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Alexandra Ferreira-Lopes

ISCTE - Lisbon University Institute
UNIDE - ECR
AV FORÇAS ARMADAS
1649-126 LISBON-PORTUGAL
http://erc.unide.iscte.pt

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Alexandra Ferreira-Lopes†

**Abstract**

Denmark, Sweden, and the UK have repeatedly refused to join the European and Monetary Union (EMU). 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 the 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 higher in the presence of persistence government consumption shocks and small trade shares with the EMU.

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†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 UK, Denmark, and Sweden 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 European and Monetary Union (EMU), for these three countries. 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 synchronized 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 preferred 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 models (DSGEM) 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 Denmark, Sweden, and the United Kingdom, 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. Holtemöller (2007) calculated an optimum currency area (OCA) index to measure the economic consequences of joining the EMU and uses a Taylor Rule similar to the one we introduced

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

here, but in a different economic framework and calibrating the model for the new member countries of the European Union. The OCA index measures the relative loss in terms of output gap and inflation variability in the two regimes stated above.

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.

Brigden and Nolan (2002) in the context of a new-keynesian model study the variability of a country's output and inflation if it decides to join a monetary union. They find that the EMU increases the volatility of output and inflation and that loosing the ability to stabilize the domestic economy is less costly if supply shocks are small. They estimate that the UK stabilization cost for joining the EMU is equivalent to a permanent reduction in GDP of between 0.6% and 2%. Pesaran et al. (2007) are also concerned with the behaviour of output and inflation regarding the decision of the UK and Sweden of joining the EMU. They perform a conterfactual analysis using a global vector autoregression (VAR) model, to assess what would have happened if the two countries have joined the EMU in 1999. Results for the UK regarding differences in output and inflation are small and change between the short and the long run, but are robust to various scenarios. Welfare results would be inconclusive, since output and inflation behave in opposite directions, and of course, would depend on the relative importance of each variable. Results for Sweden are different from those of the UK, and since output and inflation would both increase, no robust conclusion about welfare is possible.

McAvinchey and McCausland (2007) used a macroeconomic framework to estimate empirically the impact on the UK economy of joining the EMU, particularly concerning differences in income and macroeconomic policies. The authors found evidence that macroeconomic policies and economic structures of the two zones share similar time paths to those which would happen if the UK was already in the EMU.

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 calibration procedures. Section 5 contains methodology used for welfare analysis and our main results and section 6 examines their robustness. Section 7 concludes.

# 2 Empirical Evidence

In this section we analyse 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.

Denmark, Sweden, and the United Kingdom have repeatedly refuse to join the Euro. These are developed economies, with GDP *per capita* comparable to, or even higher than Germany and France, values that are shown in Table 1. By the time of the introduction of the Euro, in 1999, Denmark and Sweden were more open than Germany and France, and the UK had roughly the same degree of openness.[2]

Table 1- Comparison of GDP *per capita* and Degree of Openness in 1999

| Countries (Year of Accession) | GDP *per capita* in PPP (EU-15=100) | Degree of Openness (%) |
|---|---|---|
| Germany (1957) | 103 | 29.0% |
| France (1957) | 103 | 25.1% |
| Denmark (1973) | 115 | 38.2% |
| Sweden (1995) | 107 | 39.4% |
| UK (1973) | 101 | 27.3% |
| Data Source: Eurostat (NewCronos) | | |

[2] 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.

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 weighted 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. We can see that the cross-country correlations of output $(Y)$ and investment $(I)$ are positive for all countries. Consumption $(c)$ cross-country correlation for Denmark is negative, as well as labour $(l)$ cross-country correlation for the UK. Sweden has the strongest degree of comovement with the Eurozone.

