Inflation Differentials and Different Labor Market Institutions in the EMU*

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This draft December 2004

Abstract

Despite the creation of a single currency, inflation differentials are still significant in the euro area. In addition country data show that remarkable differences are still present in labor and product market institutions across European countries. This paper tries to assess the link between those two facts. To this aim we use a dynamic general equilibrium model for a currency area characterized by monopolistic competition and adjustment costs on pricing, matching frictions and sticky wages in the labor market. We allow for differences in labor and product market institutions and show that they can generate high (on impact) and persistent inflation differentials (hence high terms of trade volatility and persistence) even in presence of common monetary policy shock and/or symmetric technology shocks. Furthermore we show that the sensitivity of inflation in response to any shock is higher for the country with either the lower ratio of unemployment benefits to real wages or higher demand elasticity. We reconcile those facts with VAR evidence for the main euro area countries during the EMU period.

JEL Codes: F30, J30

Keywords: inflation differentials, labor and product market institutions, EMU.

1 Introduction

Inflation differentials are still pronounced in European countries despite the creation of a single currency and the existence of limits on national fiscal policies. In addition, remarkable differences still exist in national labor and product market institutions. This paper tries to assess the link between these two facts. As well understood, labor market frictions are an important determinant of the dynamics of marginal costs of firms, which are a main driver of inflation, and product market regulations affect the response of inflation to marginal costs. Hence it seems natural to assess the

*We thank Ignazio Angeloni, Giancarlo Corsetti and Julian Morgan for useful discussions. All errors are our own responsibility.

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quantitative relevance of such institutions in determining the differential inflation dynamics across European countries.

To this purpose we build a dynamic general equilibrium model with two region sharing the same currency and monetary policy and characterized by a variety of frictions: matching frictions and wage rigidity in the labor market[1], monopolistic competition in product markets and adjustment cost on pricing. We use this laboratory economy to analyze the differential impact of common monetary policy and technology shock under different types of labor and product market institutions across the two countries. We identify labor market institutions with unemployment benefits and product market institutions with the elasticity of goods demand (hence with the product mark-up). We calibrate both of them on euro area country data. We find that labor and/or product market institutions are able to generate significant and persistent inflation differentials. This result holds under common monetary policy shocks and symmetric and correlated technology shocks. Furthermore we show that inflation is more responsive in countries with lower levels of unemployment benefits and higher levels of demand elasticity. We are able to reconcile those results with evidence obtained by running simple VAR regressions for the main euro area countries during the EMU period.

The reason for which lasting inflation differentials can be a concern for policy makers is twofold. First, such differentials would lead to sustained loss in competitiveness and in national output growth, possibly harming growth in the euro area itself. Secondly, they might also be a signal of unwarranted fiscal and labor or product market national policies.

Several commentators in the past argued that inflations differentials were due to initial price and productivity differentials - i.e. such as the Balassa Samuelson effect -, and that they would have disappeared once the convergence process was complete. However after five years from the start of the EMU inflation differentials still persist and seem to have increased recently. While inflation differentials among euro area countries declined steadily in the 1990-1999 period, the standard deviation of the annual growth rates of the HIPC started to pick up again since then. Recent empirical studies also showed that euro area inflation differentials are higher than those observed in the U.S. and that factors other than price convergence seem to explain most of the cross-country differences.

Fiscal, labor and product market policies are all plausible candidates as factors explaining inflation differentials. We focus attention on the impact of labor and product market institutions for a twofold reason. First, labor market institutions have an impact on marginal cost and product market institutions have an impact on the reaction of prices to marginal costs. Hence both of them

[1]The tradition of introducing matching frictions in a dynamic general equilibrium model is at this point well established for closed economy models. Among others see Merz (1995), Andolfatto (1996), Cooley and Quadrini (2000), Cheron and Langot (1999), Walsh (2002), Krause and Lubik (2003). There is also another line of papers which introduces different types of labor market frictions into DSGE models: among others Danthine and Kurman (2003), Neiss and Pappa (2002).

have a direct effect on inflation. Secondly, and contrary to other factors, labor and product market frictions induce inefficient movements in inflation, hence they are likely to be undesirable from a welfare perspective.

We present a unitary framework whose different ingredients allow us to address the questions proposed above. The reason for introducing in the model monopolistic competition and adjustment cost on pricing a' la Rotemberg (1982) responds to the goal of studying monetary policy shocks with non-neutral effects. The typical Phillips curve generated under this assumption links inflation today to future expectations of inflation and to a measure of the marginal cost. Introducing matching frictions a' la Mortensen and Pissarides (1999) in the labor market allows us to study equilibrium unemployment in a non-Walrasian economy and to provide a rich dynamics for the formation and dissolution of employment relations. We enrich the basic matching model with two additional features which are endogenous job destruction and real wage rigidity. The first of the two has been found realistic in data for industrialized countries[2] and improves the persistence in business cycle models[3]. The second of the two allows for a muted response of marginal costs[4] and helps to recover the Beveridge curve (the negative correlation between vacancies and unemployment) as noted in Shimer (2003).

The economics behind the effects of labor market institutions on inflation is simple. Unemployment benefits affect the equilibrium value of a match which in turn affects real wages and marginal costs. Hence varying unemployment benefits allows for a differential dynamic of real wages and marginal costs. Different marginal cost dynamics then induce different inflation dynamics via the link provided by the Phillips curve.

Product market institutions in our model affect the response of inflation to marginal cost. Higher elasticity of demand implies lower mark-up and higher competition. It also implies a higher response of inflation to marginal costs.

The differential transmission mechanism also bears some important implications for the open economy dimension of the paper. Indeed the terms of trade depend from the relative distribution of work effort across the two regions and from the relative size of the mark-ups. Hence differential responses of employment and marginal costs generate endogenous terms of trade depreciation with shifts in competitiveness across countries.

The paper proceeds as follow. Section 1 reviews the empirical literature on inflation differentials and shows some stylized facts on inflation differentials and labor market differences for European countries. Section 2 presents the model. Section 3 comments on the model dynamics under the assumption that the two countries have symmetric labor and product market institutions. Section 4 comments on the dynamic properties of the model under the assumption that the two

[2] See Davis, Haltiwanger and Schuch (1996).

[3] See denHaan, Ramsey and Watson (1997).

[4] In this we follow Hall (2002).

countries have different labor and product market institutions. Section 5 concludes. Figures and tables follow.

1.1 Related Literature and Stylized Facts

There have been recently various empirical contributions on the analysis of inflation differentials in Europe.

Empirical studies such as Alberola (2000), Rogers (2002) and Ortgea (2003) show that factors other than the price convergence hypothesis and the Balassa Samuelson effect have played a significant role in explaining price and inflation divergence in Europe. In particular they stress the importance of mark-ups and wages differences as main determinant of the inflation differentials. On the other side Honohan and Lane (2003) stress the importance of the differential impact on different member states of the weakness of the euro and of international currency market. A variety of determinants for inflation differentials are instead considered in an extensive empirical study conducted by the ECB (the "Inflation Differential" report of the 2003). This is a comprehensive survey of a variety of measures for price and cost developments among the EU-12 during the 1999-2002 period. The authors of the report find important evidence of the link between inflation differentials and differences in labor costs.

Some papers in the theoretical literature have also approached similar issues. Benigno (2003) and Benigno and Lopez-Salido (2003) focus on the welfare implications (more than on the causes) of inflation differentials for euro area countries. Andres, Ortega and Valles (2003) use a two country model to asses the impact of product market regulations on inflation differentials. Finally Angeloni and Ehrmann (2004) use a 12-country model to address the impact of various factors on the inflation dynamics. Interestingly they find that the presence of inflation persistence per se induces inflation differentials.

