The Costs of EMU for Transition Countries*

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Abstract

Czech Republic, Hungary and Poland will have to join the European and Monetary Union. Surprisingly, there is very little work on the welfare consequences of the loss of monetary policy flexibility for these countries. This paper fills this void by providing a framework to evaluate quantitatively the economic costs of joining the EMU. Using a two country dynamic general equilibrium model with sticky prices we investigate the economic implications of the loss of monetary policy flexibility associated with EMU for each country. The main contribution of our general equilibrium approach is that we can evaluate the effects of monetary policy in terms of welfare. Our findings suggest that these economies may experience sizable welfare losses as a result of joining the EMU. Results show that the cost associated with the loss of the monetary policy flexibility is bigger in the presence of persistence technological shocks, weak correlation of monetary shocks, strong risk aversion and a small trade share with the EMU.

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1 Introduction

Should Poland, Hungary and Czech Republic adopt the euro? In this paper we construct a model to evaluate the economic costs of the loss of monetary policy

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due to joining EMU, for these three countries. The reason of the choice of these particular countries relies on the fact that these are the biggest economies that joined the EU in May of 2004.

Our focus is the loss of autonomy of monetary policy and its implications in respect to business cycle synchronization. Business cycle synchronization is an important decision factor to join EMU. If a country's economic cycle does not move along with the economic cycle of EMU, it is not a good decision to join the euro. The monetary policy will have different impacts on a country at different stages of the cycle.[1]

Using a two country 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 the three countries. In the model used in this work, the monetary policy has real effects in the economy, because sticky prices are introduced in the model, making agents slower in adjusting to monetary shocks. Hence, in this model, monetary policy can be used as a short run economic policy. In this work we consider a country that it is hit by shocks, and compare the resolution of the problem in two different stochastic simulations: (1) one in which the monetary policy is established by the European Central Bank (ECB), that only considers the weighted average economic situation of the Eurozone, and (2) a monetary policy established by the National Central Bank of the countries at study, in which the National Central Bank only cares about the economic situation of the domestic economy. The comparison of the two simulations has the purpose, through the calculation of a welfare analysis, to assess if consumers prefer, or not, a National Central Bank concerned with the effects of shocks in a given economy.

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. It 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 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

[1] Chamie, DeSerres and Lalonde (1994) and Gros and Hefeker (2002) discuss asymmetric shocks and the level of asymmetry between regions. Traditionally this type of work compares the EU with USA. Results show that the USA presents a higher level of symmetry between regions than EU. This supports the fact that some European countries are going to suffer more than others from joining the euro. Also, in face of shocks, European economies do not seem to converge or be symmetric in their responses, in fact they diverge. The monetary policy of the ECB in the presence of asymmetry is also discussed.

and the larger the gain in potential output (compared with the gain in potential output of a flexible exchange rate regime), (Ca'Zorzi, Santis and Zampolli, 2005).

When used to study the costs in terms of stabilization and welfare of joining a currency union, it 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 has a negative correlation with the degree of cross-country symmetry of the 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).[2]

This work tries to unify two types of literature: the optimum currency areas literature with seminal work by Mundell (1961), McKinnon (1963) and Kenen (1969) and the dynamic general equilibrium models (DSGEM) literature in the tradition of Svensson and Wijnbergen (1989), Obstfeld and Rogoff (1995, 1998) and Chari, Kehoe and McGrattan (2002*a*) in order to perform a welfare analysis for evaluating different monetary policy regimes.[3] We provide a framework to evaluate the economic costs of joining EMU, to investigate the economic implications of the loss of the monetary policy flexibility associated with EMU and to evaluate the effects of monetary policy in terms of welfare. We use this framework to study the decision of joining European Monetary Union in terms of the loss of monetary policy flexibility for Czech Republic, Hungary and Poland, calibrating models specifically for each economy, a task we never saw done in the literature and for the purpose stated above.[4]

In section 2 we present empirical evidence regarding synchronization and convergence for the three economies. In section 3 we present the model and in section 4 we show the methodology (and values) used in calibration. Section 5 discusses the results and economic intuition for the simulations and in section 6 a welfare analysis and also a sensitivity analysis are made, this last one to

[2] To see the study of this subject in limited participation models the works of Cooley and Quadrini (2003), Metz (2004) and Furstenberg and Teolis (2002) are good references. Also in the context of game theory see Hallet and Weymak (2002) and Monticelli (2003). For models with optimal linear feedback Taylor rules see Aksoy, De Grauwe and Dewachter (2002). Their results imply different conclusions about joining a currency union, with results depending, among others, on the degree of commitment to reducing inflation, on the number of countries and on the idiosyncracy, type and degree of correlation of the shocks,

[3] See Goodfriend and King (1997), Clarida, Gali and Gertler (1999) and Lane (2002) for recent discussions on this topic.

[4] For the countries at study in this paper we found that Holtemöller (2004) calculated for Czech Republic, Hungary and Poland an optimum currency area index 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 author compares national monetary policy with monetary union in a two country neo-keynesian model. 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. Results for Poland are inconclusive. Merlevede, Plasmans and Aarle (2003) use a dynamic general equilibrium model to study the effects of joining the EU on the Central and Eastern European Countries and find positive growth effects on these countries for joining the EU.

check the robustness of welfare results. Section 7 concludes and presents some discussion of the results and some limitations of this work and suggestions for future research.

2 Empirical Evidence

Czech Republic, Hungary and Poland joined the EU in May of 2004. These countries are making a substantial effort to converge both in real and nominal terms to the EU-15 average and they are obliged to join the European Monetary Union sometime in the future.[5]

Hungary plans to join the euro in 2010 and join the European Exchange Rate Mechanism II (ERM II) as soon as possible after accession. Its currency is currently pegged to the euro with a wide band of 15%. Poland plans to join the euro sometime between 2008 and 2009, but despite this goal has no target date for joining ERM II and its currency is currently floating. Czech Republic has not yet set a date for joining the euro but has the goal of joining the ERM II when convergence criteria are achieved. Its currency is on a managed float.[6]

The economic conditions of these countries do not differ much from the ones in Portugal and Greece, the poorest of the European Union economies, at the time of their accession. These countries are also small open economies like Portugal and Greece, but have a much higher degree of openness to trade. This makes them specially vulnerable to shocks and highly dependent of foreign trade partners. Table 1 shows the values for these indicators.[7]

Table 1 - Comparison of GDP *per capita* and degree of openness in the accession year

Countries	GDP per capita in PPP (EU-15=100)	Degree of Openness
Greece (1981)	62.6%	19.8%
Portugal (1986)	52.8%	31.4%
Czech Republic (2004)	63.1% (*f*)	63.6% (*f*)
Hungary (2004)	56.6% (*f*)	69% (*f*)
Poland (2004)	43.7% (*f*)	36% (*f*)
(f) - forecast. *Data Source:* NewCronos database		

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. ECB does not take in account the economic situation for each economy when establishes its monetary policy, but the average economic condition of the Eurozone. If we look at business cycle synchronization for these economies we can see that Poland has a significative positive correlation with European

[5] The reason of the choice of these particular countries relies on the fact that these are the biggest economies that joined the EU in May of 2004.

[6] See European Economy, European Commission, *Enlargement Papers N^o^* 20, November 2003.

[7] Degree of Openess is calculated as [(exports+imports)/2]/GDP*100. The variables are in nominal terms. EU-15 is the European Union with the former fifteen countries.

Union for output and investment and a slightly lower positive correlation with employment and consumption. Hungary has a strong positive correlation with European Union output and a lower positive correlation for investment and employment. Consumption does not appear to be synchronized. Synchronization does not exist between Czech Republic and European Union, with all the correlations for the variables being negative.[8] Also important is the proportion of the economic cycle of each country that is explained by an idiosyncratic component. If the idiosyncratic component is very high that could be a problem for EMU accession, because the higher the correlation between the economic cycle of a country and the Eurozone the smaller is the welfare loss of giving up monetary policy. Results for the countries at study are presented in table 2:

Table 2 - Proportion of the variability of the specific component in the total variability of the cycle

	1992 – 2004	
	Eurozone	USA
Czech Republic	0.38	0.39
Hungary	0.13	0.16
Poland	0.15	0.21

As we can see in table 2 the weight of the specific component is small in the three countries, but specially small 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.[9,10]

3 Model

We develop a dynamic equilibrium model in the tradition of Chari, Kehoe and McGrattan (2002*a*), but modified it to take into account an interest rate rule like the one suggested by Taylor (1993), allowing also forward looking behavior. This setting allows us to construct 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 EMU, to investigate the economic implications of the loss of the monetary policy flexibility associated with EMU and to evaluate the effects of monetary policy in terms of welfare.

It is a model with price rigidities in which the monetary policy has real effects. There are two countries in the model with infinitely lived consumers and also competitive final goods producers and monopolistically competitive

[8] See Appendix *II*, Tables 8, 9 and 10.

