right)^2/2 \tag{22}$$

the function is convex and satisfies the conditions $f(\delta) = 0$ and $f\prime(\delta) = 0$, implying that total and marginal costs of adjustment in steady-state are zero. b is the adjustment costs parameter.

4.3 Shocks

4.3.1 Technological Shocks

The technological shocks A_t and A_t^* are common to all intermediate goods producers of each country, following a stochastic process:

$$\log A_{t+1} = \rho^A \log A_t + \varepsilon_{t+1}^A \tag{23}$$

and

$$\log A_{t+1}^* = \rho^A \log A_t^* + \varepsilon_{t+1}^{A^*} \tag{24}$$

where technological innovations ε^A and ε^{A^*} have a normal distribution, with zero mean, σ^A standard deviation, and are cross-country correlated but are not correlated with the monetary and government consumption shocks. We estimate a $VAR[1]$ for each one of the three economies and the Eurozone for the period between 1995:01-2007:04. Solow residuals were estimated using labor data only, because quarterly capital stock data is not available for these countries.

4.3.2 Government Consumption Shocks

Government consumption shocks are modelled as stochastic processes, with the following expressions:

$$\log g_{t+1} = (1 - \rho^g) \mu^g + \rho^g \log g_t + \varepsilon_{t+1}^g \tag{25}$$

and

$$\log g_{t+1}^* = (1 - \rho^g) \mu^g + \rho^g \log g_t^* + \varepsilon_{t+1}^{g^*} \tag{26}$$

where government shocks ε^g and ε^{g^*} have a normal distribution, with μ^g mean, and σ^g standard deviation. These shocks are not correlated with monetary shocks, with technological shocks, or with the foreign government consumption shocks. We use quarterly data from the EUROSTAT National Accounts for the period between 1995:01-2007:04 to estimate the parameters.

4.3.3 Monetary Policy Shocks

In this model the National Central Bank follows a Taylor Rule, represented in equation (11). For all three countries the rule of the National Central Bank exhibits a positive correlation of 0.1 with foreign monetary shocks. We assume this since countries, although outside the Eurozone, are hit by common shocks, so monetary policy rules usually can have some level of correlation.

The policy rule of the ECB is characterized by equation (12). For this institution the parameters for ρ_r, ρ_π, and ρ_O are 0.85, 1.48, and 0.60 respectively. The volatilities of this rule differ between simulations for each country; these are 0.679%, 0.338%, and 0.605% for the Czech Republic, Hungary, and Poland, respectively. In the same order, their economic weight, ϖ, is 1.1%, 0.9%, and

3.1%. We kept a fixed exchange rate in the simulation where the ECB is in charge of monetary policy, calibrating with the most recent values for the nominal exchange rate. Policy rules for the Czech Republic, Hungary, and Poland were based on Angeloni et al. (2005). We loosely assume that all three countries have a floating exchange rate, since Hungarian and Polish currencies fluctuate, and Czech Republic has a managed float. The Taylor Rule of the ECB was taken from Hayo and Hoffman (2006).

The variances of the three shocks were calculated in order to reproduce the volatility of output close to empirical data.

4.4   Summary

Calibration for these countries exhibit some differences that are worth noting as we can see in Table 4; namely, in Hungary technological shocks are more persistent than in the other two countries, although Poland presents strong and positive cross-country correlations. The value of the elasticity of substitution between domestic and imported goods for Poland is much higher than in the other two countries. Czech Republic is the country where people spend most time working. The Taylor Rule of Hungary in simulation *Autonomous Monetary Policy* is smoother than in the other two countries. These differences are going to influence the value of the results and play an important role in the decision process to join (or not) the EMU.