Contrary to the majority of previous studies we focus on cyclical inflation dynamics and on their link with labor and product market institutions. Hence to strengthen our motivation we now document the cyclical behavior of inflation and unemployment for the major euro area countries. Furthermore we present country data on unemployment benefits which show the presence of marked differences across euro area members. The same data will also be used in the next sections for the calibration of our two region laboratory economy.

Inflation differentials. Figure (1) shows the Hodrick-Prescott de-trended measure of the log changes in CPI inflation for the period 1980-2004. We consider the four biggest euro area countries (Germany, France, Italy and Spain) and a weighted average of the same four countries. From the graph we can see that the business cycle component of inflation for the four countries considered has converged significantly up to the 1998 but is much less synchronized after then. Noticeable is the strong divergence of the Spanish inflation from the euro area average.

Next we analyze the pattern of rolling correlations of inflation, output and unemployment across the four biggest European countries - i.e. France, Germany, Italy and Spain - for the period 1976-2000. Inflation, output and unemployment have been de-trended using a band-pass filter - i.e. calculated with Baxter and King (2000) procedure[5]. Cross-correlations of inflation have converged up to the 1998 but have started to diverge again since then (see (2)). A similar pattern is observed for the cross-correlation of unemployment - e.g. (3). It is interesting to notice that the cross-correlations among continental (France and Germany) and Mediterranean (Italy and Spain) countries is in general lower than the cross-correlations among countries belonging to the same geographical area.

Labor market institutions. Table (1) shows averages over 1985 to 1995 of benefit durations for a series of industrialized countries[6]. The data show that there is considerable variation in this measure across euro area countries. In general unemployment benefits range from a minimum of 0.09 to a maximum of 0.78. Differences in labor market institutions generate of course differences in the pattern of unemployment and marginal labor cost.

2 A Model for A Currency Area with Labor and Product Market Frictions

There are two regions of equal size. Each country is inhabited by a continuum of agents with measure one. Countries are symmetric for everything apart from the labor and product market institutions.

Each economy is populated by households who consume different varieties of domestically produced and imported goods, save and work. Households save in both domestic and internationally traded bonds. Each agent can be either employed or unemployed. In the first case he receives a wage that is determined according to a Nash bargaining, in the second case he receives an unemployment benefit. The labor market is characterized by matching frictions and endogenous job separation.

The production sector acts as a monopolistic competitive sector which produces a differentiated good using capital and labor as inputs and faces adjustment costs a' la Rotemberg (1982).

Let $s^t = \{s_0, ...s_t\}$ denote the history of events up to date t, where s_t denotes the event realization at date t. The date 0 probability of observing history s^t is given by ρ_t. The initial state s^0 is given so that $\rho_0 = 1$. Henceforth, and for the sake of simplifying the notation, let's define the operator $E_t\{.\} \equiv \sum_{s_{t+1}} \rho(s^{t+1}|s^t)$ as the mathematical expectations over all possible states of nature conditional on history s^t.

[5] Data are taken from the ECB MTN dataset.

[6] Data are taken from Nickell and Nunziata (2001).

2.1 Households in the Domestic and Foreign Region

Let's denote by $c_t \equiv [(1-\gamma)^{\frac{1}{\eta}} c_{h,t}^{\frac{\eta-1}{\eta}} + \gamma^{\frac{1}{\eta}} c_{f,t}^{\frac{\eta-1}{\eta}}]^{\frac{\eta-1}{\eta}}$ a composite consumption index of domestic and imported bundles of goods, where γ is the balanced-trade steady state share of imported goods (i.e., an inverse measure of home bias in consumption preferences), and $\eta > 0$ is the elasticity of substitution between domestic and foreign goods. Each bundle is composed of imperfectly substitutable varieties (with elasticity of substitution $\varepsilon > 1$). Optimal allocation of expenditure within each variety of goods yields the following:

$$c_{h,t}^i = \left(\frac{p_{h,t}^i}{p_{h,t}}\right)^{-\varepsilon} c_{h,t} \; ; \; c_{f,t}^i = \left(\frac{p_{f,t}^i}{p_{f,t}}\right)^{-\varepsilon} c_{f,t} \tag{1}$$

where $c_{h,t} \equiv \int_0^1 [(c_{h,t}^i)^{\frac{\epsilon-1}{\epsilon}} di]^{\frac{\epsilon}{\epsilon-1}}$ and $c_{f,t} \equiv \int_0^1 [(c_{f,t}^i)^{\frac{\epsilon-1}{\epsilon}} di]^{\frac{\epsilon}{\epsilon-1}}$. Optimal allocation of expenditure between domestic and foreign bundles yields:

$$c_{h,t} = (1-\gamma)\left(\frac{p_{h,t}}{p_t}\right)^{-\eta} c_t ; \; c_{f,t} = \gamma \left(\frac{p_{f,t}}{p_t}\right)^{-\eta} c_t \tag{2}$$

where $p_t \equiv [(1-\gamma)p_{h,t}^{1-\eta} + \gamma p_{f,t}^{1-\eta}]^{\frac{1}{1-\eta}}$ is the CPI index. There is continuum of agents who maximize the expected lifetime utility.

$$E_t \left\{ \sum_{t=0}^{\infty} \beta^t \left(\frac{c_t^{1-\sigma}}{1-\sigma} + (1-\chi_t)b - \chi_t h_t\right) \right\} \tag{3}$$

where c denotes aggregate consumption in final goods, h is the time spent working, χ is an indicator function which takes the value of 1 if the worker is employed and zero if he is unemployed and b is the unemployment benefit. The household receives at the beginning of time t a labor income of $w_t h_t$ if he is employed, where w_t is the real wage bill. The contract signed between the worker and the firm specifies working time and wage and is obtained through a Nash bargaining process. In order to finance consumption at time t each agent also invests in non-state contingent nominal bonds b_t which pay a gross nominal interest rate $(1 + r_t^n)$ one period later and in non-state contingent nominal bonds which are internationally traded, b_t^*, and which pay a gross nominal interest rate $(1 + r_t^{n,f})$ one period later. As in Andolfatto (1996) and Merz (1995) it is assumed that workers can insure themselves against earning uncertainty and unemployment. For this reason the wage earnings have to be interpreted as net of insurance costs. Finally agents receive profits from the monopolistic sector which they own, Θ_t, and pay lump sum taxes, τ_t. The sequence of budget constraints in terms of domestic CPI consumption goods reads as follows:

$$c_t + \frac{b_t}{p_t} + e_t^r \frac{b_t^*}{p_t^*} \leq \chi_t w_t h_t + \frac{\Theta_t}{p_t} - \frac{\tau_t}{p_t} + (1 + r_{t-1}^n)\frac{b_{t-1}}{p_t} + (1 + r_{t-1}^{n,f}) e_t^r \frac{b_{t-1}^*}{p_t^*} \tag{4}$$

where e_t^r is the real exchange rate which in the currency area is given by $e_t^r = \frac{p_t^*}{p_t}$.Households choose the set of processes $\{c_t, h_t, b_t, b_t^*\}_{t=0}^{\infty}$ taking as given the set of processes $\{p_t, w_t, r_t^n, r_t^{n,f}, \chi_t\}_{t=0}^{\infty}$ and the initial wealth b_0, b_0^* so as to maximize (3) subject to (4). The following optimality conditions must hold:

$$c_t^{-\sigma}\frac{w_t}{p_t} = 1 \tag{5}$$

$$c_t^{-\sigma} = \beta(1 + r_t^n)E_t\left\{c_{t+1}^{-\sigma}\frac{p_t}{p_{t+1}}\right\} \tag{6}$$

$$c_t^{-\sigma} = \beta(1 + r_t^{n,f})E_t\left\{c_{t+1}^{-\sigma}\frac{p_t^*}{p_{t+1}^*}\frac{e_{t+1}^r}{e_t^r}\right\} \tag{7}$$

$$c_t^{-\sigma} = \lambda_t \tag{8}$$

Equation (5) gives the optimal choice of labor supply. Equation (6) is the Euler condition with respect to domestic bonds. Equation (7) is the optimality condition with respect to internationally traded bonds. Equations (8) is the marginal utility of consumption. Optimality requires that No-Ponzi condition on wealth is also satisfied.