[9] See Appendix *III* for further details on methodological issues.

[10] Fidrmuc and Korhonen(2003) have calculations of correlations of supply and demand shocks between the accession countries and the Eurozone. They conclude that EMU accession would be easy for Hungary, and have mixed results for Poland and Czech Republic. They also present some review of literature of business cycle syncronization between Central Europe and Eastern Countries (CEECs) and EMU.

intermediate goods producers. This last group of agents sell their products to the final goods producers, being this last type of goods non-traded. Trade between economies is in intermediate goods, produced by monopolists who can charge different prices in two countries.[11] Intermediate goods prices are set on local market currency, each producer having the right to sell his good in the two countries. Once prices are set, each intermediate goods producer must satisfy his demand.

In each period the goods existing in the economy are 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).

3.1 Consumers

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

$$\begin{aligned} & P(t)\, c(t) + M(t) + \sum_{t+1} Q(t+1 \mid t)\, B(t+1) \\ \leq \quad & P(t)\, W(t)\, l(t) + M(t-1) + T(t) + B(t) + \prod(t) \end{aligned} \tag{1}$$

and a borrowing constraint $B(t+1) \geq -P(t)\,\overline{b}$, where $c(t)$, $l(t)$ and $M(t)$ are respectively, consumption, labor and money, $T(t)$ are transfers of home currency, $\prod(t)$ represents profits of the home country intermediate goods producers, $P(t)$ is the price of the final good, $W(t)$ represents real wages and the positive constant $\overline{b}$ constrains the amount of real borrowing of consumers. The initial conditions $M(-1)$ and $B(0)$ are given. In this economy markets are complete. The asset structure is represented by having complete government bonds designated by $B(t, t+1)$, which represents the home consumers holdings of such a bond purchased in period t with payoffs contingent on period $t+1$. $B^*(t, t+1)$ is the foreign consumers holdings of this bond. $Q(t+1|t)$ is the price of this bond in units of the home currency in period t.

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

$$\sum_{t=0}^{\infty} \sum_{t} \beta^t U\left(c(t), l(t), M(t)/P(t)\right) \tag{2}$$

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

$$-\frac{U_l(t)}{U_c(t)} = W(t)$$

[11] See Knetter (1989, 1993) for empirical evidence on pricing to market.

$$\frac{U_m(t)}{P(t)} - \frac{U_c(t)}{P(t)} + \beta \sum_{t+1} \pi(t+1 \mid t) \frac{U_c(t+1)}{P(t+1)} = 0$$

$$Q(t \mid t-1) = \beta \pi(t \mid t-1) \frac{U_c(t)}{U_c(t-1)} \frac{P(t-1)}{P(t)}$$

where $Uc(t), Ul(t)$ and $Um(t)$ are the derivatives of the utility function with respect to its arguments and $\pi(t|t-1) = \pi(t)/\pi(t-1)$ is the conditional probability of t given $t-1$.

3.2 Final Goods Producers

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

$$y(t) = \left[a_1 \left(\int_0^1 y_H(i,t)^\theta \, di \right)^{\frac{\rho}{\theta}} + a_2 \left(\int_0^1 y_F(i,t)^\theta \, di \right)^{\frac{\rho}{\theta}} \right]^{1/\rho} \tag{3}$$

where $y(t)$ is the final good and $y_H(i,t)$ and $y_F(i,t)$ are intermediate goods produced in H and F respectively.[12] Parameter θ determines the markup 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, determines the elasticity of substitution between home and foreign goods. Parameters a_1 and a_2, combine with θ and ρ, determine the ratio of imports to output.

Final goods producers behave in a competitive way, choosing in each period t, inputs $y_H(i,t)$ for $i \in [0,1]$ and $y_F(i,t)$ 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:

$$y_H^d(i,t) = \frac{[a_1 P(t)]^{\frac{1}{1-\rho}} \overline{P}_H(t-1)^{\frac{\rho-\theta}{(1-\rho)(\theta-1)}}}{P_H(i,t-1)^{\frac{1}{1-\theta}}} y(t) \tag{4}$$

$$y_F^d(i,t) = \frac{[a_1 P(t)]^{\frac{1}{1-\rho}} \overline{P}_F(t-1)^{\frac{\rho-\theta}{(1-\rho)(\theta-1)}}}{P_F(i,t-1)^{\frac{1}{1-\theta}}} y(t) \tag{5}$$

where $\overline{P}_H(t-1)$ is equal to:

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

[12] This production function combines characteristics from trade and industrial organization theory, as in the works of Armington (1969) and Dixit and Stiglitz (1977).

and $\overline{P}_F(t-1)$ is equal to:

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

Because this producers behave in a competitive setting their economic profit is zero, thus the final good price is given by:

$$P(t) = \left(a_1^{\frac{1}{1-\rho}}\overline{P}_H(t-1)^{\frac{\rho}{\rho-1}} + a_2^{\frac{1}{1-\rho}}\overline{P}_F(t-1)^{\frac{\rho}{\rho-1}}\right)^{\frac{\rho}{\rho-1}} \quad (6)$$

that in period t, does not depend of the period t shock.

3.3 Intermediate Goods Producers

For each intermediate good i the technology for producing is a standard constant returns to scale production function:

$$y_H(i,t) + y_H^*(i,t) = F(k(i,t-1), A(t)\,l(i,t)) \quad (7)$$

where $k(i,t-1)$ and $A(t)$ are respectively capital and technology used in the production of the good, and $y_H(i,t)$ and $y_H^*(i,t)$ are the quantities of the intermediate good produced in H, used in the production of the final good in country H and F respectively. Intermediate producers are subject to technological shocks $A(t)$. The law of motion for capital is given by:

$$k(i,t) = (1-\delta)\,k(i,t-1) + I(i,t) - \phi\left(\frac{I(i,t)}{k(i,t-1)}\right)k(i,t-1) \quad (8)$$

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. The adjustment cost function has the following expression:

$$\phi\left(\frac{I}{k}\right) = b\left(\frac{I}{k} - \delta\right)^2/2 \quad (9)$$

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

Intermediate producers behave as imperfect competitors, setting their prices in a staggered way. In this model a monopolistic sector permits to justified why the product is determined by demand, at least in the short term when prices are fixed.[13] Specifically, in each period t, a fraction $1/N$ of producers

[13] Staggered price setting was first introduced by Fischer (1977), Phelps and Taylor (1977) and Taylor (1980). This model follows the specification of Taylor (1980). Introducing monopolists in this model is justified by recent research, which revelead the importance of a monopolistic sector in explaining such economic problems as economic growth or business cycles, as in the works of Calvo (1983), Betts and Devereux (2000) and Kollmann (2001).

in H choose a home currency price $P_H(i,t-1)$ for the home market and a price for foreign market. These prices are set for N periods, so for this group of intermediate goods producers: $P_H = (i,t+\tau-1) = P_H = (i,t-1)$ and $P_H^* = (i,t+\tau-1) = P_H^* = (i,t-1)$ for $t = 0,...,N-1$. 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.[14]

Consider for example producers in a group, namely $i \in [0,1/N]$, who choose prices $P_H(i,t-1)$ and $P_H^*(i,t-1)$, production factors $l(i,t)$, $k(i,t)$ and $I(i,t)$ to solve the following problem:

$$\max \sum_{t=0}^{\infty} \sum_{t} Q(t) \left[P_H(i,t-1)\, y_H(i,t-1) + \right.$$
$$\left. + e(t)\, P_H^*(i,t-1)\, y_H^*(i,t) - P(t)\, w(t)\, l(i,t) - P(t)\, I(i,t) \right] \tag{10}$$

subject to (7), (8) and the constraints that their supplies to home and foreign markets, $y_H(i,t)$ and $y_H^*(i,t)$, 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. $Q(t)$ is the price of one unit of home currency in t in an abstract unit of account, $e(t)$ is the nominal exchange rate and $w(t)$ is the real wage. Optimal prices for $t = 0, N, 2N$ are:

$$P_H(i,t-1) = \frac{\sum_{\tau=t}^{t+N-1} \sum_{\tau} Q(\tau)\, P(\tau)\, v(i,\tau)\, \Lambda_H(\tau)}{\theta \sum_{\tau=t}^{t+N-1} \sum_{s^\tau} Q(\tau)\, \Lambda_H(\tau)}$$

$$P_H^*(i,t-1) = \frac{\sum_{\tau=t}^{t+N-1} \sum_{\tau} Q(\tau)\, P(\tau)\, v(i,\tau)\, \Lambda_H^*(\tau)}{\theta \sum_{\tau=t}^{t+N-1} \sum_{s^\tau} Q(\tau)\, e(\tau)\, \Lambda_H^*(\tau)}$$

where $v(i,t)$ is the real unit cost which is equal to the wage rate divided by the marginal product of labor, $w(t)/Fl(i,t)A(t)$ and:

$$\Lambda_H(t) = [a_1 P(t)]^{\frac{1}{1-\rho}}\, \overline{P}_H(t-1)^{\frac{\rho-\theta}{(1-\rho)(\theta-1)}}\, y(t)$$

$$\Lambda_H^*(t) = [a_1 P^*(t)]^{\frac{1}{1-\rho}}\, \overline{P}_H^*(t-1)^{\frac{\rho-\theta}{(1-\rho)(\theta-1)}}\, y^*(t)$$

in a symmetric steady-state real unit costs are equal across firms, hence, in this steady state these formulas reduce to $P_H(i) = P_H^*(i) = Pv/\theta$, so that the law of