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

| | DNK | SWE | UK |
|---|---|---|---|
| $(Y, Y^*)$ | 0.60 | 0.77 | 0.66 |
| $(c, c^*)$ | -0.13 | 0.72 | 0.40 |
| $(I, I^*)$ | 0.36 | 0.71 | 0.48 |
| $(l, l^*)$ | 0.56 | 0.93 | -0.05 |

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 larger 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 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

| | 1960-1978 | | 1979-2007 | | 1960-2007 | |
|---|---|---|---|---|---|---|
| | Eurozone | USA | Eurozone | USA | Eurozone | USA |
| Denmark | 60% | 90% | 49% | 63% | 58% | 79% |
| Sweden | 59% | 76% | 30% | 48% | 58% | 64% |
| United Kingdom | 75% | 84% | 42% | 43% | 58% | 59% |

Data availability allows us to divide the period between 1960 until 2007 in sub-periods. We choose to split the data in the year 1979 because it is the starting year of the European Monetary System. The weight of the specific component has been declining over time, although it is still high. The specific component of business cycle of the UK is more or less the same regardless whether we use the Eurozone or the USA, reflecting the strong relation between the UK and the USA, despite the accession to the European Union. Stock and Watson (2005) show that UK business cycle is less synchronized with the European business cycle and more with the North-American cycle, between

1984-2002. They also concluded that the percentage of the business cycle that it is explained by country specific factors is increasing, contrary to common factors, that are decreasing, contrary to what our results show. This is also one of the five economic tests that the British Government analyzes from time to time in order to evaluate the benefits and costs of joining the EMU. Peersman (2007) using a two country structural vector autoregression (SVAR) also found a higher degree of business cycle synchronization with the US. Symmetric schocks with the Eurozone are important to explain UK output fluctuations, despite a strong presence of asymmetric shocks.

# 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 behaviour. This setting permits us to construct a detailed quantitative analysis for the behaviour of the main macroeconomic variables and, more importantly, to quantify the welfare cost 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; labour, 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 EMU.

## 3.1 Consumers

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

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

where $c_t$, $l_t$ and, $M_t$ are respectively, consumption, labour, and money, $T_t$ are transfers of home currency, $\Pi_t$ 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, labour, 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 $\beta$ 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 $\theta$ determines the mark-up of price over marginal cost ($\theta$ is the elasticity of substitution between goods produced in the same country, representing the market power of producers), $\rho$ along with $\theta$, determine the elasticity of substitution between home and foreign goods. Parameters $a_1$ and $a_2$, combined with $\theta$ and $\rho$, 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:

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

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 $\delta$ 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 $P^H_{i,t-1}$ 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: $P^H_{i,t+\tau-1} = P^H_{i,t-1}$ and $P^{H^*}_{i,t+\tau-1} = P^{H^*}_{i,t-1}$ 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 $P^H_{i,t-1}$ and $P^{H^*}_{i,t-1}$, production factors $l_{i,t}$, $k_{i,t}$ and $I_{i,t}$ to solve the following problem:

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

subject to (7), (8), and the constraints that their supplies to home and foreign markets, $y^H_{i,t-1}$ and $y^{H^*}_{i,t-1}$, 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:

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

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

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

$$\Lambda^H_t = [a_1 P_t]^{\frac{1}{1-\rho}} \overline{P}^H_{t-1}{}^{\frac{\rho-\theta}{(1-\rho)(\theta-1)}} y_t$$

$$\Lambda^{H^*}_t = [a_2 P^*_t]^{\frac{1}{1-\rho}} \overline{P}^{H^*}_{t-1}{}^{\frac{\rho-\theta}{(1-\rho)(\theta-1)}} y^*_t$$

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 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 studies 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, $\sigma^{r^N}$ 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:

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

where $\varpi$ 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 labour 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. [3]

# 4 Calibration and Data

The calibration for the models is made in order to reproduce the long term properties of each one of the economies at study. 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.

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

## 4.1 Preferences

The functional form of the utility function is:

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

whose arguments are real consumption ($c$), labour ($l$) and a real money aggregate ($M/P$). The discount factor $\beta$ is calculated using annual data, 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, for the 1961-2007 period. The value for $\sigma$ is 0.0001 for all countries and $k$ is the relative risk aversion coefficient. In order to have a balanced growth we impose $\gamma=\sigma$. The weight on leisure, $\varphi$, 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, between 1983 and 2007 for Denmark and the UK, and between 1995 and 2007 for Sweden.