Table 4 - Calibration Values for the Three Countries at Study

	CZE	HUN	POL
Preferences			
β	0.995	0.996	0.991
φ	335	245	319
η	-0.222	-0.100	-0.299
κ	3.52	2.73	3.51
Final Good Technology			
ρ	0.346	0.265	0.691
a_1	0.635	0.672	0.634
a_2	0.365	0.328	0.366
Intermediate Good Technology			
α	0.385	0.385	0.400
δ	1.18%	1.18%	1.18%
θ	0.915	0.922	0.938
b	48	46	29
Taylor Rule National Bank			
ρ^r	0.90	0.95	0.90
ρ^π	1.27	1.18	1.18
ρ^O	0.11	0.50	0.79
σ^r	0.004	0.002	0.006
Technological Shocks			
ρ^A	0.376	0.826	0.530
σ^A	0.005	0.012	0.010
$corr(\varepsilon^A, \varepsilon^{A^*})$	0.017	0.178	0.422
Government Consumption Shocks			
ρ^g	0.972	0.983	0.981
σ^g	0.005	0.012	0.010
μ^g	0.119	0.138	0.110

5   Results

5.1   Methodology

The main purpose of this work is to formally analyze the consequences of different rules for monetary policy, in terms of consumer welfare in the three countries. We therefore ask how much consumption consumers are willing to give (or receive) in order to remain indifferent between the *Common Monetary Policy* and the *Autonomous Monetary Policy* regimes. This corresponds to calculating the compensating variation associated to the full elimination of the *Autonomous Monetary Policy* regime. The welfare analysis follows the Lucas (1987) method.

A simulation of 1000 periods was made in both regimes. In the *Common Monetary Policy* regime technological and government consumption shocks take place both in the domestic and foreign economy, whereas monetary shocks only occur in the foreign economy, representing the Eurozone. In the *Autonomous Monetary Policy* regime, both economies suffered all three shocks. Based on the simulated time series we calculate the average value of the utility function for both regimes. Given the average values, we calculated the compensating

variation in terms of consumption in the following way:

$$U_0 \left(\lambda c_0, l_0, M/P_0 \right) = U_1 \left(c_1, l_1, M/P_1 \right)$$

where U_0 uses the values for c, l, and M/P of the *Common Monetary Policy* regime and U_1 uses the values of the *Autonomous Monetary Policy* regime. The value of λ represents the gains (or losses) of welfare in terms of consumption percentage.

The main purpose of this section is to analyze the behavior of these three economies in the presence of shocks, but we also verify if the model can replicate some of the main features of business cycle stylized facts. We first analyze the results for business cycles statistics of the simulated economies in the two monetary regimes. Tables A1 to A3 in Appendix A present the results in the third and fourth column of the statistics for the *Common Monetary Policy* and *Autonomous Monetary Policy* simulations, respectively, for the domestic economy.

Variables are more volatile in the *Autonomous Monetary Policy* simulation for all three countries, where not only are there government consumption and technological shocks, but also the monetary policy shock in the domestic economy. In the *Common Monetary Policy* simulation there are no monetary policy shocks in the domestic economy, since monetary policy is established by the European Central Bank; hence, volatility is lower in this simulation. In addition, when we impose equation (13) the volatility of variables decrease. Simulation *Autonomous Monetary Policy* returns, on average, volatilies more similar to the data than the other simulation.

Although comparisons of the behavior of autocorrelations differ from country to country and depend on the magnitude of the shocks and the comovements between them, on average persistence is higher in the *Autonomous Monetary Policy* simulation. This is a logical result, since monetary policy is oriented towards the domestic economy, which means that monetary policy stabilizes the economy more, making variables more persistent.

Analyzing the cross-country correlations we find that simulation *Common Monetary Policy* has on average the higher cross-country correlations. This happens also because of the imposition of equation (13), so especially for consumption and investment, these cross-country correlations are very high and seem to dominate the pattern of cross-country correlations. Simulation *Autonomous Monetary Policy* returns, on average, cross-country correlations more similar to the data than simulation *Common Monetary Policy*.

5.2 Welfare Calculations

The results based on the methodology decribed are presented in Table 5 and are very similar across countries. Consumers in the Czech Republic and Poland are willing to give up consumption in order to live in an economy where the monetary policy is established by the National Central Bank. Hungarian consumers

prefer, marginally, to enter the Eurozone.