[14] The most important justification for the existence of price rigidity is found in the menu costs theory developed by Akerlof and Yellen (1985) and Mankiw (1985).

one price holds for each good and prices are set as a markup $(1/\theta)$ over marginal costs Pv.[15]

3.4 Monetary Authority

In this model the National Central Bank uses a forward looking Taylor type interest rule formulated by Clarida, Gali and Gertler (2000), represented in the following way:[16]

$$r_t^N = \rho_r r_{t-1}^N + (1-\rho_r)[\rho_\pi \pi_{t+1} + \rho_O O_t] + \varepsilon_{r^N,t} \tag{11}$$

where r_t^N is the nominal interest rate in period t for the domestic economy (representing each one of the countries at study), π_{t+1} is the inflation rate between period t to $t+1$ for the domestic economy and O_t is the real gross domestic product at t of the domestic economy. $\varepsilon_{r^N,t}$ are shocks with a normal distribution, zero average, σ_{r^N} standard deviation and positive cross-country correlation. The rule exhibits some degree of inertia, represented by $\rho_r r_{t-1}^N$, meaning that the Central Bank does not fully adjust to current changes in the economy.

The ECB uses a special kind of forward looking Taylor Rule, which has the following functional form:

$$\begin{aligned} r_t^{*N} \;=\;& \rho_r r_{t-1}^{*N} + (1-\rho_r)[W\rho_\pi \pi_{t+1} + (1-W)\rho_\pi \pi_{t+1}^* + \\ & + W\rho_O O_t + (1-W)\rho_O O_t^*] + \varepsilon_{r^N,t}^* \end{aligned} \tag{12}$$

where W represents the weight of each specific country at study relatively to the Eurozone. When the simulation is represented by the National Central Bank W is zero. r_t^{*N} is the nominal interest rate in period t for the foreign economy (representing the Eurozone), π_{t+1}^* is the inflation rate between period t to $t+1$ for the Eurozone and O_t^* is the real gross domestic product at t of the Eurozone $\varepsilon_{r^N,t}^*$ are shocks 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, so we imposed the following restriction on the nominal interest rate:

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

[15] There are some empirical estimates and evidences of markup for the three countries at study, although evidence for Czeh Republic seems to show a high degree of price-taking. See Gjersem, Hemmings and Reindl (2004), Barry, Bradley, Kejak and Vavra (2003), Maliszewska (2004) and Dobrinsky, Korosi, Markov and Halpern (2004).

[16] 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). Clarida, Gali and Gertler (1999), state that the Taylor Rule is consistent with the principles for optimal monetary policy, because implies the convergence of inflation to its target over time, also implies that the nominal interest rate adjusts more than one for one with the inflation rate and finally the rule suggests that the policy maker should offset demand shocks and accommodate supply shocks, since these type of shocks do not affect the output gap, because they simultaneously affect effective and potential output.

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

$$P(t) * g(t) + T(t) = M(t) - M(t-1) \tag{14}$$

like in Cooley and Hansen (1989). This last equation represents the home government budget constraint, where $g(t)$ is government consumption. In this model there are government consumption shocks.

3.5 Equilibrium Conditions

All maximization problems for country F are analogous to these problems, where the allocations and prices in the foreign country are denoted with an asterisk. An equilibrium requires several market-clearing conditions. The resource constraint in the home country is given by:

$$y(t) = c(t) + g(t) + \int_0^1 I(i,t)\, di \tag{15}$$

The labor market-clearing condition is:

$$l(t) = \int l(i,t)\, di \tag{16}$$

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

$$B(t) + B^*(t) = 0 \tag{17}$$

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 and monopolists know the past and current realizations of technological and government consumption shocks, but only know past realizations of monetary shocks. [17] 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

[17] Different timing assumptions lead to similar conclusions.

we solve the system of equations. We use the approach of Blanchard and Kahn (1980) to solve the model. [18,19]

4 Calibration and Data

The calibration for the models is made in order to reproduce the long term properties of Czech, Hungarian and Polish economies. In this case where the economies at study are transition countries, calibration is a rough exercise. Parameter values for these countries are presented in Appendix I. We follow the calibration procedure of Cooley (1995).

4.1 Preferences

The functional form of the utility function is:

$$U\left(c, L, \frac{M}{P}\right) = \frac{\left[\frac{c^{(1-k)}}{(1-k)} + \frac{w\left(\frac{M}{P}\right)^{\frac{\eta-1}{\eta}}}{\frac{\eta-1}{\eta}} + \varphi\frac{(1-l)^{(1-\gamma)}}{1-\gamma}\right]^{1-\sigma}}{1-\sigma} \tag{18}$$

whose arguments are consumption (c), labor (l) and a real money aggregate (M/P). The discount factor β is calculated using annual data from EUROSTAT for $\beta = \frac{1}{(1+r^{LT})}$, where r^{LT} is the real long term interest rate for government bond yields. r^{LT} was deflationed using the consumer price index for the $1999 - 2003$ period. The value for σ is 0.0001 and k is the relative risk aversion coefficient (or the inverse of the elasticity of intertemporal substitution). Because this last parameter is one of the most difficult values to estimate empirically, we perform a sensitivity analysis to this parameter value. In order to have a balanced growth we impose $\gamma = \sigma$.[20] The value for φ, the weight on

[18] We use a first order Taylor expansion loglinearized around the steady state. Several authors suggest that first order Taylor expansions may produce welfare reverse ordering, for example in situations where we want to compare different types of economic regimes (incomplete markets with complete markets for instance). See Sims (2002), Kim and Kim (2003) and Schmitt-Grohé and Uribe (2004) for discussions on this problem. That is not the case here, with the only difference being the policy rule of the Central Bank. Besides, computational costs can increase substantially as the order of the Taylor expansion increases. There are few specific literature about higher order expansions and some approaches can in fact result in the accumulation of useless higher order terms.

[19] The growth rate of prices mu is respectively 1.13, 1.3 and 1.19 for Czech Republic, Hungary and Poland, implying inflation rates respectively of 2.6, 6.8 and 4.4% for these countries.

[20] In the market sector suppose that technology for each intermediate good producer is given by $F(k_t, z_t l_t)$, where z_t grows at a constant rate z. In the nonmarket sector suppose that technological progress increases the productivity of time destined to nonmarket activities, so that an input of $(1 - l_t)$ units of time out of the market, produces $z_t(1 - l_t)$ units of leisure services. With these kind of preferences, if c_t and m_t grow at a z_t rate and if l_t is constant, then $-\frac{U_{lt}}{U_{ct}} = k\frac{(1+z)^{(1-\gamma)t}}{(1+z)^{-\sigma t}}$ where k is a constant. Along a balanced growth path wages grow at the same z rate, so in order for the economy to have a balanced growth path, we must have $\gamma = \sigma$.

leisure, is calculated in order to make the time that families dedicate to work equal to a value that matches estimates from OECD and EUROSTAT for the $1995-1999$ period.

Parameters concerning money demand are estimated according to the money demand theory, using the following equation for the first order condition for a nominal bond, which costs one euro at t and pays R euros in $t+1$:

$$\log\frac{M(t)}{P(t)}=-\eta\log\frac{w}{1-w}+\log c(t)-\eta\log\left(\frac{R^N(t)-1}{R^N(t)}\right) \tag{19}$$

we estimated a regression with quarterly data for the period $1994:01-2003:02$, 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, where R^N is the gross nominal interest rate, defined as $(1+r^N)$. Seasonality was removed using the $X12-ARIMA$ procedure. The value for w is implicitly taken after knowing the value for η, the interest elasticity of real money demand, and the value for the constant.

4.2 Technology for the Final Goods Producers

The elasticity of substitution between home and foreign goods was defined as $\frac{1}{(1-\rho)}$. Some studies, like the one by Whalley (1985), found this elasticity to be in a range between 1 and 2, being lower for Japan and Europe than for the USA. The value found for this elasticity is calculated by using the expression of the first order condition for the demand functions of the input intermediate goods:

$$\log\frac{IMP}{D}=b_0+b_1\log\frac{PD}{PIMP}+b_2\log Y \tag{20}$$

where IMP are imports at constant 1995 prices, D is national production subtracted of exports at constant 1995 prices, $PIMP$ is the imports deflator, PD is the deflator for D and Y is national income at constant 1995 prices, for the $1990-2002$ period, using Annual National Accounts data.