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

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

we estimated regressions with quarterly data, where $M1$ is used for money (except in the case of Sweden, where we use M3, since data for M1 was not available), 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 $\eta$, the interest elasticity of real money demand, and the value for $w$ is residual, which we set equal for all countries. The period for the estimations is 1993:01-2006:03, 1987:01-2007:04, and 1986:03-2007:04 respectively for Denmark, Sweden, and the UK.

## 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 be in 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:

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

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 1966-2007, 1970-2007, and 1980-2007, respectively for Denmark, Sweden, and the UK.

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. Shares for each country are calculated assuming that there are only two countries in the world, each one of the three 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:

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

We calculated the share of capital, $\alpha$, using OECD statistics for the capital income share of the private sector.

For the mark-up parameter we used data between 1966 and 2005, 1993 and 2004, and 1970 and 2005, respectively for Denmark, Sweden, and the UK, 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 $\Pi/y$ 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 $\Pi/y$. Using the last value, we find the markup, which implies the value for $\theta$.

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** The depreciation rate for capital, $\delta$, was calculated implicitly by the following formula:

$$K_t = (1 - \delta) K_{t-1} + I_t \tag{21}$$

The data series for the capital stock and gross fixed capital formation (GFCF) was taken from AMECO, for the period between 1960-2007.

**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 $A_t^*$, respectively for the home and the foreign economy, 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 $\varepsilon^A$ and $\varepsilon^{A^*}$ have a normal distribution, with zero mean, and $\sigma^A$ 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 labour 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 $\varepsilon^g$ and $\varepsilon^{g^*}$ have a normal distribution, with $\mu^g$ mean, $\sigma^g$ 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 1977:01-2007:04, 1980:01-2007:04, and 1955:01-2007:04, respectively for Denmark, Sweden, and the UK, to estimate the parameters.

#### 4.3.3 Monetary Policy Shocks

In this model the National Central Bank follows a Taylor Rule, represented by equation (11). For all three countries the rule of the National Central Bank exhibits a positive correlation of 0.1 with the foreign monetary shock. 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 $\rho_r$, $\rho_\pi$, and $\rho_O$ are 0.85, 1.48, and 0.60 respectively. The volatilities of this rule differ between simulations for each country; these are 0.065%, 0.425%, and 0.177% for Denmark, Sweden, and the United Kingdom, respectively. In the same order, their economic weight, $\varpi$, is 2.5%, 4%, and 19.7%. 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 UK and Sweden were based on Adam et al. (2005) and Sturm and Wollmershaüser (2008), respectively. The Taylor Rule for the ECB was taken from Hayo and Hoffman (2006). Denmark follows an exchange rate peg to the euro and is currently inside the European Exchange Rate Mechanism II (ERM II), so the Taylor Rule was not used for this country. We modelled Danish monetary policy as a fixed exchange rate policy and fixed the exchange rate of the Danish Krone to the Euro with a value of 7.45.

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

### 4.4 Summary

Table 4 presents calibrated parameter values for the three countries.

Table 4 - Calibration Values for the Three Countries

| | DNK | SWE | UK |
|---|---|---|---|
| Preferences | | | |
| $\beta$ | 0.987 | 0.995 | 0.996 |
| $\varphi$ | 300 | 285 | 175 |
| $\eta$ | -0.189 | -0.104 | -0.547 |
| $\kappa$ | 3.6 | 3.5 | 3.98 |
| Final Good Technology | | | |
| $\rho$ | 0.252 | 0.492 | 0.194 |
| $a_1$ | 0.816 | 0.749 | 0.839 |
| $a_2$ | 0.184 | 0.251 | 0.161 |
| Intermediate Good Technology | | | |
| $\alpha$ | 0.359 | 0.378 | 0.378 |
| $\delta$ | 1.17% | 1.11% | 0.98% |
| $\theta$ | 0.975 | 0.951 | 0.951 |
| $b$ | 10 | 57 | 63 |
| Taylor Rule National Bank | | | |
| $\rho^r$ | $n.a.$ | 0.93 | 0.85 |
| $\rho^\pi$ | $n.a.$ | 1.89 | 1.89 |
| $\rho^o$ | $n.a.$ | 1.48 | 1.30 |
| $\sigma^r$ | $n.a.$ | 0.004 | 0.003 |
| Technological Shocks | | | |
| $\rho^A$ | 0.443 | 0.794 | 0.755 |
| $\sigma^A$ | 0.017 | 0.009 | 0.007 |
| $corr(\varepsilon^A, \varepsilon^{A^*})$ | 0.473 | 0.327 | 0.300 |
| Government Consumption Shocks | | | |
| $\rho^g$ | 0.991 | 0.983 | 0.995 |
| $\sigma^g$ | 0.017 | 0.009 | 0.007 |
| $\mu^g$ | 0.117 | 0.120 | 0.114 |