Table 5- Welfare Results for Benchmark Economies

	c	l	M/P	U	λ
Czech Republic					
Common Monetary Policy	0.191	0.251	0.199	224.55	-0.63%
Autonomous Monetary Policy	0.191	0.250	0.197	224.76	
Hungary					
Common Monetary Policy	0.125	0.240	0.458	164.08	+0.05%
Autonomous Monetary Policy	0.125	0.240	0.457	164.02	
Poland					
Common Monetary Policy	0.188	0.237	0.099	216.02	-0.22%
Autonomous Monetary Policy	0.188	0.237	0.099	216.06	

The nominal interest rate in the *Autonomous Monetary Policy* regime is on average higher than in simulation *Common Monetary Policy*, in accordance to happens in these economies, where inflation rates are also higher. Higher interest rates bringing about a higher drop in average consumption. Therefore, on average labour has to rise by less in order to satisfy the increase in consumption and also to satisfy output demand. The behaviour of labour explains why consumers prefer the *Autonomous Monetary Policy* regime, at least in Poland and in the Czech Republic. Labour in this simulation is on average lower; as a result there is more leisure and consumers are better off. In Hungary, consumers prefer, marginally, to join the Eurozone. The Hungarian monetary polic rule proves to be less stabilizing than the interest rate rule of the ECB, since the interest rate smoothing parameter is very high in comparison with the EMU. This means that the interest rate rule in Hungary does not disturb much the economy but can not perform its stabilizing role. It is enough to increase the response of the inflation parameter of the Hungarian domestic central bank to invert results.

Nominal exchange rate stability can be one of the benefits of joining the EMU, since in simulation *Common Monetary Policy* both volatilities of the price ratio between countries and the real exchange rate are lower than in simulation *Autonomous Monetary Policy*. But as we can see, for these countries, the costs of relinquishing monetary policy are higher, except for the case of Hungary. In simulation *Autonomous Monetary Policy* for the Hungarian economy the volatility of the price ratio is well above the values found for the other two economies, reenforcing once again the weaker stabilization role of the interest rate rule for this economy.

Results are also in agreement with some of the empirical evidence of Section 2, namely idiosyncratic shocks in Hungary have a smaller role than those of the Czech Republic and Poland. If a country has a smaller specific component of a given shock, costs of entering a common currency and monetary policy area and relinquishing its monetary policy are obviously lower. Also, cross-country correlations between Hungary and the Eurozone are the highest of the three countries at study, meaning that business cycle synchronization, an important

aspect to be taken in account in the decision of joining EMU, is high. The empirical evidence also explains part of the results for the Czech Republic, since the proportion of idiosyncratic shocks is higher and business cycle synchronization is low.

The main differences between simulations within each country are the volatility of the monetary policy shocks, the parameters of the Taylor rules, and the difference between who runs the monetary policy (i.e., Taylor Rule, with or without economic weights). The different welfare results for each country are explained obviously by different parameters, but most importantly by differences regarding the magnitude of technological, government consumption, and monetary policy shocks. In the next section we are going to analyze and discuss some of these parameters.

6 Robustness

In this section we analyze the robustness of the model in terms of the benchmark welfare value (λ) computed above. For simplicity we restrict our discussion to the most significant parameters in the model.[3] All simulations follow the procedure described before. Table 6 summarizes the results for each of the three transition countries. These results reinforce the decision of Poland and of the Czech Republic not to join the Eurozone, at least in the near future. Results for Hungary are less clear cut.

Table 6 - Results for Sensitivity Analysis

CZE	HUN	POL
Benchmark		
-0.63%	+0.05%	-0.22%
No Technological Shocks		
-0.63%	-0.15%	-0.22%
No Government Consumption Shocks		
-0.43%	+0.02%	-0.11%
Same Volatility for Taylor Rules		
-1.91%	-0.27%	-0.23%
Weight of imported goods from the Eurozone		
-0.84%	-0.23%	-0.28%
Increase in Risk Aversion		
+0.12%	-0.60%	-0.22%

Generally we find that changes in the values of the import share and government consumption shocks seem to have the biggest impact in the change of the welfare value.

Technological shocks do not change much the results for these countries, except in the case of Hungary where they are significantly more persistent. It seems that the Taylor rule of the ECB stabilizes more technological shocks for

---

[3] We increase the correlations of monetary policy shocks to 0.5, increase the relative risk aversion coefficient by 25%, and decrease the weight of imported goods from the Eurozone to 25% less of its initial value.

the Hungarian economy, than the monetary policy rule of the domestic economy, and in fact the output parameter of the Taylor rule of the ECB is higher than the one of the Hungarian Central Bank. When technological shocks are removed consumption rises by more, but labour also rises by more to compensate the excess demand, since the income effect prevails, so utility falls in the *Common Monetary Policy* simulation. In the other simulation, since the output parameter does not react much to the technological shock, utility is constant.