For the a_1 and a_2 parameters, representing respectively the weights of domestic and imported goods, we used annual data of bilateral trade of CHELEM data base for the $1991-2001$ period.[21] Shares for each model are calculated assuming that there are only two countries in the world, each one of the transition countries and the Eurozone. To calculate a_1 and a_2 in their steady state values the following relation is established $y_h/y_f=[a_1/a_2]^{\frac{1}{1-\rho}}$.

4.3 Technology for the Intermediate Goods Producers

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

[21] CHELEM is a data base managed by CEPII - Centre D'Etudes Prospectives et D'Information Internationales.

$$F(k, Al) = k^{\alpha} (Al)^{1-\alpha} \tag{21}$$

For the technology parameters we calculated the share of capital used in the production of the good, α. We used OECD statistics for the capital income share of the private sector for the period between $1994 - 2002$, for the Czech Republic.[22] The depreciation rate for capital, δ, was calculated implicitly by the following formula:

$$K_t = (1 - \delta) K_{t-1} + I_t \tag{22}$$

using annual data. The data series for the capital stock and gross fixed capital formation (GFCF) was taken from AMECO, a European Commission data base, for the $1960-2002$ period.[23] We tried to adjust the adjustment cost parameter b in equation (**??**) in order to achieve the volatility of investment relative to output of the empirical data.

For the markup parameter we used data for the $1990 - 2002$ period, taken from the NewCronos data base. To calculate this 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 $\Pi = y - vy$. In steady state $v = \theta$, so $\Pi/y = 1 - \theta$. To obtain a estimate of Π/y we follow Domowitz, Hubbard and Petersen (1986). So, we first calculate 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 calculated the denominator as Jorgensson, Gollop and Fraumeni (1987) and calculated 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 $N = 6$ for the number of periods that prices stay fixed for each group of producers, as in Gali, Gertler and Lopez-Salido(2001) for all these countries.

4.4 Technological Shocks

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

$$\log A_{t+1} = \rho_A \log A_t + \varepsilon_{A,t+1} \tag{23}$$

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

[22] 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).

[23] We could not find available data for capital stock for Czech Republic, Hungary and Poland, so we use data for EU15, assuming that the steady-states for these economies will be close to the EU15 value.

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 transition economies and the EU for the period between 1994 : 01 and 2003 : 03. Solow residuals were estimated using employment data only, because capital stock data is not available for these countries.

4.5 Government Consumption Shocks

In the context of dynamic general equilibrium models with sticky prices, output in the short run is demand driven, so in this model we used government consumption shocks.[24] Government consumption shocks are modeled as $AR[1]$ processes, having the following expressions:

$$\log g_{t+1} = \left(1 - \rho_g\right) \mu_g + \rho_g \log g_t + \varepsilon_{g_{t+1}} \tag{25}$$

$$\log g_{t+1}^* = \left(1 - \rho_g\right) \mu_g + \rho_g \log g_t^* + \varepsilon_{g_{t+1}}^* \tag{26}$$

we use quarterly data from EUROSTAT (NewCronos) for the period between 1995 : 01 − 2004 : 01 to estimate μ_g, ρ_g and $\varepsilon_{g_{t+1}}$. These shocks are not correlated with monetary shocks, with technological shocks and with the foreign government consumption shocks.

4.6 Monetary Policy Shocks

The theoretical debate about the policy rule of the Central Bank is very extensive. 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.

The policy rule of the ECB is characterized by equation (12). For the European Central Bank the parameters for ρ_r, ρ_π and ρ_O are respectively 0.86, 1.12 and 1.03. The volatilities of this rule differs between simulations for each country being respectively 1.14, 0.64 and 0.695 for Czech Republic, Hungary and Poland. In the same order, their economic weight, W, is 0.8, 0.7 and 2.1%. We kept a fixed exchange rate in the simulation *Common Monetary Policy*, calibrating with the most recent values from the *Financial Times* online database. Policy rules for Czech Republic and for Hungary and Poland were based on Laxton and Pesenti (2003) and Mohanty and Klau (2004) respectively. We changed the inflation parameter for these rules because it was smaller than one, leading to problems of multiple equilibrium. The Taylor Rule for the ECB was taken from Hayo and Hoffman (*forthcoming*).

[24] Demand side shocks are usually represented by taste shocks. These shocks usually affect the consumption of tradable and non tradable goods. Government consumption consists mostly of non-traded goods. Hence, in a large proportion, government spending shocks can be a substitute for taste shocks.

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

Calibration for these countries exhibit some differences that are worth pointing out as we can see in Appendix I, namely in Poland technological shocks have a greater persistence than in the other two countries, and in the case of government consumption shocks the persistence is much bigger in Czech Republic and Hungary. Volatilities of these shocks are also different between these economies, being much stronger.in Hungary and Czech Republic than in Poland. Another significant difference is the value of the elasticity of substitution between domestic and imported goods. These differences are going to influence the value of the results and have an important role in the decision process of joining (or not).

5 Behavior of the economies under different shocks and different monetary policy regimes

Before we analyze the results of the model with the calibration specified, we will explain the behavior of the simulations in three different scenarios: first, a recession period caused by a negative government consumption shock in economy H; second, a recession period caused by a negative technological shock in economy H and finally a negative shock in monetary policy (a fall in the interest rate).

5.1 Government Consumption Shocks

When a negative government consumption shock affects the domestic economy in simulation *Common Monetary Policy*, the domestic government reduces its consumption, output decreases initially in the first period and employment falls in the first six. By the opposite, a decrease in government consumption makes private consumption increase permanently. This effect happens because consumers expect taxes to decrease in the future now that government consumption has fallen, so they increase actual consumption. Because consumption initially increases more in the foreign economy, the marginal utility of consumption decreases by more in the foreign economy, so the real exchange rate decreases (the domestic currency appreciates). Employment falls because consumption increases for the same level of work, because of the anticipated increase in wealth (due to the expected fall in taxes). The movements of domestic and foreign consumption and investment are very correlated because they follow the same interest rate when making their decisions. Investment in both economies rise, because the nominal interest rate falls.

Because consumption and investment rise, output begins also to increase after the first period, because demand increased for the final good. To satisfy the increasing demand for the final good, final good producers increase their demands for intermediate goods.

Prices of the final good in the domestic economy fall as well as prices in the foreign economy. Final goods price in the foreign economy decrease, because of higher labor supply that makes the marginal utility of work decrease and by that reduces marginal costs, and hence prices of intermediate goods that influence the price of the final goods. Interest rate also begins to increase after some periods, lowering investment and consumption gradually, making prices decrease even more.

The nominal interest rate decreases in the first period because output and prices, both in the foreign and in the domestic economy, have decreased. A lower interest rate in the first periods and a higher share of consumption make money demand increase. When the interest rate starts to increase money demand and consumption decrease.

Exports movements depend on consumption and investment relative movements. Due to the existence of complete markets the risk sharing effect prevails and exports increase initially. The domestic economy is lending resources to the foreign economy, making consumption higher in both economies.

The increase in the demand for intermediate goods in the domestic economy is extended to the foreign economy, so intermediate goods producers in that economy begin to produce more goods and hire more workers and use more capital. Output in this economy also rises. When goods start being exported to the domestic economy, the trade balance starts to decrease its surplus.

In the simulation *Autonomous Monetary Policy* a negative shock in government consumption has relatively the same effects that in the previous simulation, except in the behavior of domestic final good price and the domestic nominal interest rate. Final goods producers buy intermediate goods at a higher price, so they will charge also a higher final good price. Intermediate goods producers from the foreign economy anticipate a increase in demand after output in the domestic economy starts to rise again, and increase the price of intermediate goods, hence also increasing the price of the final good. They can increase the price, because the share of imports to the domestic economy is high in these countries, specially in Czech Republic and Hungary.

The nominal domestic interest rate decreases in the first periods because output has decreased, although prices have increased. The fall in the interest rate does not happen for as many periods as in the simulation, because of the increase in prices in the domestic economy. The movements of domestic and foreign consumption and investment are correlated in a negative way, because they follow opposite changes in their respective nominal interest rates, with the domestic interest rate decreasing in the final periods and the foreign increasing.

5.2 Technological Shocks

A negative technological shock does not influence by much the behavior of variables, except for employment that increases by a significative amount, contrary to what happens in negative government consumption shocks. The effect of the technological shock on employment dominates the entire results for this variable in both monetary policy regimes. Employment behavior depends on the substitution and income effects. Because of diminishing wages, leisure becomes a cheaper good, so workers trade work for leisure due to the substitution effect. On the other hand, income effect leads to an employment increase, because the purchasing power of workers has fallen. Given the choice of parameters for this model, employment increased because the income effect is bigger. Employees are going to work more to compensate their lost income. The loss of productivity and the higher employment level make marginal costs increase and prices increase.