Arbitrage condition and accumulation of assets. Due to imperfect capital mobility and/or in order to capture the existence of intermediation costs in foreign asset markets workers pay a spread between the interest rate on the foreign currency portfolio and the interest rate of the foreign country. This spread is proportional to the (real) value of the country's net foreign asset position:

$$\frac{(1 + r_t^{n,f})}{(1 + r_t^{n,*})} = \zeta\left(e_t^r\frac{b_t^*}{p_t^*}\right) \tag{9}$$

where $\zeta > 0$[7], $\zeta' > 0$. In addition we assume that the initial distribution of wealth between the two countries is symmetric. Aggregating the budget constraints of the workers, substituting for (9) and assuming that domestic bonds are in zero net supply we obtain the following law of motion for the accumulation of bonds:

$$e_t^r\frac{b_t^*}{p_t^*} \leq (1 + r_{t-1}^{n,*})\zeta\left(e_t^r\frac{b_{t-1}^*}{p_{t-1}^*}\right)\frac{b_{t-1}^*}{p_t^*} + [\chi_t w_t h_t + \frac{\Theta_t}{p_t} - \frac{\tau_t}{p_t}] - c_t \tag{10}$$

Workers in the Foreign Region. We assume throughout that all goods are traded, that both countries face the same composition of consumption bundle and that the *law of one price*

[7] As shown in Schmitt-Grohe and Uribe (2001) and Benigno (2002) this assumption is needed in order to maintain the stationarity in the model. Schmitt-Grohe and Uribe (2001) also show that adding this spread - i.e. whose size has been shown negligible in Lane and Milesi-Ferretti (2001) - does not change significantly the behavior of the economy as compared to the one observed under the complete asset market assumption or under the introduction of other inducing stationarity elements - see Mendoza (1991), Senhadji (1994), Ghironi (2001).

holds. This implies that $p_{h,t} = e_t p^*_{h,t}, p_{f,t} = e_t p^*_{f,t}$. Under the currency union assumption the nominal exchange rate is equal one.

Foreign workers face an allocation of expenditure and wealth similar to the one of workers in the domestic region except for the fact that they do not pay an additional spread for investing in the international portfolio. The budget constraint of the foreign representative household will read - i.e. expressed in units of foreign consumption index -:

$$c^*_t + \frac{b^*_t}{p^*_t} \leq \chi^*_t w^*_t h^*_t + \frac{\Theta^*_t}{p^*_t} - \frac{\tau^*_t}{p^*_t} + (1 + r^{n,*}_{t-1}) \frac{b^*_{t-1}}{p^*_t} \tag{11}$$

The efficiency condition for bonds' holdings will read as follow:

$$(c^*_t)^{-\sigma} = \beta(1 + r^{n,*}_t) E_t \left\{ (c^*_{t+1})^{-\sigma} \frac{p^*_t}{p^*_{t+1}} \right\} \tag{12}$$

All other optimality conditions are like in the home region. After substituting equation (9) into equation (7) and after merging with (7) we obtain the following relation:

$$E_t \left\{ \frac{\lambda^*_{t+1}}{\lambda^*_t} \right\} = E_t \left\{ \frac{\lambda_{t+1}}{\lambda_t} \frac{e^r_{t+1}}{e^r_t} \zeta \left(e^r_t \frac{b^*_t}{p^*_t} \right) \right\} \tag{13}$$

which states that marginal utilities across countries are equalized up to the spread for the country risk.

2.2 The Production Sector In the Domestic and the Foreign Region

The maximization problem which characterize the production sector are symmetric across the two economies (they will only differ in terms of their parametrization). Hence in the next section we show only the ones for the home region.

Firms in the production sector sell their output in a monopolistic competitive market and meet workers on a matching market. The labor relations are determined according to a standard Mortensen and Pissarides (1999) framework. Workers must be hired from the unemployment pool and searching for a worker involves a fixed cost. Workers wages and hours of work are determined through a Nash decentralized bargaining process which takes place on an individual basis. Finally the relationship between a matched worker and a firm can be endogenously discontinued.

2.2.1 Search and Matching in the Labor Market of the Home Region

The search for a worker involves a fixed cost κ and the probability of finding a worker depends on a constant return to scale matching technology which converts unemployed workers u and vacancies v into matches, m:

$$m(u_t, v_t) = m u^\xi_t v^{1-\xi}_t \tag{14}$$

where $v_t = \int_0^1 v_{i,t} di$. Defining labor market tightness as $\theta_t \equiv \frac{v_t}{u_t}$, the firm meets unemployed workers at rate $q(\theta) = \frac{m(u_t,v_t)}{v_t} = m\theta_t^{-\xi}$, while the unemployed workers meet vacancies at rate $\theta_t q(\theta_t) = m\theta_t^{1-\xi}$. If the search process is successful, the firm in the monopolistic good sector operates the following technology:

$$y_{i,t} = z_t n_{i,t} \int_{\tilde{a}_{i,t}}^{\infty} a \frac{f(a)}{1 - F(\tilde{a}_{i,t})} da = z_t n_{i,t} H(\tilde{a}_{i,t}) \tag{15}$$

where z_t is the aggregate productivity shock which follows a first order autoregressive process, $e^{z_t} = e^{\rho_z z_{t-1}} \varepsilon_{z,t}$, $n_{i,t}$ is the number of workers hired by each firm, and $a_{i,t}$ is an idiosyncratic shock to firms which is assumed to be identically and independently distributed across firms and times with cumulative distribution function $F : [0, \infty] \to [0, 1]$. It is assumed that the idiosyncratic shock is observed before the firm starts production. The firm will endogenously discontinue the match if the realized shock, $a_{i,t}$, is above a certain cut-off value, $\tilde{a}_{i,t}$. The threshold for endogenous separation is determined as a function of the state of the economy using firms' optimality conditions. Matches are destroyed at varying rate $\rho(\tilde{a}_{i,t})$ given by the following expression:

$$\rho(\tilde{a}_{i,t}) = \rho^x + \rho^n(\tilde{a}_{i,t})(1 - \rho^x) \tag{16}$$

where ρ^x is the exogenous break-up rate and $\rho^n(\tilde{a}_{i,t}) = F(\tilde{a}_{i,t})$ is the endogenous break-up rate.