In Denmark an interest rate rule is inexistent in simulation *Autonomous Monetary Policy* because the country follows an exchange rate peg to the Euro, so monetary policy is used to maintain that peg. Also in Denmark, technological shocks have a smaller persistence than in the other two countries, although cross-country correlations are higher. In Sweden the trade share with the EMU is bigger than in the other two countries, and the elasticity of substitution between domestic and imported goods is higher. In the UK people spend most time working than in the other two countries. Taylor Rule for the UK is less smoother than the Taylor Rule for Sweden in simulations *Autonomous Monetary Policy*. 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.

# 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 $\lambda$ represents the gains (or losses) of welfare in terms of consumption percentage.

The main purpose of this section is to analyze the behaviour 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 of the statistics for simulations *Common Monetary Policy* and *Autonomous Monetary Policy*, for the domestic economy in all three countries.

The values of the statistics for the simulations support some of the stylized facts found in the literature and in the section of empirical evidence above, for instance, output is more volatile than net exports, but less volatile than investment. Autocorrelations are usually persistent as in the data.

In simulation *Common Monetary Policy* there are not monetary policy shocks in the domestic economy, since monetary policy is established by the European Central Bank, so volatility is lower in this simulation. We modelled the monetary policy of the Danish Central Bank as an exchange rate peg to the euro, so the policy rule does not follow a Taylor Rule, hence there is not any volatility at all for these shock, making variables in this country less volatile in simulation *Autonomous Monetary Policy* instead.

Comparisons of the behaviour of autocorrelations differ from country to country, and depend of the magnitude of the shocks and the comovements between them, but persistence is on average higher in simulation *Autonomous Monetary Policy.* This is a logical result, since monetary policy is oriented towards the domestic economy, hence monetary policy stabilizes more the domestic economy, 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 because of the imposition of equation (13), so especially for consumption and investment, these cross-country correlations are very high, especially in Sweden and in the UK.

Denmark has a different behaviour from the other countries in the cross-country correlations of output, investment, and labour in simulation *Common Monetary Policy*, because the volatility of the interest rate shock is insignificant. This simulation is then dominated by the stronger shock present in the simulation, the government consumption shock and restriction (13). The restriction imposes a strong correlation between consumption in the two economies. The government consumption shock makes correlations between output, investment, and labour negative. If we think of a negative consumption shock; output, labour, and investment in these economy decrease, but consumption increases. Net exports movements depend on consumption and investment relative movements. Due to the existence of complete markets the risk sharing effect prevails and net exports increase initially. The domestic economy is lending resources to the foreign economy, making consumption higher in both economies. Because consumption has increased, output increases and because the economy needs more factors of production, so does investment.