5.3 Monetary Policy Shocks

A negative monetary policy shock is a decrease in the nominal interest rate. In simulation *Common Monetary Policy* both foreign and domestic nominal interest rate fall, leading to an increase in consumption and investment and hence an increase in the demand for the final good. Since consumers want to spend more of their income and firms are paying higher wages to meet the increase in demand, employment must also increase. Real money balances also rises. Since $r^*=r$, movements in consumption, investment, labor and output in the foreign economy are similar to those of the domestic economy.

A decrease in the nominal interest rate also makes markups smaller which makes output increase, because reduces monopoly power. Since the markup decreases and output increases, prices tend to go down.

In simulation *Autonomous Monetary Policy* the negative monetary policy shock happens in the domestic economy. For the mentioned economy the effects are the same that in simulation *Common Monetary Policy*, but the effects on the foreign economy change substantially, because when the nominal interest rate decreases at home making consumption and investment increase, and hence output increase, these movements also lead to an increase in the demand for foreign intermediate goods, making the balance of trade negative. Initially consumption, investment and output in the foreign economy decrease, but employment increases because of the increase in the domestic economy demand. Also, because demand rises the price of the intermediate good rises making the price of the final good also rise. When the price of the final good increases the nominal interest rate increases, adjusting monetary policy to the current and future conditions of the economy.

6 Results

6.1 Methodology

The main purpose of this section is to analyze the behavior of these three economies in the presence of shocks. We also verify if the model can replicate some of the main features of business cycle stylized facts.

We use a theoretical model which mimics the characteristics of the economies at study, with the purpose of finding out if these economies find it more difficult to handle shocks within the Eurozone, because they can't use the monetary policy as a short run economic policy. H-P filter was used to detrend variables, with a value for lambda of 1600. In this work, we made two simulations: (1) one in which the country is currently inside EMU, so the monetary policy rule is established by the European Central Bank that follows a Taylor Rule, designated by *Common Monetary Policy* and (2) other where the country is outside EMU, so the monetary policy is established by the country's National Central Bank that also follows a Taylor Rule, designated by *Autonomous Monetary Policy*. Simulations were used for two main goals: to verify if the model can replicate some of the main features of business cycle stylized facts and to analyze the behavior of the economy in the presence of shocks, specially to compare the effects of shocks under alternative monetary policy regimes.

We compare simulation (1) and (2) with the goal of finding out if consumers prefer a Central Bank that doesn't care about the shocks hitting the domestic economy (*Common Monetary Policy*), or instead, that they prefer one that does (*Autonomous Monetary Policy*).

In the next sections we test if the model can replicate some features observed in the empirical data and perform a welfare analysis based in simulated times series values for (1) and (2).

6.2 Simulation Results

Tables 8, 9 and 10 in Appendix *II* present the results in the third and fourth column of the statistics for simulations *Common Monetary Policy* and *Autonomous Monetary Policy* respectively, for the domestic economy. The second column presents statistics calculated from empirical data. The values of the statistics for the simulations support some of the stylized fact found in the literature, namely: Output is more volatile than consumption, but less volatile than investment.

Variables are more volatile in the simulation "Autonomous Monetary Policy" for all three countries, where besides occurring government consumption and technological shocks, also occurs the monetary policy shock in the domestic economy. In the simulation *Common Monetary Policy* there are not monetary policy shocks in the domestic economy, since monetary policy is established by the foreign economy representing the Eurozone and the monetary policy of the European Central Bank, so volatility is lower in this simulation. Besides, when we impose equation (13) the volatility of variables decrease because their behavior it is totally commanded by this restriction.

Comparisons of the behavior of autocorrelations differ from country to country and depend on the magnitude of the shocks and the comovements between them.

Analyzing the cross-correlations we find that the 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 correlation. Monetary policy shocks also dominate the behavior of consumption and investment in the simulation

Autonomous Monetary Policy but in the opposite way to the other simulation. The role of each shock in determining the pattern of cross-country correlations once again depends on the magnitude of the shocks. Technological and government consumption shocks play a significant role in explaining the behavior of net exports and technological shocks play an important role in determining the behavior of employment along with monetary policy shocks, this last one because of the effects on prices and real wages.

6.3 Benchmark Economy Analysis

The purpose of this section is to formally analyze the consequences of different rules for monetary policy, in terms of consumer welfare in the three countries. So we ask which amount of consumption are consumers willing to give (or receive) in order to stay indifferent between monetary policy defined by the European Central Bank, and that only takes in account what happens in the domestic economy to the extent of its economic weight in the rule (*Common Monetary Policy*), and monetary policy defined by the National Central Bank (*Autonomous Monetary Policy*) that considers only the domestic economy situation when establishes the rule. This corresponds to calculating the compensating variation associated to the full elimination of an *Autonomous Monetary Policy* in this economy. Welfare analysis follows the method of Lucas (1987):[25]

1. Two models were compared, one where the monetary policy of the domestic economy is inexistent because is governed by the European Central Bank, and the other where the National Central Bank is in charge of monetary policy for the domestic economy. In all models a simulation of 1000 periods each was made. In simulation *Common Monetary Policy* there are technological and government consumption shocks in both economies of the model, but the monetary shocks only happen in the foreign economy, representing the Eurozone. In simulation *Autonomous Monetary Policy*, both economies suffered all three shocks.

2. Based on the simulated time series for consumption, labor and real money aggregate we calculate the average value of utility function for both models.

3. Given the average values for both utility functions, we calculated the compensating variation in terms of consumption (λ) in the following way:

$$U_0\left(\lambda c_0, l_0, M/P_0\right) = U_1\left(c_1, l_1, M/P_1\right) \tag{27}$$

[25] Clarida, Gali and Gertler (1999) criticize this approach of measuring welfare, stating that: " If some groups suffer more in recessions than others and there are incomplete insurance and credit markets, then the utility of a hypothetical representative agent might not provide an accurate barometer of cyclical fluctuations in welfare." For the purpose of this paper, which is measuring the total loss of a country of loosing the monetary policy we are going to disregard this critic. Besides, our model does not have the features that Clarida, Gali and Gertler criticize.

Where U_0 uses the values for c, l and M/P of the simulation *Common Monetary Policy* and U_1 uses the values of the *Autonomous Monetary Policy* simulation.

The value of λ represents the gains (or losses) of welfare in terms of consumption percentage. Results are presented in the next table. Consumers are willing to give up consumption in order to live in an economy where the monetary policy is established by the National Central Bank in all three countries.

Table 3- Welfare Results for Benchmark Economies

	C	L	M/P	U	λ
Czech Republic					
Benchmark					-0.262%
Common Monetary Policy	0.1878	0.2361	0.4570	241.1444	
Autonomous Monetary Policy	0.1875	0.2355	0.4538	241.1601	
Hungary					
Benchmark					-0.181%
Common Monetary Policy	0.1468	0.2411	0.1791	133.4543	
Autonomous Monetary Policy	0.1464	0.2405	0.1778	133.4648	
Poland					
Benchmark					-0.252%
Common Monetary Policy	0.1823	0.2168	0.2376	245.5851	
Autonomous Monetary Policy	0.1822	0.2163	0.2368	245.6652	

Results are very similar across these countries. The main differences between simulations within each country are volatility of the monetary policy shocks, the parameters of the Taylor rules and the differences between who runs the monetary policy (i.e., Taylor Rule, with or without economic weights). Monetary policy shocks dominate the behavior of economies more than technological and government consumption shocks. The reason why consumers seem to prefer the *Autonomous Monetary Policy* simulation is the behavior of employment. Employment in this simulation is on average lower, so leisure is higher and consumers are better off.

So why do variables behave in this manner in each simulation? The main reason for this behavior in simulation *Common Monetary Policy* is the restriction imposed on interest rates r*=r, making variables respond in a more similar way in both countries. Like it was said previously, monetary policy shocks dominate the behavior of these economies. The monetary policy shock happens in the foreign economy, but because the previous restriction is imposed it has the same effects in the domestic economy. When the restriction is imposed, consumption, investment and output react in similar ways in both economies, increasing when the nominal interest rate is reduced and decreasing when the opposite happens. In simulation *Autonomous Monetary Policy* the monetary policy shock only happens in the domestic economy. For the mentioned economy the effects are the same that in simulation *Common Monetary Policy*, but when the nominal interest rate decreases at home making consumption and investment increase, and hence output increase, these movements also lead to an increase in the demand for foreign intermediate goods, making the balance of trade negative. The effects on the foreign economy change relative to the other simulation. The increase in demand for intermediate goods by the domestic economy, increases demand and also prices, making the nominal interest rate increase. When the interest rate increases, consumption and investment in the foreign economy decrease. Due to the increase in demand, foreign goods producers need to hire more workers and offer a higher real wage, so employment increases. Employment in the domestic economy, in simulation *Autonomous Monetary Policy* does not increase by as much as in simulation *Common Monetary Policy* because the demand for domestic and foreign intermediate goods in the foreign economy decreases (foreign consumption, investment and output initially decline) reducing the need for hiring workers. Also, the average values of consumption and investment on average are smaller in simulation *Autonomous Monetary Policy*, because we have a more aggressive inflation parameter for all three countries. A more aggressive inflation parameter means that whenever prices increase the interest rate response is higher, making average consumption and investment smaller. So on average employment has to rise by less in order to satisfy consumption increase.