We are now in the position to determine the law of motion for the workers employed and the ones seeking for a job. Labor force is normalized to unity. The number of employed people at time t in each firm i is given by the number of employed people at time $t-1$ plus the flow of new matches concluded in period $t-1$ who did not discontinue the match:

$$n_{i,t} = (1 - \rho(\tilde{a}_{i,t}))(n_{i,t-1} + v_{i,t-1} q(\theta_{i,t-1})) \tag{17}$$

Unemployment is given by total labor force minus the number of employed workers:

$$u_t = 1 - n_t \tag{18}$$

Finally we define the gross job destruction rate:

$$jd_t = \rho(\tilde{a}_{i,t}) - \rho^x \tag{19}$$

and job creation rate:

$$jc_t = \frac{(1 - \rho(\tilde{a}_{i,t})) v_{t-1} q(\theta_{t-1})}{n_{t-1}} - \rho^x \tag{20}$$

2.2.2 Open Economy Relations

The consumers and workers maximization problems have been derived assuming normalization to CPI index since the bundles consumed are aggregates of domestic and foreign goods. On the other side firms will deflate their profits by referring to the domestic GDP deflator. It is necessary at this point to introduce a series of relationships linking real quantities to the relevant relative prices. The terms of trade is the relative price of imported goods:

$$s_t \equiv \frac{p_{f,t}}{p_{h,t}} \tag{21}$$

It can be related to the CPI-PPI ratio as follows:

$$\phi_t \equiv \frac{p_t}{p_{h,t}} = [(1-\gamma) + \gamma s_t^{1-\eta}]^{\frac{1}{1-\eta}} \tag{22}$$

The terms of trade and the inflation rates are linked through the following equation:

$$s_t = \frac{\pi_{f,t}}{\pi_{h,t}} s_{t-1} \tag{23}$$

2.2.3 Monopolistic Firms

Firms in the monopolistic sector (of the home region) use labor to produce different varieties of consumption good and face a quadratic cost of adjusting prices. Hours worked and wages are determined through the bargaining problem analyzed in the next section. Here we develop the dynamic optimization decision of firms choosing prices, $p^i_{h,t}$, number of employees, $n_{i,t}$, number of vacancies, $v_{i,t}$, and the endogenous separation threshold, $\tilde{a}_{i,t}$, to maximize the discounted value of future profits and taking as given the wage schedule. Let's denote the total real wage bill of firm i (measured in CPI goods) by:

$$W_{i,t} = n_{i,t} \int_{\tilde{a}_{i,t}}^{\infty} w(a) \frac{f(a)}{1-F(\tilde{a}_{i,t})} da \tag{24}$$

where $w(a_{i,t})$ denotes the fact that the bargained wage might depend on idiosyncratic shock and other time varying factors. The representative firm in the domestic region chooses $\left\{p^i_{h,t}, n_{i,t}, v_{i,t}, \tilde{a}_{i,t}\right\}$ to solve the following maximization problem (in real terms):

$$Max\Pi_{i,t} = E_0 \sum_{t=0}^{\infty} \beta^t \frac{\lambda_t}{\lambda_0} \left\{ \frac{p^i_{h,t}}{p_{h,t}} y^i_t - \phi_t W_{i,t} - \kappa v_{i,t} - \frac{\psi}{2} \left(\frac{p^i_{h,t}}{p^i_{h,t-1}} - 1 \right)^2 y^i_t \right\} \tag{25}$$

subject to

$$\text{s.to:} \qquad y^i_t = \left(\frac{p^i_{h,t}}{p_{h,t}} \right)^{-\epsilon} y_t = z_t n_{i,t} H(\tilde{a}_{i,t}) \tag{26}$$

$$\text{and: } n_{i,t} = (1-\rho(\tilde{a}_{i,t}))(n_{i,t-1} + v_{i,t-1}q(\theta_{i,t-1})) \tag{27}$$

where $\frac{\psi}{2}\left(\frac{p^i_{h,t}}{p^i_{h,t-1}}-1\right)^2 y^i_t$ represent the cost of adjusting prices, ψ can be thought as the sluggishness in the price adjustment process and κ as the cost of posting vacancies. Let's define mc_t, the lagrange multiplier on constraint (26), as the marginal cost of firms and μ_t, the lagrange multiplier on constraint (27), as the marginal value of one worker. Since all firms will chose in equilibrium the same price and allocation we can now assume symmetry and drop the index i. First order conditions for the above problem read as follows:

- n_t :

$$\mu_t = mc_t z_t H(\tilde{a}_t) - \phi_t \frac{\partial W_t}{\partial n_t} + \beta E_t(\frac{\lambda_{t+1}}{\lambda_t})((1-\rho(\tilde{a}_{t+1}))\mu_{t+1}) \tag{28}$$

- v_t :

$$\frac{\kappa}{q(\theta_t)} = \beta E_t(\frac{\lambda_{t+1}}{\lambda_t})((1-\rho(\tilde{a}_{t+1}))\mu_{t+1}) \tag{29}$$

- $p_{h,t}$:

$$1-\psi(\pi_{h,t}-1)\pi_{h,t} + \beta E_t(\frac{\lambda_{t+1}}{\lambda_t})[\psi(\pi_{h,t+1}-1)\pi_{h,t+1}\frac{y_{t+1}}{y_t}] = (1-mc_t)\varepsilon \tag{30}$$

- $\tilde{a}_t$:

$$\mu_t \rho'(\tilde{a}_t)(n_{t-1} + v_{t-1}q(\theta_{t-1})) + \phi_t \frac{\partial W_t}{\partial \tilde{a}_t} = mc_t z_t n_t H'(\tilde{a}_t) \tag{31}$$

Merging equations (28) and (29) gives the marginal value of an extra worker, μ_t, which is obtained by trading-off the cost of maintaining the match with an existing worker with the cost of posting a new vacancy:

$$\mu_t = mc_t z_t H(\tilde{a}_t) - \phi_t \frac{\partial W_t}{\partial n_t} + \frac{\kappa}{q(\theta_t)} \tag{32}$$

After substituting the marginal value of an extra worker, μ_t,into the optimality condition, (31), and using the constraint which describes the evolution of employment, (27), we obtain the condition which determines the threshold value for the idiosyncratic shock:

$$mc_t z_t H(\tilde{a}_t) - \phi_t \frac{\partial W_t}{\partial n_t} + \frac{\kappa}{q(\theta_t)} = \frac{mc_t z_t H'(\tilde{a}_t)}{\rho'(\tilde{a}_t)}(1-\rho(\tilde{a}_t)) - \phi_t \frac{\partial W_t}{\partial \tilde{a}_t}\frac{(1-\rho(\tilde{a}_t))}{\rho'(\tilde{a}_t) n_t} \tag{33}$$

We can finally simplify equation (33) so as to obtain a relation between the threshold value and the real wage schedule:

$$mc_t z_t \tilde{a}_t - w(\tilde{a}_t)\phi_t + \frac{\kappa}{q(\theta_t)} = 0 \tag{34}$$

2.2.4 Bellman Equations, Wage Setting and Nash Bargaining

The wage schedule is obtained through the solution to an individual Nash bargaining process. To solve for it we need first to derive the marginal values of a match for the both, firms and workers. Those values will indeed enter the sharing rule of the bargaining process. Let's denote by $V_t^J(a_t)$ the marginal discounted value of a match for a domestic firm measured in terms of domestic prices:

$$V_t^J(a_t) = mc_t z_t \tilde{a}_t - \phi_t w(a_t) + E_t\{(\beta\frac{\lambda_{t+1}}{\lambda_t})[(1-\rho(\tilde{a}_{t+1})) \int_{\tilde{a}_t}^{\infty} V_{t+1}^J(a_{t+1})\frac{dF(a_{t+1})}{F(\tilde{a}_{t+1})}da]\} \tag{35}$$

The marginal value of a match depends on real revenues minus the real wage plus the discounted continuation value. With probability $(1-\rho(\tilde{a}_{t+1}))$ the job remains filled and earns the expected value and with probability, $\rho(\tilde{a}_{t+1})$, the job is destroyed and has zero value. Using the equation (34) we can rewrite equation (35) as:

$$V_t^J(a_t) = \frac{-\kappa}{q(\theta_t)} + E_t\{(\beta\frac{\lambda_{t+1}}{\lambda_t})[(1-\rho(\tilde{a}_{t+1})) \int_{\tilde{a}_t}^{\infty} V_{t+1}^J(a_{t+1})\frac{dF(a_{t+1})}{F(\tilde{a}_{t+1})}da]\} \tag{36}$$

Since the value of a match for the firm must be zero in equilibrium the following zero profit condition must be satisfied:

$$\frac{\kappa}{q(\theta_t)} = E_t\{(\beta\frac{\lambda_{t+1}}{\lambda_t})[(1-\rho(\tilde{a}_{t+1})) \int_{\tilde{a}_t}^{\infty} V_{t+1}^J(a_{t+1})\frac{dF(a_{t+1})}{F(\tilde{a}_{t+1})}da]\} \tag{37}$$

Equation (37) is an arbitrage condition for the posting of new vacancies. It implies that in equilibrium the cost of posting a vacancy must equate the discounted expected return from posting the vacancy.