## 5.2 Welfare Calculations

The results based on the methodology described in the previous sub-section are presented in Table 5. 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 5 - Welfare Results for the Three Economies - Benchmark Simulations

| | $c$ | $l$ | $M/P$ | $U$ | $\lambda$ |
|---|---|---|---|---|---|
| *Denmark* | | | | | |
| *Common Monetary Policy* | 0.217 | 0.209 | 0.289 | 216.21 | -5.26% |
| *Autonomous Monetary Policy* | 0.216 | 0.207 | 0.287 | 216.78 | |
| *Sweden* | | | | | |
| *Common Monetary Policy* | 0.213 | 0.207 | 0.489 | 206.39 | -0.54% |
| *Autonomous Monetary Policy* | 0.213 | 0.207 | 0.488 | 206.60 | |
| *UK* | | | | | |
| *Common Monetary Policy* | 0.306 | 0.214 | 0.034 | 125.92 | -0.51% |
| *Autonomous Monetary Policy* | 0.306 | 0.213 | 0.034 | 126.07 | |

The nominal interest rate in the *Autonomous Monetary Policy* regime is on average higher than in simulation *Common Monetary Policy*, in accordance to what happens in these economies. These economies have a more aggressive inflation parameter in the Taylor Rule for the National Central Bank, namely Sweden and the UK. As a result, when prices increase, the interest rate response is higher, 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. Labour in this simulation is on average lower; as a result there is more leisure and consumers are better off.

In the case of Denmark because monetary policy shocks are absent from simulation *Autonomous Monetary Policy*, hence don't produce volatility, and because consumers dislike volatility because they are risk averse, the preference for not joining the EMU is substantially higher than in the other two countries. Since Denmark already has a fixed exchange rate to the euro, consumers in Denmark are already taking benefit of some exchange rate stability, that consumers in Sweden and in the UK are not. 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.

Results are also in agreement with some of the empirical evidence of Section 2, namely idiosyncratic shocks in Denmark have a bigger magnitude than those of Sweden and the UK in the recent period (1979-2007). If a country has a bigger specific component of a given shock, costs of entering and relinquishing its monetary policy are obviously higher. Also, cross-country correlations between Denmark and the Eurozone are the lowest 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 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 ($\lambda$) for the three countries.[4] Results are presented in Table 6 below and seem to be, on average, quite robust, reenforcing the decision of these countries not to join the EMU.

[4] We increase the correlations of monetary policy shocks in the *Autonomous Monetary Policy* simulation to 0.5 and the weight of imported goods from the Eurozone, as well as the weight of the country in the Eurozone to 25% more of their initial value. Results for Denmark concerning an increase in the weight of imported goods from the Eurozone are not presented due to the instability of the results in this simulation.

Table 6 - Results for Sensitivity Analysis

| DNK | SWE | UK |
|---|---|---|
| *Benchmark* | | |
| -5.26% | -0.54% | -0.51% |
| *No Technological Shocks* | | |
| -4.11% | -0.49% | -0.50% |
| *No Government Consumption Shocks* | | |
| +0.09% | -0.19% | -0.006% |
| *Correlation of Monetary Policy Shocks* | | |
| *n.a.* | -0.52% | -0.50% |
| *Weight of imported goods from the Eurozone* | | |
| *n.a.* | -0.42% | -0.40% |
| *Same Taylor Rule, Volatility, and Correlation* | | |
| *n.a.* | -0.49% | -0.49% |
| *Weight of the country in the Eurozone* | | |
| -4.21% | -0.53% | -0.42% |

Generally we find that changes in the values of the weight of imported goods from the Eurozone and of the government consumption shocks seem to have the biggest impact in the change of the welfare value.

Technology shocks have a small impact on the welfare results, since the persistence of these shocks for these countries is lower than government spending shocks, but still the cost of entering EMU decreases with the disappearing of these costs. Although these shocks are positively cross-county correlated, much of its persistence has its effects on the domestic economy, although much less than the government consumption shocks. Hence, when the shocks is eliminated so is the need to stabilize it. Since the output parameter of the Taylor rule of each the central banks of Sweden and the UK are higher they perform better at stabilizing these type of shocks The effect of these shocks depends on the substitution and income effects. In this model, and given the choices of parameters for these countries, the substitution effect prevails, so whenever there is a positive technological shock labour increases, and so does consumption.

Consumers are more indifferent between the two regimes, when demand shocks are removed. Volatility in both simulations are reduced and the need to stabilize idiosyncratic domestic spending shocks disappears, making consumers more willing to join the EMU. Results are stronger for Denmark and the UK since the persistence of this shock is higher for these countries.