When we remove government consumption shocks from both simulations, results for Hungary are negiglible but for Poland and the Czech Republic are strong. The need to stabilize idiosyncratic domestic spending shocks disappears, making consumers more willing to join the EMU. Hungary, due to its weak inflation parameter in the domestic central bank again needs the more agressive monetary policy rule of the ECB to control domestic shocks. We tested for a more agressive inflation parameter in the Hungarian central bank and results invert, namely in the absence of a domestic shock consumers in Hungary prefer more to join the Euzone, just like in the other two countries.

In these economies the monetary policy rule of the domestic central bank has always a lower volatility than the monetary policy rule of the ECB. When we increase the volatility of the first rules in order to match the volatility of the ECB, these three countries prefer even more to stay out of the Eurozone. If we look at Table 4, we can see that the interest rate smoothing parameter is always higher in the monetary policy rule of the domestic central bank. This means that intervention by each one of these central banks is not done in a quick way, but also does not introduce volatility in the economy. However, since these economies do not have a very high value for the inflation parameter, but do have high inflation rates, higher than the ones observed in the Eurozone, some volatility of the monetary policy shock is needed in order for monetary policy to have some effect. That is why they even prefer more to stay out of the Eurozone, even with higher volatility of the shocks, because they need this volatility. We perform another simulation where these three countries have a lower interest rate smoothing parameter, which is equal to the one of the ECB, and results are the opposite, since now they are able to stabilize the economy more and they do not need extra volatility.

For these countries we find that decreases in trade volume with the Eurozone increases the costs of adopting a common monetary policy. This finding is consistent with the theory of the endogeneity of optimum currency areas (Frankel and Rose, 1998). A low trade volume increases the domestic economies exposure to idiosyncratic shocks and makes a common monetary policy less desirable.

Increasing the relative risk aversion coefficient increases the preferences of consumers for present consumption. So, consumers will prefer a regime where interest rates are lower in order to have higher consumption, but without making labour increase by much or volatility in the economy. This happens in the Eurozone, where interest rates are lower than in the three transition countries. The impact of this change also depends on the discount factor β, since a high

discount factor reveals preference for present consumption.

7   Conclusions

Although convergence is moving at a significant pace in the three transition economies, some flexibility regarding monetary policy is needed to accommodate shocks, especially in the Czech Republic and Poland. As a result, on average EMU membership can be a costly decision for these two countries in terms of the loss of monetary policy. For the Hungarian economy, results are lower and it seems that Hungarian consumers are somehow indifferent between the monetary policy of their National Central Bank and the monetary policy of the ECB.

Detailed analysis of the results shows that the loss of monetary policy flexibility is more or less costly depending on several factors. The decision to enter is more costly when government shocks are important (for the Czech Republic and Poland), when technological shocks are important (for Hungary), and it also depends on the value of the import share between the countries under study and the EMU. Benefits of joining EMU, for some countries, can arise from a more active monetary policy and if consumers have a strong preference for present consumption.

One of the most important benefits of joining the EMU is the elimination of transaction costs. For transition countries there are already some studies that try to assess the benefits of this elimination. For Poland, Wojcik (2000) found that the country could gain 0.1% of GDP every year by eliminating transaction costs. Estimates for this benefit from the National Bank of Poland (2004) reached a value of 0.2% of GDP per year. The National Bank of Hungary reached a value for Hungary of between 0.18-0.3% of GDP (Csajbók, Csermely, eds., 2002). In countries which have a poorly developed financial system, the gains from eliminating transaction costs are higher, since they have fewer financial products to defend themselves from exchange rate risk. Brouwer et al. (2008) also state that the trade and foreign direct investment (FDI) for Central and Eastern European countries of joining the euro would be positive, being smaller for Poland and larger for Hungary.