One last question remains in this section: What are the reasons that make countries have different welfare results? Obviously that different parameters between countries play an important role, but the main role is played by differences regarding the magnitude of shocks, in this specific case technological, government consumption and monetary policy shocks. Higher volatilities of technological shocks tend to make the country more willing not to join the EMU. In opposite, higher volatilities of government consumption shocks tend to make the country less willing not to join the EMU, except in Poland. In what concerns monetary policy shocks, higher volatilities inside EMU in comparison with domestic monetary policy tend to make the countries more willing not to join the EMU. We will analyze this questions in detail in the following section.

7 Robustness

In this section we analyze the robustness of the model in terms of welfare value. We perform a sensitivity analysis to some parameters, chosen given their relevance for the purpose of this work. The simulations follow the method described in the previous section. Table 4 presents the results for the following subsections that assess robustness for benchmark simulations for each one of the three countries. Detailed results for robustness can be found in Appendix II, tables 11, 12 and 13.

Table 4 - Results for sensitivity analysis

CZE	HUN	POL
No Technological Shocks		
-0.26%	-0.179%	-0.206%
No Government Consumption Shocks		
-0.293%	$-0.449\%^{*}$	-0.248%
Correlation of the monetary policy shocks		
-0.10%	-0.04%	-0.251%
Weight of the country in the Eurozone		
-0.264%	-0.216%	-0.244%
Relative Risk Aversion Coefficient		
-0.311%	-0.231%	-0.253%
Weight of imported goods from the Eurozone		
-0.37%	-0.68%	-0.256%

$*-$ this simulation was done with 819 periods to avoid problems with multiple equilibrium.

7.1 No Technological Shocks

We remove the technological shocks to analyze its impact in both simulations. We arrive to an interesting conclusion, since as we can see in the table presented above, all three countries seem less willing not to enter. It seems that technological shocks play an important role in achieving the welfare result of not entering, specially in the case of Poland where technological shocks are stronger in persistence. When technological shocks are removed the average time that people spend working decreases in all simulations, leaving other utility function variables relatively unaffected by the change. Although, it seems that the reduction in employment is stronger in simulation *Common Monetary Policy*, that is why consumers seem less willing not to enter the Eurozone. The difference of response to technological shocks between the Eurozone and the domestic economy with the independent central bank is the explanation for the differences in response. Employment increases by more in simulation *Common Monetary Policy* concerning the impact of a technological shock, so the reduction in employment when we remove these shocks must be higher.

For intuition let us think of a negative technological shock in the domestic economy. The first consequence is an increase in employment, since the decrease in productivity also reduces real wages, hence inducing the willingness to work. After the first period, employment starts to decrease, but because the output gap parameter is higher in simulation *Common Monetary Policy* than in simulation "Autonomous Monetary Policy, the decreasing of employment is smaller in the first simulation, so employment is relatively higher in simulation *Common Monetary Policy*. What is the influence of this parameter in this simulation? When output in the foreign economy begins to increase, a higher output gap parameter makes interest rate increase by more than a smaller parameter value.

But the rise in the interest rate also affects the domestic economy since r*=r, but in this economy output is decreasing, so the effect in this economy is an even bigger decrease in output. Once employees see this happening the decrease in the supply of employment is not so high due to the income effect. The decrease in real wages makes workers relatively more willing to work.

7.2 No Government Consumption Shocks

In this experiment we remove the government consumption shocks from the two simulations to see the impact of this shock in the welfare value. Czech Republic and Hungary prefer more not to enter, but Poland prefers marginally less. The impact of this shock is specially stronger in the first two mentioned countries, and seem to have an important impact, since when government consumption shocks are not present in the simulations, both countries increase their willingness not to enter. So, government consumption shocks decrease the willingness not to enter, hence increase the willingness to enter. But why does this happen in the former referred countries but does not happen in Poland? We analyze separately impulse response functions for negative government consumption shocks for each of the three countries and for the two cases: within the EMU or out of the EMU. The first reaction of this kind of shock is a decline in output and employment, but an increase in consumption. We noticed that in Czech Republic and Hungary the price of the final good in the experiment with the independent central bank increases, while in Poland decreases. This increase in prices, despite the initial decrease in output, makes producers anticipate a higher demand for their products and hence increase the demand for labor. So when employment starts to increase again, increases by more than if prices decrease, as in Poland, because in this country demand for intermediate goods is not going to increase. So, if employment decreases by more in simulation *Common Monetary Policy* than in simulation *Autonomous Monetary Policy* due to this effect just described, if government consumption shocks are removed, employment must increase by more in simulation *Common Monetary Policy*. But why do prices increase in Czech Republic and Hungary and not in Poland? After some research we came to the conclusion that the main reason is the higher share of imports in the first two countries compared with the relatively lower share for Poland, that made prices go up. Producers in Czech Republic and Hungary are more dependent of the foreign economy, so producers in that economy can charge higher prices to these countries when anticipate a rise in the demand for their goods.

7.3 Correlation of Monetary Policy shocks

Could a high correlation of monetary policy shocks be a perfect substitute for joining a monetary union? If two countries share a high positive correlation of monetary policy shocks, the comovements between economies are very similar, so business cycles synchronization must be high, because the behavior of the domestic and foreign nominal interest rate are significantly similar. If this happens, when we increase the correlation of the monetary policy shocks in simulation *Autonomous Monetary Policy*, countries must be more willing to join a monetary union. We increase this parameter to 0.5, instead of 0.1. All three countries are more willing to join the monetary union. What changes does these parameter implies? For all countries real consumption, labor and real money balances increase. The increase in labor makes consumers worse than in the benchmark simulation *Autonomous Monetary Policy.* Variables in this simulation behave in a more similar way that variables in simulation *Common Monetary Policy*, so consumers are less willing not to join the Eurozone. Poland does not change by much in this simulation contrary to what happens in the other two countries. The reasons are because technological shocks, are higher and trade shares between Poland and the eurozone are smaller.[26]

7.4 Weight of the country in the Eurozone

These countries have a relatively low share of economic weight in the Eurozone. The biggest country is Poland who has a weight of 2.1% of GDP in the Eurozone weight. Czech Republic and Hungary have respectively 0.8 and 0.7%. In this experiment we change their weights to 10% of GDP in simulation *Common Monetary Policy.* Intuition tell us that the higher the share of a country in the Taylor rule of the ECB, the more willing the country is to join the monetary union, because monetary policy will be more "costumed made" to its needs. Despite this intuition only Poland seems more willing to join the Eurozone if it had a bigger weight, although the change of the welfare value relatively to the benchmark is very small. Czech Republic and Hungary both increase their willingness not to join, especially Hungary. In these last two countries the value of utility for simulation "Common Monetary Policy decreases, while in Poland increases. The reason for this difference lies in the relative strength of government consumption and technological shocks. Technological shocks are more persistence in Poland relative to government consumption shocks and the country prefers less not to join the Eurozone. Government consumption shocks are more persistence in Czech Republic and Hungary relative to technological shocks and these countries prefer more not to join the Eurozone. The bigger impact that this experiment has on Hungary is due to the magnitude of the volatility of the shocks.[27]

7.5 Preferences Parameter - Relative Risk Aversion Coefficient

This particular parameter is one of the hardest to estimate empirically and for this reason we have made a sensitivity analysis. It is an important parameter in terms of the definition of the value of preferences, being able to affect substantially the result of the welfare analysis. We performed an experiment with

[26] See section 6.2.2. and 6.2.7. for details of these conclusions about Poland.

[27] See sections 6.2.1. and 6.2.2. for detailed explanations of the behavior of government and technological shocks.

a value for this parameter of 5. It is a significative change compared to the benchmark values, but it is justifiable by the diversity of its value found in the literature, varying between 1 and 20.

An economic agent is risk averse when his preferences are described by an utility function with diminishing marginal utility in wealth. A consumer has a lower marginal utility of additional wealth when it has a higher income. An increase in the value of the relative risk aversion coefficient makes the curvature of the utility function even bigger, translating in a decrease in future marginal utility of consumption relative to the present one. The result is a decrease in saving, which will result in an increase in present consumption. A raise in consumption leads to a raise in employment and in output.