In Denmark, since the country does not follow a Taylor rule like the other two, the reason why the removal of these shocks decrease the cost of joining is just a matter of making both simulations more similar in terms of volatility.

Changes in the correlation of the monetary policy shocks also seem important, and make consumers in Sweden and in the UK more indifferent to the choice of regime. This is intuitive since increasing the correlation of monetary policy shocks in simulation *Autonomous Monetary Policy* makes domestic and foreign nominal interest rates react in a similar way. As two policies become more alike, consumers become more indifferent between the two monetary regimes.

Also, for the UK and Sweden we find that increases in the trade volume with the Eurozone decreases 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). Higher trade shares increase the exposure of the country to foreign shocks and hence decrease the possibility of experiencing idiosyncratic shocks.

We conduct an experiment where we change the Taylor rule of the National Central Bank to be equal to the Taylor rule of the ECB, as well as its volatility and the cross-country correlation of the monetary policy shock, i.e., simulations become more alike. Sweden and the UK present lower costs of joining the EMU and relinquishing their monetary policy, but since these countries do not make the entire Eurozone alone, the cost still exists. The Taylor rule of the ECB is less volatile and also, for the case of Sweden, less smoother, being more agressive and quicker in the stabilization process.

In order to assess the importance of the weight of the country in the monetary policy rule of the ECB we increase the weight of these countries in the Eurozone. Results are very intuitive, since now the countries have a smaller cost in joining the EMU. If the economic dimension of the country increases, its influence in the weighted average of the economic conditions of the EMU is also going to increase, and hence monetary policy is more suitable for its economic conditions. This is especially relevant in the case of the UK, where costs decrease substantially.

# 7 Conclusions

The use of this model for these three countries illustrates in an explicit way the main result of this work: consumers are willing to give up part of their consumption in order to stay in an economy where the monetary policy is conducted on a national level. We must emphasize the fact that these results were obtained in the context of a complete markets model, 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 government consumption shocks are stronger and when the trade share with the Eurozone is smaller, emphasizing the importance of idiosyncratic characteristics for these countries.

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 UK there are several studies that try to assess the benefit of loosing the exchange rate *vis-a-vis* the other EMU members. The European Commission (EC) in 1990 estimate this value to be

0.1% of GDP for the UK and 0.4% of GDP for the average of the European Union. In 1996, a study by IFO for the EC, claims that the last value had increased to 1% of GDP. Calmfors et al. (1997) found a 0.3% of GDP benefit for Sweden. In countries which have a highly developed financial system, the gains from eliminating transaction costs are lower, since they have more 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 0.3% and 2.9% 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, except in the case of Denmark.

## References


[1] Adam, C., Cobham, D., Girardin, E., 2005. Monetary Frameworks and Institutional Constraints: UK Monetary Policy Reaction Functions, 1985-2003. *Oxford Bulletin of Economics and Statistics* 67, 497-516.

[2] Beggs, D. et al., 2003. The Consequences of Saying No - An Independent Report into the Economic Consequences of the UK Saying No to the Euro. Report for the Commission, May.

[3] Blanchard, O., Kahn, C., 1980. The Solution of Linear Difference Models under Rational Expectations. *Econometrica* 48 (5), July, 1305 - 1311.

[4] Brigden, A., Nolan, C., 2002. Monetary Stabilization Policy in a Monetary Union: Some Simple Analytics. *Scottish Journal of Political Economy* 49 (2), 196-215.

[5] Calmfors L. et al., 1997. EMU - a Swedish Perspective. Kluwer Academic Publishers.

[6] Carré, M., Collard, F., 2003. Monetary Union: a Welfare Based Approach. *European Economic Review* 47, 521-552.

[7] Ca'Zorzi, M., Santis, R. A. de, Zampolli, F. , 2005. Welfare Implications of Joining a Common Currency. European Central Bank, *Working Paper Series* 445, February.

[8] Chari, V.V., Kehoe, P. J., McGrattan, E. R., 2002a. Can Sticky Price Models Generate Volatile and Persistent Real Exchange Rates?. *Review of Economic Studies* 69 (3), July, 533-563.