Converting our benchmark results to percentage of GDP, we find that in Poland and in the Czech Republic, consumers are willing to give up between 0.1 and 0.3% of their consumption as a percentage of GDP, to live in an economy with an autonomous central bank. The calculation of some benefits and other costs are excluded, but the values found in this work for the costs of the loss of monetary policy flexibility are similar to the benefits associated with the disappearance of transaction costs.

References

[1] Angeloni, I., Flad, M., Mongelli, F. P., 2005. Economic and Monetary Integration of the New Member States - Helping to Chart the Route. *ECB*

Occasional Paper Series N° 36, September.

[2] Blanchard, Oliver; Kahn, Charles, 1980. The solution of linear difference models under rational expectations. *Econometrica* 48 (5), July, 1305 - 1311.

[3] Brouwer, J., Paap, R., Viaene, J.M., 2008. The Trade and FDI Effects of EMU Enlargment. *Journal of International Money and Finance* 27, 188-208.

[4] Bruha, J., Podpiera, J., Polák, S., 2007. The Convergence Dynamics of a Transition Economy: The Case of the Czech Republic. *IMF Working Paper 07/116*, May.

[5] Carré, Martine; Collard, Fabrice, 2003. Monetary Union: a welfare based approach. *European Economic Review* 47, 521-552.

[6] Ca' Zorzi, Michele; Santis, Roberto A. de; Zampolli, Fabrizio, 2005. Welfare implications of joining a common currency. European Central Bank, *Working Paper Series* 445, February.

[7] Chari, V.V.; Kehoe, Patrick J.; McGrattan, Ellen R., 2002a. Can sticky price models generate volatile and persistent real exchange rates? *Review of Economic Studies* 69 (3), July, 533-563.

[8] Chari, V.V.; Kehoe, Patrick J.; McGrattan, Ellen R., 2002b. Technical Appendix: Can sticky price models generate volatile and persistent real exchange rates? Federal Reserve Bank of Minneapolis, *Research Department Staff Report* 277.

[9] Clarida, Richard; Gali, Jordi; Gertler, Mark, 1999. The Science of Monetary Policy: A New Keynesian Perspective. *Journal of Economic Literature* XXXVII, December, 1661-1707.

[10] Clarida, Richard; Gali, Jordi; Gertler, Mark, 2000. Monetary Policy Rules and Macroeconomic Stability. *The Quarterly Journal of Economics* 115, 147–180.

[11] Cooley, Thomas F. editor, 1995. Frontiers of business cycles research. Princeton University Press.

[12] Corsetti, G., 2008. A Modern Reconsideration of the Theory of Optimal Currency Area. *European Economy Economic Papers 308*, March, European Commission, Directorate-General for Economic and Financial Affairs.

[13] Csajbók, Attila; Csermely, Ágnes, eds., 2002. Adopting the euro in Hungary: expected costs, benefits and timing. *National Bank of Hungary Occasional Papers* 24.

[14] Domowitz, Ian; Hubbard, R. Glenn; Petersen, Bruce C., 1986. Business Cycles and the relationship between concentration and price cost-margins. *Rand Journal of Economics* 17, 1-18.

[15] Fidrmuc; J.; Korhonen, I., 2003. Similarity of supply and demand shocks between the euro area and the CEECs. *Economic Systems* 27, 313-334.

[16] Frankel, J. A.; Rose, A.K., 1998. The Endogeneity of the Optimum Currency Area Criteria. *Economic Journal* 108(449), 1009-1025.

[17] Furceri, D., Karras, G., 2006. Are the New Members Ready for the Euro? A Comparison of Costs and Benefits. *Journal of Policy Modeling* 28, 25-38.

[18] Gali, Jordi; Gertler, Mark; Lopez-Salido, J. David, 2001. European inflation dynamics. *European Economic Review* 45, 1237-1270.

[19] Goodfriend, Marvin; King, Robert G., 1997. The New Neoclassical Synthesis and the Role of Monetary Policy. *NBER Macroeconomics Annual*, 231-283.

[20] Hayo, Bernd, Hoffman, B., 2006. Comparing Monetary Policy reactions functions: ECB versus Bundesbank. *Empirical Economics*, Vol. 31, Issue 3, pp. 645-662.