For each worker, the values of being employed and unemployed are given by V_t^E and V_t^U (expressed in terms of CPI):

$$V_t^E(a_t) = [w_t + E_t\{(\beta\frac{\lambda_{t+1}}{\lambda_t})[(1-\rho(\tilde{a}_{t+1})) \int_{\tilde{a}_t}^{\infty} V_{t+1}^E(a_{t+1})\frac{dF(a_{t+1})}{F(\tilde{a}_{t+1})}da + \rho(\tilde{a}_{t+1})V_{t+1}^U]\} \tag{38}$$

$$V_t^U = [b+E_t\{(\beta\frac{\lambda_{t+1}}{\lambda_t})[\theta_t q(\theta_t)(1-\rho(\tilde{a}_{t+1})) \int_{\tilde{a}_t}^{\infty} V_{t+1}^E(a_{t+1})\frac{dF(a_{t+1})}{F(\tilde{a}_{t+1})}da+(1-\theta_t q(\theta_t)(1-\rho(\tilde{a}_{t+1})))V_{t+1}^U]\} \tag{39}$$

where b denotes real unemployment benefits.

Nash bargaining. Workers and firms are engaged in a Nash bargaining process to determine wages and hours worked. The standard Nash bargaining problem is given by:

$$\max_w \left(\phi_t(V_t^E(a_t) - V_t^U)\right)^{\varsigma} \left(V_t^J(a_t)\right)^{1-\varsigma} \tag{40}$$

where ς stands for the bargaining weight of the workers. The optimal sharing rule is:

$$\phi_t(V_t^E(a_t) - V_t^U) = \frac{\varsigma}{1-\varsigma} V_t^J(a_t) \tag{41}$$

After substituting the previously defined value functions it is possible derive the following wage schedule:

$$w_t(a_t) = \varsigma(mc_t z_t a_t + \theta_t \kappa)\frac{1}{\phi_t} + (1-\varsigma)b \tag{42}$$

Finally using the individual wage schedule, (42), the condition for the threshold value, (34), becomes:

$$\tilde{a}_t = \frac{b\phi_t}{mc_t z_t} + \frac{1}{mc_t z_t}\frac{\kappa}{1-\varsigma}(\varsigma\theta_t - \frac{1}{q(\theta_t)})) \tag{43}$$

The average real wage is obtained by aggregating across employees:

$$w_t = \int_{\tilde{a}_t}^{\infty} w_t(a)\frac{f(a)}{1-F(\tilde{a}_t)}da = \varsigma mc_t z_t \frac{1}{\phi_t}\int_{\tilde{a}_t}^{\infty} a\frac{f(a)}{1-F(\tilde{a}_t)}da + \varsigma\theta_t\kappa\frac{1}{\phi_t} + (1-\varsigma)b \tag{44}$$

Real wage rigidity. From equation (28) we can derive a measure of the marginal cost in our model which reads as follows:

$$mc_t = \frac{1}{z_t H(\tilde{a}_t)}[\frac{\partial W_t}{\partial n_t} + \mu_t - \frac{\kappa}{q(\theta_t)}]$$

The first component of this measure is given by the marginal wage bargained divided by the labor productivity. Since our goal is to obtain persistent dynamic for marginal cost and inflation we introduce real wage stickiness following Hall (2003). In particular we assume that the individual real wage is weighted average of the one obtained through the Nash bargaining process and the one obtained as solution to the steady state:

$$w_t(a) = \lambda[\varsigma(mc_t z_t a_t + \theta_t\kappa)\frac{1}{\phi_t} + (1-\varsigma)b] + (1-\lambda)w(a)$$

2.3 The Monetary Policy Rule in the Currency Area

An active monetary policy sets the short term nominal interest rate by reacting to an average of the inflation levels in the area. This rule rationalizes the behavior of the stability pact signed by European countries:

$$r_t^n = \exp(\frac{1-\chi}{\beta})(r_{t-1}^n)^{\chi}((\frac{\pi_t + \pi_t^*}{2})^{b_\pi})^{1-\chi} m_t \tag{45}$$

b_π is the weight that the monetary authority puts on the deviation of CPI inflation and is set equal to 1.5. m_t is a temporary monetary policy shock. In addition following Clarida, Gali' and Gertler (2000) and Rotemberg and Woodford (1997) we assume that monetary policy applies a certain degree χ of interest rate smoothing. Aside from being consistent with most evidence on monetary policy rules the interest rate smoothing helps to generate more persistent effect of monetary policy shocks.

2.4 Equilibrium Conditions

Aggregate output is obtained by aggregating production of individual firms and by subtracting the resources wasted into the search activity:

$$Y_t = n_t z_t \int_{\tilde{a}_t}^{\infty} a_t \frac{f(a)}{1 - F(\tilde{a}_t)} da - \kappa v_t \tag{46}$$

Market clearing for domestic variety i must satisfy:

$$\begin{aligned} y_t^i &= c_{h,t}^i + c_{h,t}^{i,*} + \frac{\psi}{2}\left(\frac{p_{h,t}^i}{p_{h,t-1}^i} - 1\right)^2 y_t^i \\ &= \left(\frac{p_{h,t}^i}{p_{h,t}}\right)^{-\varepsilon}\left[\left(\frac{p_{h,t}}{p_t}\right)^{-\eta}(1-\gamma)c_t + \left(\frac{p_{h,t}^*}{p_t^*}\right)^{-\eta}\gamma^* c_t^*\right] + \frac{\psi}{2}\left(\frac{p_{h,t}^i}{p_{h,t-1}^i} - 1\right)^2 y_t^i \end{aligned} \tag{47}$$

for all $i \in [0,1]$ and t. After substituting (47) into the definition of aggregate output $y_t \equiv \left[\int_0^1 (y_t^i)^{1-\frac{1}{\varepsilon}}\, di\right]^{\frac{\varepsilon}{\varepsilon-1}}$, imposing symmetry and recalling that $p_{h,t} = e_t p_{h,t}^*$, we can express the resource constraint as:

$$n_t z_t \int_{\tilde{a}_t}^{\infty} a_t \frac{f(a)}{1 - F(\tilde{a}_t)} da - \kappa v_t = \left(\frac{p_{h,t}}{p_t}\right)^{-\eta}(1-\gamma)\, c_t + \left(\frac{p_{h,t}}{e_t p_t^*}\right)^{-\eta}\gamma^* c_t^* + \frac{\psi}{2}\left(\frac{p_{h,t}^i}{p_{h,t-1}^i} - 1\right)^2 y_t \tag{48}$$

We assume zero total net supply of bonds.

2.5 Calibration

Preferences. Time is taken as quarters. We set the discount factor $\beta = 0.99$, so that the annual interest rate is equal to 4 percent. We set the elasticity of substitution between domestic and foreign goods η equal to 1.5 as in Backus, Kehoe and Kydland (1994). The parameter on consumption in the utility function is set equal to one. This value is compatible with a steady state trade balanced growth path. We set the steady state balanced growth ratio of exports over GDP to $\gamma = 0.4$, value compatible with data for European countries. Finally We assume that the steady state net asset position is symmetric between the two countries. Following Schmitt-Grohe and Uribe (2002) and consistently with Lane and Milesi-Ferretti (2002) We set the elasticity of the spread on foreign bonds to the net asset position equal to 0.000742.