[9] Chari, V.V., Kehoe, P. J., McGrattan, E. 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.

[10] Clarida, R., Gali, J., Gertler, M., 1999. The Science of Monetary Policy: A New Keynesian Perspective. *Journal of Economic Literature* XXXVII, December, 1661-1707.

[11] Clarida, R., Gali, J., Gertler, M., 2000. Monetary Policy Rules and Macroeconomic Stability. *The Quarterly Journal of Economics* 115, 147–180.

[12] Cooley, T. F. editor, 1995. Frontiers of Business Cycles Research. Princeton University Press.

[13] 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.

[14] Domowitz, I., Hubbard, R. G., Petersen, B. C., 1986. Business Cycles and the Relationship between Concentration and Price Cost-Margins. *Rand Journal of Economics* 17, 1-18.

[15] European Commission, 1990. One Market, One Money. *European Economy* 44, Directorate-General for Economic and Financial Affairs.

[16] European Commission, 1996. Economic Evaluation of the internal market. *European Economy Reports and Studies*, 4, Directorate-General for Economic and Financial Affairs.

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

[18] Gali, J., Gertler, M., Lopez-Salido, J. D., 2001. European Inflation Dynamics. *European Economic Review* 45, 1237-1270.

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

[20] Gros, D., Hefeker, C., 2002. One Size Must Fit All, National divergences in a monetary union. *The German Economic Review* 3 (3), August, 247-262.

[21] Hayo, B., Hoffman, B., 2006. Comparing Monetary Policy Reactions Functions: ECB versus Bundesbank. *Empirical Economics*, Vol. 31, Issue 3, pp. 645-662.

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

[23] Jorgenson, D., Gollop, F., Fraumeni, B., 1987. Productivity and US Economic Growth. Cambridge, Massachusetts, MIT Press.

[24] Kenen, P., 1969. The Theory of Optimum Currency Areas: An Eclectic View. In: Mundell, R. and Swoboda, A. K. (Eds.), Monetary Problems of the International Economy, Chicago, University of Chicago Press, pp. 41-60.

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

[26] Lucas Jr., R., 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] McAvinchey, I., McCausland, W.D., 2007. The Euro, Income Disparity and Monetary Union. *Journal of Policy Modelling* 29, 869-877.

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

[30] Mundell, R., 1961. A Theory of Optimum Currency Areas. *American Economic Review* 51, March, 657-665.

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

[32] Obstfeld, M., Rogoff, K., 1998. Foundations of International Macroeconomics. MIT Press.

[33] Peersman, G., 2007. The Relative Importance of Symmetric and Asymmetric Shocks: The Case of United Kingdom and Euro Area. *Oesterreichische Nationalbank Working Paper* N$^o$ *136*, October.

[34] Pesaran, M. Hashem, L. Vanessa Smith and Ron P. Smith (2007), "What if the UK or Sweden had Joined the Euro in 1999? An Empirical Evaluation Using a Global VAR", *International Journal of Finance and Economics*, 12: 55-87.

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

[36] Stock, J. H., Watson, M. W., 2005. Understanding Changes in International Business Cycle Dynamics. *Journal of the European Economic Association*, 3 (5), September, 968-1006.

[37] Sturm, J.E., Wollmershaüser, T., 2008. The Stress of Having a Single Monetary Policy in Europe. *CESifo Working Paper* N$^o$ *2251*, March.

[38] Taylor, J., 1993. Discretion Versus Policy Rules in Practice. *Carnegie-Rochester Conference Series on Public Policy* 39, 195-214.

[39] Whalley, J., 1985. Trade Liberalization Among Major World Trading Areas. Cambridge, Massachusetts, MIT Press.

[40] Woodford, M., 2003. Interest and Prices - Foundations of a Theory of Monetary Policy. Princeton University Press.