[21] Holtemöller, O., 2007. The Effects of Joining a Monetary Union on Output and Inflation Variability in Accession Countries. *Mimeo*. April.

[22] Jorgenson, Dale; Gollop, Frank; Fraumeni, Barbara, 1987. Productivity and US economic growth, Cambridge, Massachusetts, MIT Press.

[23] Kenen, P., 1969. The theory of optimum currency areas: an eclectic view. In: R. Mundell and A. K. Swoboda (Eds.), Monetary Problems of the International Economy, Chicago, University of Chicago Press, pp. 41-60.

[24] Lane, Philip, 2001. The New Open Economy Macroeconomics: A survey. *Journal of International Economics* 54 (2), August, 235-266.

[25] Levasseur, S., 2008. Updating Empirical Evidence on Business Cycles Synchronization between CEECs and the Euro Area: How Important is the Recent Period. *Document de Travail Nº 2008-11*, April, OFCE.

[26] Lucas Jr., Robert, 1987. Models of Business Cycles. Yrjö Jahnsson Lecture Series, Basil Blackwell Publishers.

[27] Mackinnon; R.I., 1963. Optimum currency areas. *American Economic Review* 53, 717-725.

[28] Marcin, K., 2008. Structural Heterogeneity or Asymmetric Shocks? Poland and the Euro Area through the Lens of a Two-Country DSGE Model. *MPRA Working Paper Nº 8750*, May.

[29] Monacelli, Tommaso, 2000. Relinquishing Monetary Policy Independence. *Boston College Working Papers in Economics* 483.

[30] Mundell, Robert, 1961. A theory of optimum currency areas. *American Economic Review* 51, March, 657-665.

[31] National Bank of Poland, 2004. A report on the costs and benefits of Poland's adoption of the euro. March.

[32] Obstfeld, M.; Rogoff, K., 1995. Exchange Rate Dynamics Redux. *Journal of Political Economy* 103, 624-660.

[33] Obstfeld, Maurice; Rogoff, Kenneth, 1998. Foundations of International Macroeconomics. MIT Press.

[34] Prescott, E., 1986. Theory Ahead of Business-Cycle Measurement. *Carnegie-Rochester Conference on Public Policy* 24, 11-44.

[35] Sánchez, M., 2007. Monetary Stabilisation in a Currency Union: The Role of Catching-Up Member States. *Journal of Policy Modeling* 29, 29-40.

[36] Sánchez, M., 2008. Implications of Monetary Unions for Catching-Up Member States. *Open Economies Review* 19, 371-390.

[37] Taylor, John B., 1993. Discretion versus Policy Rules in Practice. *Carnegie-Rochester Conference Series on Public Policy* 39, 195-214.

[38] Whalley, John, 1985. Trade liberalization among major world trading areas. Cambridge, MA, MIT Press.

[39] Wojcik, Cezary, 2000. A critical review of unilateral euroization proposals: the case of Poland. *Focus on Transition* 2, Austrian National Bank, 48-76.

[40] Woodford, Michael, 2003. Interest and Prices - Foundations of a theory of monetary policy. Princeton University Press.

[41] Zienkowski, Leszek, 2000. Labor and Capital Productivity in Poland. Central Statistics Office, Poland.

8   Appendix A - Data Specification and Results for Business Cycle Statistics

Data was taken from the Quarterly National Accounts of NewCronos, an electronic database from EUROSTAT. The variables used are output (y), private consumption (c), investment (I), net exports as a percentage of GDP (nx), all at constant prices, and employment (l). We used quarterly data for the Czech Republic, Hungary, Poland, and the Eurozone at 15 member countries for the period between 1995:01 and 2007:04. H-P filter was used to remove the trend and X-12 was used to remove seasonality, whenever data was not seasonally adjusted. All variables are in logarithms except net exports as a percentage of GDP. The cross-country correlations are for each of the three countries and the

Eurozone. Results are presented in the second column of Tables A1, A2, and A3.