Production. Following Basu and Fernald (1997) We set the value added mark-up of prices over marginal cost to 0.2. This generates a value for the price elasticity of demand, ε, of 6. We set the cost of adjusting prices $\psi = 100$ to generate a slope of the log-linear Phillips curve equal to 0.10. This is compatible with the estimates by Benigno and Lopez-Salido (2003) for France and Germany.

Labor market frictions parameters. The matching technology is a homogenous of degree one function which is characterized by the parameter ξ. Consistently with estimates by Blanchard and Diamond (1989) we set this parameter to 0.6. We set the firm matching rate, $q(\theta)$, to 0.7 which is the value used by denHaan, Ramsey and Watson (1997). The probability for a worker of finding a job, $\theta q(\theta)$, is set equal to 0.6, which implies an average duration of unemployment of 1.67 as reported ion Cole and Rogerson (1996). With those values it is possible to determine the number of vacancies as well as the vacancy/unemployment ratio.

We set the exogenous separation probability, ρ^x, to 0.068 and the steady state overall separation rate, $\rho(\tilde{a})$, to 0.1. With those values it is possible to obtain the endogenous separation rate, $\rho^n(\tilde{a}) = \frac{(\rho(\tilde{a})-\rho^x)}{(1-\rho^x)}$, and the threshold value, $\tilde{a} = F^{-1}(\rho^n)$. The idiosyncratic shock is distributed as a lognormal with unitary mean and standard deviation equal to 0.15.

Finally we set the degree of wage rigidity, λ, equal to 0.5.

Labor market institutions. We need to assign values for the unemployment benefit. The latter is determined endogenously given the remaining steady state parameters values and is changed in the simulations. To assign a value to this parameter we follow an indirect calibration strategy. We calculate the implied values for b and the steady state individual wage schedule w as function of the remaining model parameters and other steady state variables. We then set a value of the bargaining parameter, ς, so as to generate values for the $\frac{b}{w}$ ratio which are close to the ones observed in the data for the four biggest European countries (Germany, France, Italy and Spain). Data for the $\frac{b}{w}$ ratio are taken from the data-set constructed by S. Nickell and L. Nunziata (2001) and are reported in table (1).

Exogenous shocks and monetary policy: We consider domestic and foreign aggregate productivity shocks, z_t and z_t^*. We follow Backus, Kehoe and Kydland (1994) and calibrate their standard deviations to 0.008, their correlation to 0.25 and their persistence to 0.95. We also consider an i.i.d. common monetary policy shock, m_t, whose standard deviation is calibrated using data from Mojon and Peersman (2002). Following several empirical studies for Europe (see Clarida, Gali' and Gertler (2000), Angeloni and Dedola (1998) and Andres, Lopez-Salido and Valles (2001) among others) we set the interest rate smoothing parameter, χ, equal to 0.8.

All values for the parameters and shocks are reported in Table (2) and (3).

3 Dynamic of Variables Under Symmetric Labor and Product Market Regulations

It is instructive to start our impulse response analysis by analyzing monetary and technology shock under symmetric labor and product market regulations. This will indeed allow us to understand the key mechanisms behind the international transmission of shocks in our model, a key step before analyzing the sources of inflation divergence.

Figure (4) shows impulse responses of several domestic and foreign variables to a common monetary policy tightening. Since the two countries are perfectly symmetric and since they are subject to the same shocks the dynamic pattern of all variables is perfectly symmetric as well. For the same reason we do not observe movements in the terms of trade.

In response to a monetary policy tightening output and employment decrease in both countries. Both variables show a hump shaped dynamics with employment falling considerably more than output. This is due to the fact that the increase in the optimal threshold value for the idiosyncratic shock preserves firm-worker matches. The survival of worse matches also induces a decrease in the real marginal costs which in turn induces a decrease in real wages and inflation. The decrease in employment is accompanied by an increase in unemployment and job destruction. The latter is due to the increase in the endogenous separation rate. Due to the wage rigidity firms face an incentive to decrease the number of vacancies which therefore move oppositely to unemployment (phenomenon known as Beveridge curve).

Figure (5) shows impulse responses of several domestic and foreign variables to a domestic raise in aggregate productivity. Obviously since we are now examining an idiosyncratic shock we observe asymmetric responses across the two countries and considerable movements in the terms of trades. We start by analyzing domestic variables. Output raises. On the other side employment falls. This is due to the sticky prices assumption which leaves aggregate demand unchanged thereby reducing the need for labor input in correspondence of a raise in productivity. The fall in employment and labor input is followed by a fall in marginal cost, which in turn reduces real wages and inflation. Finally the increase in the domestic endogenous separation rate and the drop in domestic vacancies induce an increase in unemployment.

Under a domestic productivity shock the dynamic patterns of the foreign variables is the result of two competing effects. First of all, the fall in the inflation of the home region shifts consumption demand from domestically to foreign produced goods (*switching expenditure effect).* This implies a depreciation in the terms of trade (a loss in competitiveness for the foreign country), a fall in foreign consumption demand and a fall in foreign inflation. This detrimental effect is partly to fully compensated by a beneficial effect generated by the endogenous reaction of the common monetary policy (*the monetary transmission mechanism).* Since inflation falls in both countries the common monetary policy authority reduces the nominal interest rate thereby boosting foreign output and employment. The raise in foreign employment induces also a raise in foreign real wages and marginal costs.

4 Differential Inflation Responses Under Common Shocks and Different Labor or Product Market Regulations

We are now in the position to analyze the differential impact on inflation and labor market variables generated by the shocks under the assumption of different labor and product market regulations.

4.1 Varying Unemployment Benefit Across Countries

Figure (6) shows responses to a common monetary policy shock for foreign and domestic CPI inflation levels, the inflations differential (measured by the absolute difference between CPI inflations) and the marginal costs differential under three different labor market scenarios for the home country corresponding to three different levels of unemployment benefits. The calibration of the labor market scenarios follows the one presented in table (3). In particular increasing levels of bargaining power are associated with decreasing ratios of unemployment benefits to real wage for the home country.

The impulse responses show that two countries have marked differences in inflation dynamics. In the third the inflation differential can reach a pick on impact of about 2.7 percentage points and can last for a to 4 years (16 quarters). The inflation differential as well as the marginal cost differential is big on impact and persistent. The reason for this being as follows. The decrease in demand - due to the negative monetary policy shock - has a differential impact on the value of a match depending on the deep parameters that characterize labor market institutions. The different degree of sensitivity of the value of a match generates differential responses of real wages, marginal costs and therefore of inflation.

Another important implication of the model is that countries with lower ratios of unemployment benefits to real wages (typically Italy and Spain) tend to have marginal cost and inflation which respond more to aggregate shocks. In general the sensitivity of the inflation response is negatively correlated with the ratio of unemployment benefit to real wages. This is so since higher levels of bargaining power induce higher levels of real wages (hence lower ratios of unemployment benefits to real wages) and more pronounced real wages and marginal costs dynamics. As a consequence inflation dynamics become more sensitive to aggregate shocks as well.

Figure (7) shows responses to a common technology shock for foreign and domestic CPI inflation levels, the inflations differential (measured by the difference between CPI inflations) and the marginal costs differential under the labor market scenarios considered in table (3).

Once again the two countries show marked differences in inflation and marginal cost responses.

As before the country with the lower level of unemployment benefit shows higher sensitivity of marginal cost and inflation to aggregate shocks. However now and contrary to the previous case inflation differentials are lower on impact and more persistent. The inflation differential reaches a maximum pick of 0.2 percentage points in the third scenario and last for about 10 years (40 quarters).

4.2 Varying the Elasticity of Demand Across Countries

We analyze now inflation and marginal cost differentials in response to a change in the elasticity of varieties. This parameter is used as a proxy for the degree of product market competition. We identify the different product market scenarios by fixing the elasticity of the foreign country to 4 and by varying the elasticity of the home country from 6 to 10. Lower demand elasticity generates higher mark-ups hence lower competition.