An increase in the value of k raised consumer preferences in all countries for the "Autonomous Monetary Policy " simulation, preferring to give up between 0.23% (Hungary) and 0.31% (Czech Republic) of their consumption than to live in the economy *Common Monetary Policy*. The ratio of consumption, labor, real money balances and total utility in simulation *Autonomous Monetary Policy* relative to simulation *Common Monetary Policy* increases when compared to the benchmark ratio, meaning that the increase in this variables are higher in the last simulation. This contributes to the rise of the welfare result of choosing not to enter. Only the relative increase in employment contributes negatively for the final welfare result, but the relative increase in the other variables, more than compensates the relative increase in employment. Real money balances and consumption are very sensitive to changes in interest rate and preferences for this model are non-separable, making interaction between variables increase. Consumption is now much more sensitive to changes in the nominal interest rate, so it takes a smaller change in the nominal interest rate, than in the benchmark simulation, to make consumption react to that change. The reactions of the Taylor rules in both simulations are the same to all type of shocks, but now consumption reacts more to those changes. The result depends significantly on the reaction of the interest rate rule in each simulation and on the relative strength/persistence of the shocks. For instance, technological shocks do not make the interest rate change by as much as other shocks, hence consumption with this shock does not change by much, so in Hungary and Czech Republic where this shock is not so persistence, is where the change in k made the bigger impact. Of course in Poland, where this shock has a greater persistence than government consumption shocks, the impact was much smaller. In simulation *Common Monetary Policy*, negative shocks in government consumption make interest rate decrease in the first periods and increase in the last, and negative monetary policy shocks make the interest rate decline in the first period and increase in all other periods, except in the last, where decreases again but not in a significant way, so consumption does not increase in the last period. But in simulation *Autonomous Monetary Policy* both government consumption and monetary policy shocks decrease substantially the nominal interest rate in the last periods, making consumption increase, hence the difference between these variables in the two simulations decreases, increasing welfare in simulation *Au-*

tonomous Monetary Policy.[28]

7.6 Weight of imported goods from the Eurozone

Endogeneity of optimum currency area criteria is a theory proposed by Frankel and Rose (1998). Their theory states that entering a currency union is not a cost in terms of the loss of monetary policy flexibility, since trade with other member countries increase only by the mere fact of belonging to the same currency area and once this happens business cycle synchronization is established. Joining a monetary union for these countries would then be less costly. In this experiment we will test this theory, by reducing the share of imported goods from the Eurozone to 11% for the three countries at study. Czech Republic, Hungary and Poland have a significant import quota from the Eurozone countries (30%, 27% and 15% respectively). Like we can see in table 4, when we reduce this parameter, countries are even less willing to join the monetary union, since their trade relations are not so high, specially in Hungary and Czech Republic where the trade shares were higher. In both simulations consumption and real money balances rise due to the rise of production at home, but employment falls due to the income effect. The theory of the endogeneity of optimum currency area seems to apply to these economies.

The change in the value of welfare is explained in a substantial proportion by the movements of government consumption shocks in these simulations, specially in the differences of simulation *Autonomous Monetary Policy* compared with this same simulation in the benchmark model. Suppose that the economy faces a negative government consumption shock. In the benchmark simulation consumption would increase due to ricardian equivalence, output and employment would decrease and because of the higher share of imports, final goods price would increase, because foreign goods producers anticipate a rise in demand (when domestic output starts to rise again) and will increase the price of the intermediate goods sold to the domestic economy. So, the interest rate would decrease because output decrease, but not by much because prices increase. In the same simulation but with a smaller value for imports, final good prices would not increase since the weight of the foreign intermediate good is now smaller and output would still decrease, so the interest rate decreases by more than in benchmark, making consumption and real money balances increase by more. Because prices fall, production also falls for intermediate goods and the demand for workers falls, lowering employment. Hence, because consumption an real money balances are relatively higher and employment relatively lower, the welfare value of not entering increases in all countries.

[28] See Section 5.1. for detailed explanations of the behavior of variables for each shock. The same reasoning was applied here.

8 Conclusions

Although convergence is being done at a significative pace in the three transition economies, some flexibility is needed to accommodate shocks. As a result EMU membership can be, on average, a costly decision for these countries in what concerns the loss of monetary policy. We must emphasize the fact that these results were obtained in the context of complete markets, making them even more important, because, even in a situation where consumers share the risk across countries, they are on average not willing to join the Eurozone.

Detailed analysis of the results shows that the loss of monetary policy flexibility is more or less costly depending on several factors. The decision of entering is more costly when technological shocks are stronger, when correlation of the monetary policy shocks is weaker, when consumers are more risk averse and when the import share between the countries at study and the EMU is lower. Government consumption shocks do not present clear results about the decision of joining the EMU, depending on the proportion of import share between these countries and the EMU. The weight of the country in the Eurozone also presents some mixed results, depending on the relative weight of technological and government consumption shocks.

Besides discussing the costs of belonging to a Monetary Union, optimum currency area theory also discusses the benefits. It seems proper in this work to compare the results of the loss of independence of monetary policy with some of the benefits. 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 benefit of loosing the exchange rate vis-a-vis the other EMU members. 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 similar value for Hungary of between $0.18 - 0.3\%$ of GDP (see Csajbók, Csermely, eds. (2002)). In countries which have a poorly developed financial system, the gains from eliminating transaction costs are higher, since they have less financial products to defend themselves from exchange rate risk.

Converting our benchmark results to percentage of GDP, we find that in the three countries at study, consumers are willing to give up between 0.1 and 0.2% of their consumption in percentage of GDP to live in an economy with an autonomous central bank. Of course that the calculation of some benefits and costs are excluded, but the values found in this work for the costs of the loss of monetary policy flexibility, are close to the benefits associated with the disappearance of transaction costs.

One of the shortcomings of this work concerns the fact that we are working with a two country model with symmetric economies. The economies of the member states of the EMU are very different between them, so in the EMU context it would be more interesting to work with a model with asymmetric economies and heterogenous agents, that is, a model with different calibration for the economies modelled. For example the introduction of a third country in the model would permit the differentiation between economies in terms of its economic weight and economic structure. With this heterogeneity it would be interesting to apply a common shock to all economies in the model to analyze the differences of behavior of those economies. This seems a good avenue for future research.

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9 Appendix I - Calibration values for the three transition economies

Parameter values for the three transition countries are presented in the tables below. The calibration method followed and the data sources were described in section 4.

Table 5 - Parameter values for Czech Republic

Benchmark Model	
Preferences	$\beta = 0.996$, $\varphi = 350$, $\sigma = \gamma = 0.0001$
	$\eta = 0.108$, $\omega = 0.0076$, $k = 3.48$
Final Good Technology	$\rho = 0.2366$, $a_1 = 0.656$, $a_2 = 0.344$
Intermediate Good Technology	$\alpha = 0.385$, $\delta = 1.15\%$, $\theta = 0.951$, $b = 50$, $N = 6$
Taylor Rule National Bank	$\rho_r = 0.81$, $\rho_\pi = 1.26$, $\rho_O = 0.15$
	$var(\varepsilon_\mu) = var(\varepsilon_\mu^*) = 0.0091^2, corr(\varepsilon_\mu, \varepsilon_\mu^*) = 0.1$
Technological Shocks	$\rho_A = 0.54$, $corr(\varepsilon_A, \varepsilon_A^*) = 0.019$
	$var(\varepsilon_A) = var(\varepsilon_A^*) = 0.005^2$
Government Consumption Shocks	$\rho_g = 0.92$, $\mu_g = 0.114$
	$var(\varepsilon_g) = var(\varepsilon_g^*) = 0.005^2$

Table 6 - Parameter values for Hungary

Benchmark Model	
Preferences	$\beta = 0.999$, $\varphi = 200$, $\sigma = \gamma = 0.0001$
	$\eta = 0.23$, $\omega = 0.0076$, $k = 2.8$
Final Good Technology	$\rho = 0.435$, $a_1 = 0.635$, $a_2 = 0.365$
Intermediate Good Technology	$\alpha = 0.385$, $\delta = 1.15\%$, $\theta = 0.922$, $b = 46$, $N = 6$
Taylor Rule National Bank	$\rho_r = 0.8$, $\rho_\pi = 1.2$, $\rho_O = 0.35$
	$var(\varepsilon_\mu) = var(\varepsilon_\mu^*) = 0.0069^2$, $corr(\varepsilon_\mu, \varepsilon_\mu^*) = 0.1$
Technological Shocks	$\rho_A = 0.51$, $corr(\varepsilon_A, \varepsilon_A^*) = 0.34$
	$var(\varepsilon_A) = var(\varepsilon_A^*) = 0.019^2$
Government Consumption Shocks	$\rho_g = 0.97$, $\mu_g = 0.12$,
	$var(\varepsilon_g) = var(\varepsilon_g^*) = 0.019^2$