Table A1 - Statistics and Stylized Facts for Czech Republic

	Data	Common Monetary Policy	Autonomous Monetary Policy
Standard Deviations			
Y	1.31	1.31	1.31
NX	1.55	0.17	1.51
Standard Deviations Relative to GDP			
c	1.42	0.48	0.66
I	3.71	2.96	3.88
l	0.72	1.79	2.20
Autocorrelations			
Y	0.60	0.54	0.65
c	0.66	0.54	0.64
I	0.68	0.53	0.63
l	0.85	0.56	0.64
NX	0.65	0.73	0.61
Cross-Country Correlations			
(Y, Y^*)	0.09	1.00	0.81
(c, c^*)	-0.44	1.00	-0.02
(I, I^*)	-0.33	1.00	-0.05
(l, l^*)	-0.22	0.95	0.35
(Y, NX)	-0.004	0.04	0.25

Table A2 - Statistics and Stylized Facts for Hungary

	Data	Common Monetary Policy	Autonomous Monetary Policy
Standard Deviations			
Y	0.81	0.81	0.81
NX	2.06	0.63	0.97
Standard Deviations Relative to GDP			
c	2.82	0.57	0.69
I	8.07	2.49	3.18
l	0.99	2.91	3.05
Autocorrelations			
Y	0.70	0.65	0.69
c	0.82	0.61	0.59
I	0.40	0.56	0.58
l	0.81	0.69	0.68
NX	0.41	0.75	0.66
Cross-Country Correlations			
(Y, Y^*)	0.23	0.65	0.60
(c, c^*)	0.02	0.96	0.05
(I, I^*)	0.26	0.98	-0.11
(l, l^*)	0.62	0.30	0.18
(Y, NX)	-0.27	0.37	0.29

Table A3 - Statistics and Stylized Facts for Poland

	Data	Common Monetary Policy	Autonomous Monetary Policy
Standard Deviations			
Y	1.36	1.36	1.36
NX	1.58	0.34	1.00
Standard Deviations Relative to GDP			
c	0.76	0.38	0.50
I	5.18	3.70	4.88
l	1.15	2.03	2.10
Autocorrelations			
Y	0.62	0.50	0.37
c	0.79	0.54	0.58
I	0.88	0.52	0.56
l	0.78	0.54	0.53
NX	0.30	0.00	0.13
Cross-Country Correlations			
(Y, Y^*)	0.35	0.92	0.36
(c, c^*)	-0.24	0.99	-0.04
(I, I^*)	0.51	1.00	-0.16
(l, l^*)	-0.12	0.84	0.26
(Y, NX)	-0.28	0.13	-0.09

9   Appendix B - Some Further Business Cycle Calculation

The data was taken from AMECO database, an online annual database of the European Commission. We estimated an OLS regression based on the following expression:

$$
\begin{aligned}
y\_cic_t &= \beta_1 y\_cic_{t-1} + \beta_2 y\_cic_{t-2} + \beta_3 y\_cic_t^* + \\
&\quad \beta_4 y\_cic_{t-1}^* + \beta_5 y\_cic_{t-2}^* + \varepsilon_t
\end{aligned} \tag{27}
$$

where y_cic is the cyclical component of real GDP of the domestic economy and y_cic^* is the cyclical component of real GDP of the foreign economy. ε_t can be regarded as the idiosyncratic component of the domestic economy fluctuations, i.e., the part of the domestic economy cycle that is not explained by the Eurozone business cycle (or alternatively the USA) nor by the past behavior of the country cycle. The variables were detrended using H-P filter with a value of 100. For each country we try several estimations in order to achieve the best possible fit. This means that whenever variables were not statistical significant, they were removed.

Our purpose with these calculations was to assess the proportion of the business cycle explained by idiosyncratic shocks in each of the three countries. This proportion is calculated in the following way: $\frac{\sigma_{\varepsilon_t}}{\sigma_{y\_cic_t}}$, where σ_{ε_t} is the standard deviation of the idiosyncratic component of the cycle and $\sigma_{y\_cic_t}$ is the total standard deviation of the cycle in the domestic economy. So, the

bigger the value of this ratio, the bigger the proportion of the business cycle is due to specific country shocks. Our aim was also to compare the importance of the Eurozone and the USA in explaining the economic cycle of these countries, which is why we made two estimations for each country: one where the foreign economy is the Eurozone, and another where the foreign economy is the USA.