Figure (8) and (9) show the impulse responses to common monetary policy and technology shock respectively for foreign and domestic CPI inflation levels, for the inflations differential (measured by the absolute difference between CPI inflations) and the marginal costs differential under the three different product market scenarios.

Under both shocks there are marked differences in the dynamic paths of inflation across the two countries. Under monetary policy shocks the inflation differential can reach a pick of about 2.4 percentage points under the third scenario and can last for a to 4 years (16 quarters). Under productivity shocks inflation differentials are lower on impact and more persistent. They indeed reach a pick on impact at about 0.31 percentage points and last for more than 10 years.

Under a monetary policy tightening the decrease in demand associated with sticky prices induces an increase of the mark-up and a decrease of the marginal cost and of inflation. Clearly the higher is the elasticity of demand (more competitive product markets) the higher is the fall in the marginal cost and in inflation.

With an increase in productivity there is a fall in labor demand which induces a decrease in the marginal cost and in inflation. Clearly the higher is the demand elasticity (more competitive product markets) the higher is the fall in the marginal costa and in inflation.

In general we can conclude that the response of inflation to any type of shocks is more pronounced in countries with higher demand elasticity (hence with higher competition).

5 VAR Evidence for The Main Euro Area Countries

One of the model predictions concerned the relation between the sensitivity of the inflation in response to monetary policy shocks and the labor market institutions. In particular our model predicts that lower levels of unemployment benefits are associated with higher sensitivity of inflation in response to monetary policy shocks.

To verify whether our predictions is confirmed by the data we run simple VAR regressions for each of the four biggest euro area countries (Germany, France, Italy and Spain) during the EMU period which we set between the 1998 and the 2004. Given the scarcity of data in our short sample we run simple VAR's with few variables. The vector of endogenous variables[8] consists of real GDP, y_t, consumer price index inflation, π_t, and the euro area short term nominal interest rate, r_t^n,[9]. Data are in levels, quarterly and seasonally adjusted. For the monetary policy shock we use standard identification strategies as in Christiano, Eichenbaum and Evans (1999). The euro area monetary policy shock is identified through a Choleski decomposition with the variables ordered as follows:

$$Y_t = [y_t, \pi_t, r_t^n]$$

The underlying assumption is that policy shocks have no contemporaneous impact on output and inflation. Figure (10) shows impulse responses of real GDP and inflation for all the four countries considered. Confidence bands generated through monetcarlo simulations. As expected in all countries inflation and output decrease in response to a monetary tightening.

It stands clear that the inflation responses in Italy and Spain are much stronger (in terms of magnitude) than the ones observed for Germany and France. We can also recall from table (1) that Italy and Spain have levels of unemployment benefit (0.09 and 0.26 respectively) which are much lower than the ones observed for Germany and France (0.61 and 0.49 respectively). From those two observation we can conclude that our model replicates fairly well the VAR evidence for euro area countries. Indeed the model predicts that countries with lower levels of unemployment benefits tend to show higher sensitivity of inflation response as opposed to countries with higher levels of unemployment benefits.

6 Conclusion

Inflation differentials should be a main concern for the newly created central bank for two reasons. First, they lead to sustained differences in competitiveness which might eventually harm price stability. Secondly, whenever they occur on top and above the ones associated with productivity differences, they might signal differences in efficiency of labor and product market structures due to inappropriate national policies.

This paper aims at studying the quantitative importance of labor and product market differences in generating differential inflation dynamics across euro area countries. It is indeed well understood that labor market frictions are an important determinant of the dynamics of marginal costs of firms, which are a main driver of inflation, while product market regulations affect the response of inflation to marginal costs. We find that even in response to common shocks differences

[8] Due to the scarcity of data we use the least possible number of variables in our VARs.

[9] For this variable we use the three month money market rate.

in both types of institutions can generate significant inflation differentials. Furthermore we show that the sensitivity of inflation in response to monetary and technology shocks is higher under either lower ratios of unemployment benefits to real wages or higher demand elasticity.

Inflation differentials due to productivity catch-ups should not be a concern for monetary policy since they are transitory and since they are associated with efficient reallocations of resources or international competition. On the contrary asymmetric development in labor and product market institutions are linked to various sources of inefficiencies which might be welfare detrimental for the entire currency area as well. For this reason a micro-founded model like the one used here could be used in the future also to answer questions on the welfare gains from different structural reforms. These issue, already relevant today, will become much more pressing in the future, when the euro-zone will include new entrants from eastern Europe.

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Table 1: **Masures of unemployment benefits. Average over 1985 to 1995.**

Countries	Benefit Duration
Austria	0.75
Belgium	0.77
Denmark	0.78
Finland	0.53
France	0.49
Germany	0.61
Ireland	0.54
Italy	0.09
Netherlands	0.47
Portugal	0.60
Spain	0.26

Table 2: **Model parameters and shock calibration.**

Parameters and shocks	Mnemonics	Values
Workers Discount factor	β	0.99
Elasticity of home and foreign goods	η	1.5
Parameter on consumption utility	σ	1
Matching function parameter	ξ	0.6
Share of exports over GDP	γ	0.2
Elasticity of spread to bond accumulation	ζ	0.000742
Matching rate	$q(\theta)$	0.7
Exogenous separation rate	ρ^x	0.068
Endogenous separation rate	$\rho(a)$	0.1
Elasticity of variety demand	ε	6
Prices adjustment cost	ψ	17.5
Wage rigidity	λ	0.5
Standard deviation idiosyncratic shock	σ_a	0.15
Persistence of area wide monetary shock	$\rho_{m^{EU}}$	0
Standard deviations of area wide monetary shock	$\sigma_{m^{EU}}$	1.0007
Persistence of technology shocks	ρ_z, ρ_{z^*}	0.95
Standard deviations of technology shocks	σ_z, σ_{z^*}	0.008
Correlation of technology shocks	$Corr(\varepsilon_z, \varepsilon_{z^*})$	0.25