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

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 Sweden, Denmark, the UK, 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 Denmark

| | Data | Common Monetary Policy | Autonomous Monetary Policy |
|---|---|---|---|
| Standard Deviations | | | |
| $Y$ | 1.04 | 1.04 | 0.89 |
| $NX$ | 1.00 | 0.83 | 0.40 |
| Standard Deviations Relative to GDP | | | |
| $c$ | 1.32 | 0.58 | 0.09 |
| $I$ | 4.84 | 5.10 | 3.18 |
| $l$ | 0.66 | 5.53 | 3.36 |
| Autocorrelations | | | |
| $Y$ | 0.42 | 0.63 | 0.65 |
| $c$ | 0.60 | 0.68 | 0.65 |
| $I$ | 0.37 | 0.13 | 0.48 |
| $l$ | 0.78 | 0.10 | 0.47 |
| $NX$ | 0.61 | 0.33 | 0.15 |
| Cross-Country Correlations | | | |
| $(Y, Y^*)$ | 0.60 | -0.54 | 0.51 |
| $(c, c^*)$ | -0.13 | 0.90 | 0.05 |
| $(I, I^*)$ | 0.36 | -0.41 | 0.15 |
| $(l, l^*)$ | 0.56 | 0.08 | 0.39 |
| $(Y, NX)$ | 0.05 | 0.08 | -0.23 |

Table A2 - Statistics and Stylized Facts for Sweden

| | Data | Common Monetary Policy | Autonomous Monetary Policy |
|---|---|---|---|
| Standard Deviations | | | |
| $Y$ | 0.83 | 0.83 | 0.83 |
| $NX$ | 0.68 | 0.27 | 0.44 |
| Standard Deviations Relative to GDP | | | |
| $c$ | 1.03 | 0.52 | 0.62 |
| $I$ | 5.84 | 2.74 | 3.23 |
| $l$ | 1.34 | 2.38 | 2.44 |
| Autocorrelations | | | |
| $Y$ | 0.86 | 0.45 | 0.42 |
| $c$ | 0.79 | 0.54 | 0.59 |
| $I$ | 0.61 | 0.53 | 0.57 |
| $l$ | 0.92 | 0.62 | 0.61 |
| $NX$ | 0.44 | -0.50 | -0.40 |
| Cross-Country Correlations | | | |
| $(Y, Y^*)$ | 0.77 | 0.79 | 0.19 |
| $(c, c^*)$ | 0.72 | 0.99 | 0.06 |
| $(I, I^*)$ | 0.71 | 0.99 | -0.01 |
| $(l, l^*)$ | 0.93 | 0.53 | 0.12 |
| $(Y, NX)$ | -0.07 | 0.14 | 0.05 |

Table A3 - Statistics and Stylized Facts for The UK

| | Data | Common Monetary Policy | Autonomous Monetary Policy |
|---|---|---|---|
| Standard Deviations | | | |
| $Y$ | 0.37 | 0.37 | 0.37 |
| $NX$ | 0.41 | 0.12 | 0.17 |
| Standard Deviations Relative to GDP | | | |
| $c$ | 1.35 | 0.55 | 0.67 |
| $I$ | 8.18 | 2.67 | 3.40 |
| $l$ | 0.50 | 3.49 | 3.78 |
| Autocorrelations | | | |
| $Y$ | 0.80 | 0.50 | 0.45 |
| $c$ | 0.60 | 0.60 | 0.60 |
| $I$ | 0.57 | 0.53 | 0.51 |
| $l$ | 0.45 | 0.66 | 0.63 |
| $NX$ | 0.48 | -0.32 | -0.16 |
| Cross-Country Correlations | | | |
| $(Y, Y^*)$ | 0.66 | 0.72 | 0.24 |
| $(c, c^*)$ | 0.40 | 0.99 | 0.23 |
| $(I, I^*)$ | 0.48 | 0.95 | -0.05 |
| $(l, l^*)$ | -0.05 | 0.32 | 0.03 |
| $(Y, NX)$ | -0.05 | -0.03 | -0.13 |

# 9 Appendix B - Some Further Business Cycle Calculations

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. $\varepsilon_t$ 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 behaviour 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 $\sigma_{\varepsilon_t}$ 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.