Table 7 - Parameter values for Poland

Benchmark Model	
Preferences	$\beta = 0.991$, $\varphi = 350$, $\sigma = \gamma = 0.0001$
	$\eta = 0.184$, $\omega = 0.0076$, $k = 3.48$
Final Good Technology	$\rho = 0.6$, $a_1 = 0.67$, $a_2 = 0.33$
Intermediate Good Technology	$\alpha = 0.40$, $\delta = 1.15\%$, $\theta = 0.938$, $b = 31$, $N = 6$
Taylor Rule National Bank	$\rho_r = 0.87$, $\rho_\pi = 1.32$, $\rho_O = 0.47$
	$var(\varepsilon_\mu) = var(\varepsilon_\mu^*) = 0.0057^2$, $corr(\varepsilon_\mu, \varepsilon_\mu^*) = 0.1$
Technological Shocks	$\rho_A = 0.74$, $corr(\varepsilon_A, \varepsilon_A^*) = 0.21$
	$var(\varepsilon_A) = var(\varepsilon_A^*) = 0.01^2$
Government Consumption Shocks	$\rho_g = 0.63$, $\mu_g = 0.10$
	$var(\varepsilon_g) = var(\varepsilon_g^*) = 0.01^2$

10 Appendix II - Detailed Data specification and Results for business cycle statistics and Detailed Results for the Sensitivity Analysis

Data

Most of the data was taken from NewCronos, an electronic database from EUROSTAT. The variables used are output (y), private consumption (c), investment (I), all at constant prices, net exports as a percentage of GDP in current prices (nx) and employment (l). We used quarterly data for Czech Republic, Hungary, Poland and the European Union for the $1991:01 - 2003:03$ period. H-P filter was used to remove the tendency and X12-ARIMA to remove seasonality. All variables are in logarithms, except net exports as a percentage of GDP. The cross-countries correlations are for each of the three transition economies and the European Union.

Table 8 - Statistics and Stylized Facts

	Czech Republic *Data*	*Common Monet.Policy*	*Autonomous Monet. Policy*
Standard Deviation			
Y	1.83	1.83	1.83
NX/Y	1.81	0.15	2.30
Standard Deviation Re*lative to GDP*			
C	1.24	0.47	0.69
I	3.51	2.86	4.14
L	0.40	1.73	1.91
Autocorrelations			
Y	0.73	0.51	0.58
C	0.63	0.51	0.60
I	0.55	0.50	0.59
L	0.91	0.53	0.58
NX/Y	0.59	0.71	0.58
$Cross - Correlations$			
(Y, Y^*)	-0.15	1.00	0.92
(C, C^*)	-0.49	1.00	-0.12
(I, I^*)	-0.18	1.00	-0.12
(L, L^*)	-0.36	0.97	0.54
$(Y, NX/Y)$	-0.58	0.03	0.21

Table 9 - Statistics and Stylized Facts

	Hungary Data	*Common Monet.Policy*	*Autonomous Monet. Policy*
Standard Deviation			
Y	1.16	1.16	1.16
NX/Y	1.93	0.72	1.98
Standard Deviation Re*lative to GDP*			
C	1.91	0.47	0.82
I	8.84	2.48	4.35
L	0.80	2.65	2.81
Autocorrelations			
Y	0.49	0.53	0.52
C	0.61	0.54	0.59
I	0.30	0.50	0.57
L	0.78	0.53	0.51
NX/Y	0.50	0.72	0.62
$Cross - Correlations$			
(Y, Y^*)	0.65	0.92	0.92
(C, C^*)	-0.003	0.92	-0.29
(I, I^*)	0.29	1.00	-0.37
(L, L^*)	0.22	0.63	0.41
$(Y, NX/Y)$	-0.36	0.15	0.16

Table 10 - Statistics and Stylized Facts for Poland

	Poland Data	*Common Monet.Policy*	*Autonomous Monet. Policy*
Standard Deviation			
Y	1.24	1.24	1.24
NX/Y	1.16	0.23	0.80
Standard Deviation Relative to GDP			
C	0.94	0.39	0.53
I	5.90	3.73	5.03
L	1.09	1.98	2.23
Autocorrelations			
Y	0.82	0.47	0.46
C	0.65	0.50	0.57
I	0.63	0.49	0.56
L	0.74	0.51	0.53
NX/Y	0.51	-0.26	0.34
Cross − Correlations			
(Y, Y^*)	0.52	0.94	0.47
(C, C^*)	0.23	1.00	-0.13
(I, I^*)	0.72	1.00	-0.16
(L, L^*)	0.06	0.74	0.14
$(Y, NX/Y)$	-0.54	0.06	-0.27

Table 11 - Welfare Results for Sensitivity Analysis - Czech Republic

	C	L	M/P	U	λ
Government Consumption Shocks Only					
Common Monetary Policy	0.1878	0.2360	0.4570	241.1645	−0.26%
Autonomous Monetary Policy	0.1875	0.2354	0.4538	241.1789	
Technological Shocks Only					
Common Monetary Policy	0.1878	0.2362	0.4569	241.0884	−0.293%
Autonomous Monetary Policy	0.1875	0.2356	0.4538	241.1229	
Correlation of the Monetary Policy Shocks					
Common Monetary Policy	0.1878	0.2361	0.4570	241.1444	−0.10%
Autonomous Monetary Policy	0.1877	0.2359	0.4559	241.0991	
Weight of the Country in the Eurozone					
Common Monetary Policy	0.1878	0.2361	0.4570	241.1431	−0.2644%
Autonomous Monetary Policy	0.1875	0.2355	0.4538	241.1601	
Relative Risk Aversion Coefficient					
Common Monetary Policy	0.3122	0.3334	0.4570	206.3103	−0.31%
Autonomous Monetary Policy	0.3118	0.3326	0.4538	206.3513	
Weight of the imported goods from the Eurozone					
Common Monetary Policy	0.2086	0.1750	0.4753	268.5821	−0.37%
Autonomous Monetary Policy	0.2082	0.1747	0.4721	268.5083	

Table 12 - Welfare Results for Sensitivity Analysis - Hungary

	C	L	M/P	U	λ
Government Consumption Shocks Only					
Common Monetary Policy	0.1468	0.2410	0.1791	133.4686	−0.1787%
Autonomous Monetary Policy	0.1464	0.2404	0.1778	133.4787	
Technological Shocks Only					
Common Monetary Policy	0.1462	0.2456	0.1780	132.4221	−0.449%
Autonomous Monetary Policy	0.1460	0.2447	0.1770	132.5239	
Correlation of the Monetary Policy Shocks					
Common Monetary Policy	0.1468	0.2411	0.1791	133.4543	−0.04%
Autonomous Monetary Policy	0.1466	0.2408	0.1783	133.4283	
Weight of the Country in the Eurozone					
Common Monetary Policy	0.1468	0.2411	0.1791	133.4417	−0.2162%
Autonomous Monetary Policy	0.1464	0.2405	0.1778	133.4648	
Relative Risk Aversion Coefficient					
Common Monetary Policy	0.3412	0.4199	0.1787	96.8123	−0.23%
Autonomous Monetary Policy	0.3407	0.4190	0.1775	96.8737	
Weight of the imported goods from the Eurozone					
Common Monetary Policy	0.1615	0.1946	0.1902	145.6451	−0.68%
Autonomous Monetary Policy	0.1613	0.1937	0.1894	145.7741	

Table 13 - Welfare Results for Sensitivity Analysis - Poland

	C	L	M/P	U	λ
Government Consumption Shocks Only					
Common Monetary Policy	0.1824	0.2166	0.2377	245.6585	−0.206%
Autonomous Monetary Policy	0.1822	0.2162	0.2368	245.7089	
Technological Shocks Only					
Common Monetary Policy	0.1823	0.2169	0.2376	245.5522	−0.248%
Autonomous Monetary Policy	0.1822	0.2164	0.2368	245.6299	
Correlation of the Monetary Policy Shocks					
Common Monetary Policy	0.1823	0.2168	0.2376	245.5851	−0.2507%
Autonomous Monetary Policy	0.1824	0.2164	0.2374	245.6955	
Weight of the Country in the Eurozone					
Common Monetary Policy	0.1823	0.2168	0.2377	245.5904	−0.2435%
Autonomous Monetary Policy	0.1822	0.2163	0.2368	245.6652	
Relative Risk Aversion Coefficient					
Common Monetary Policy	0.3059	0.3116	0.2377	211.3227	−0.253%
Autonomous Monetary Policy	0.3057	0.3110	0.2368	211.4342	
Weight of the imported goods from the Eurozone					
Common Monetary Policy	0.1859	0.2054	0.2406	250.9021	−0.26%
Autonomous Monetary Policy	0.1857	0.2049	0.2398	250.9780	

11 Appendix III - Some Further Business Cycle Calculation

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

$$
\begin{aligned}
y\_cic_t \quad = \quad & \beta_1 y\_cic_{t-1} + \beta_2 y\_cic_{t-2} + \beta_3 y\_cic_t^* + \\
& \beta_4 y\_cic_{t-1}^* + \beta_5 y\_cic_{t-2}^* + \varepsilon_t
\end{aligned} \tag{28}
$$

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, that is why we made two estimations for each country. One where the foreign economy is the Eurozone and other where the foreign economy is the USA.