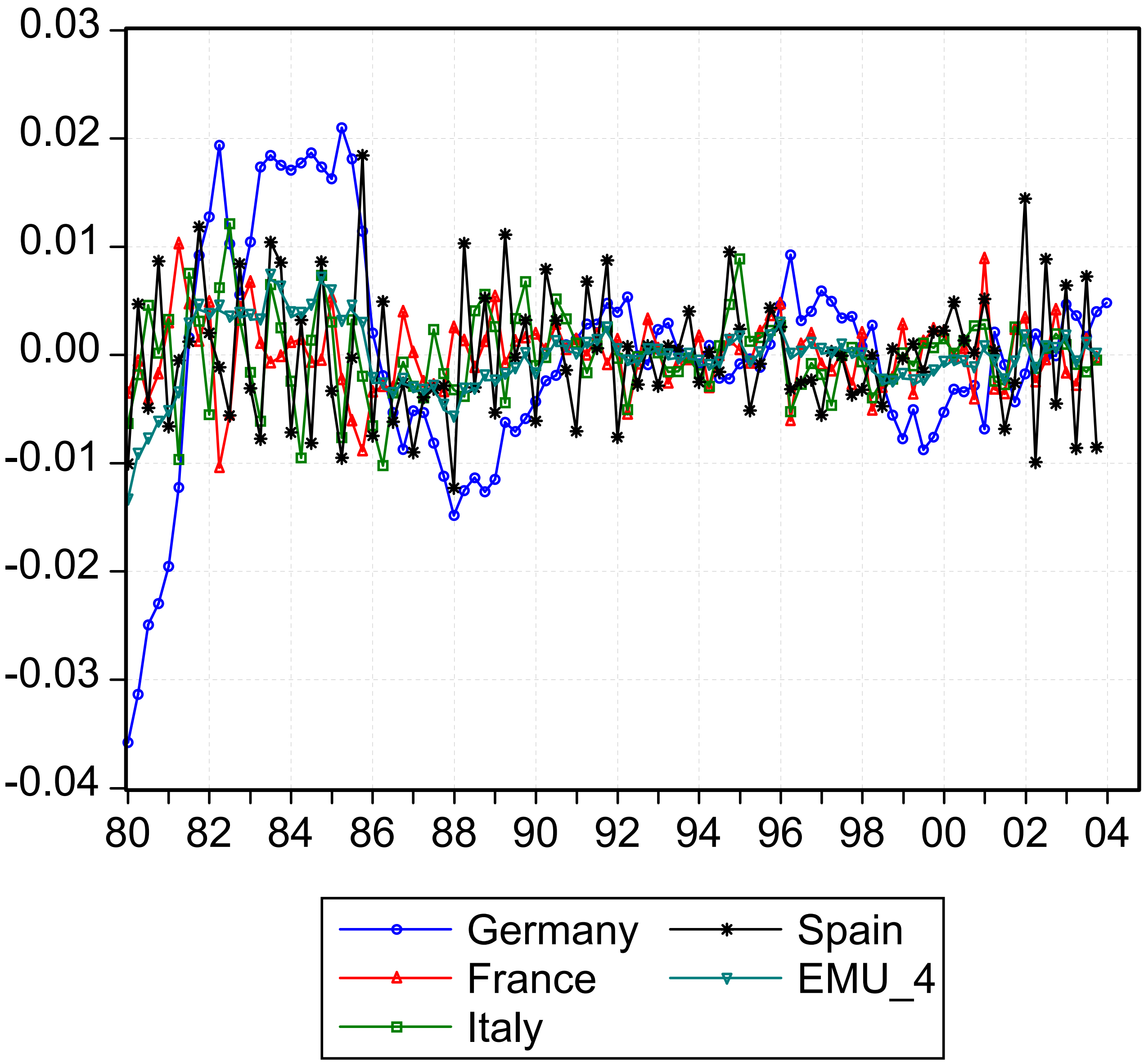

Figure 1: **CPI inflation quarterly log change Hodrick-Prescot de-trended. Period 1980-2004.**

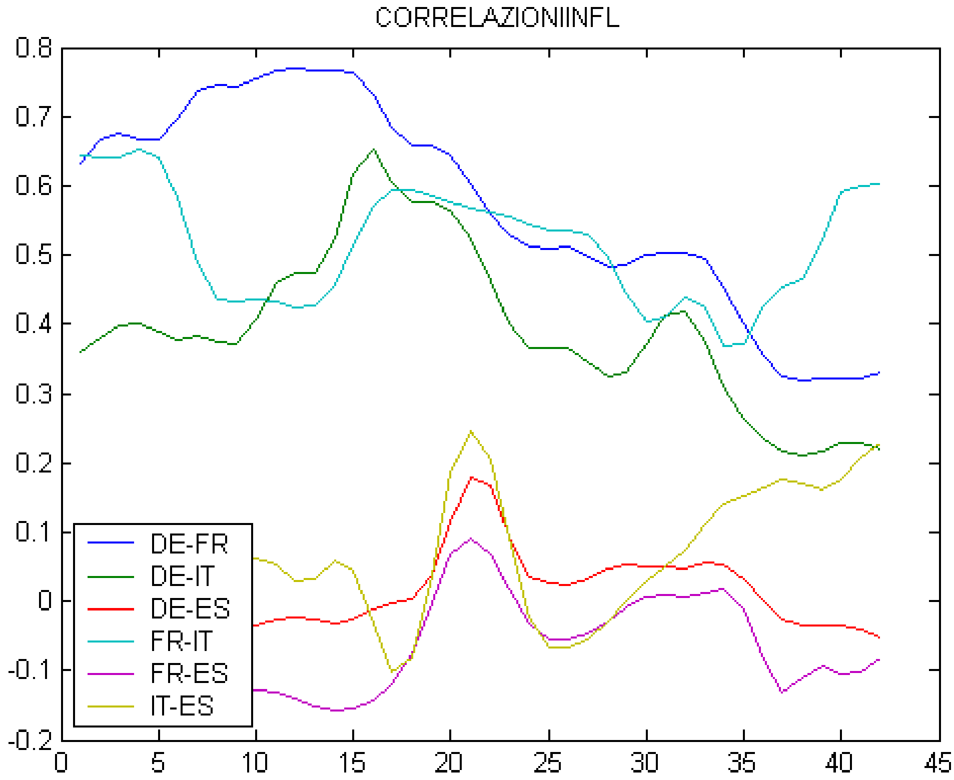

Figure 2: **Rolling correlation of inflation for main EMU countries calculated with band pass filter from Baxter and King (2000) and with a window of 20 years. Period 1976-2000.**

Table 3: **Calibration of the labor market scenarios.**

Labor institution parameters	Mnemonics	Foreign country	Home country		
			Scenario 1	Scenario 2	Scenario 3
Baragaining power	η	0.2	0.3	0.5	0.7
Unemployment benefit over wage	$\frac{b}{w}$	0.9	0.84	0.67	0.34

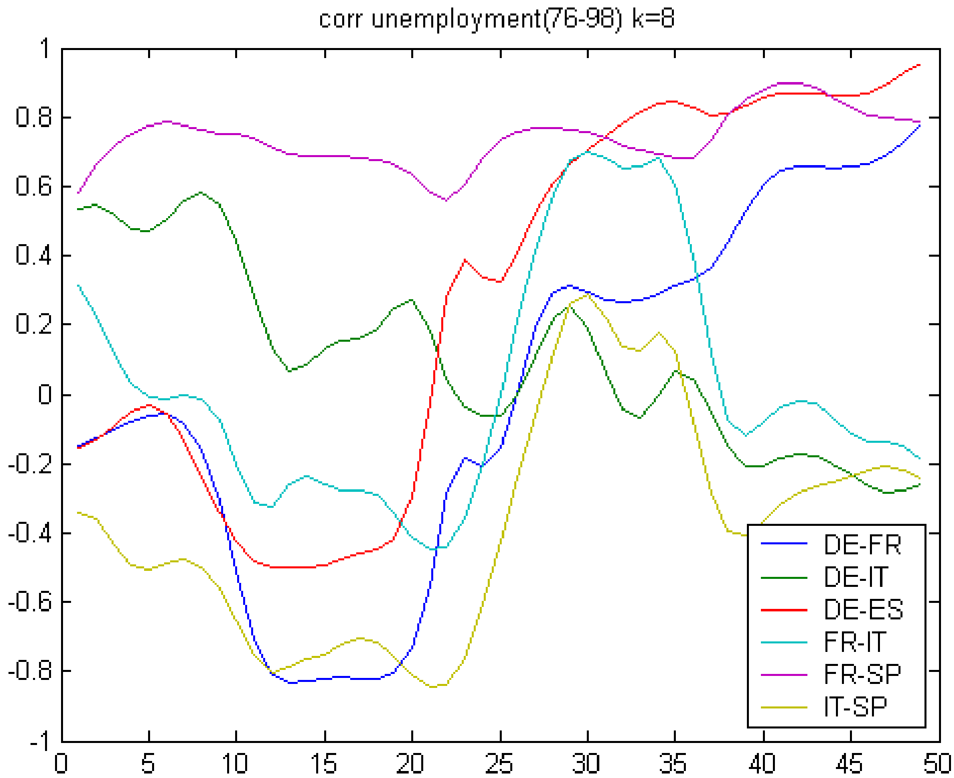

Figure 3: **Rolling correlation of unemployment for main EMU countries calculated with band pass filter from Baxter and King (2000) and with a window of 20 years. Period 1976-1998.**

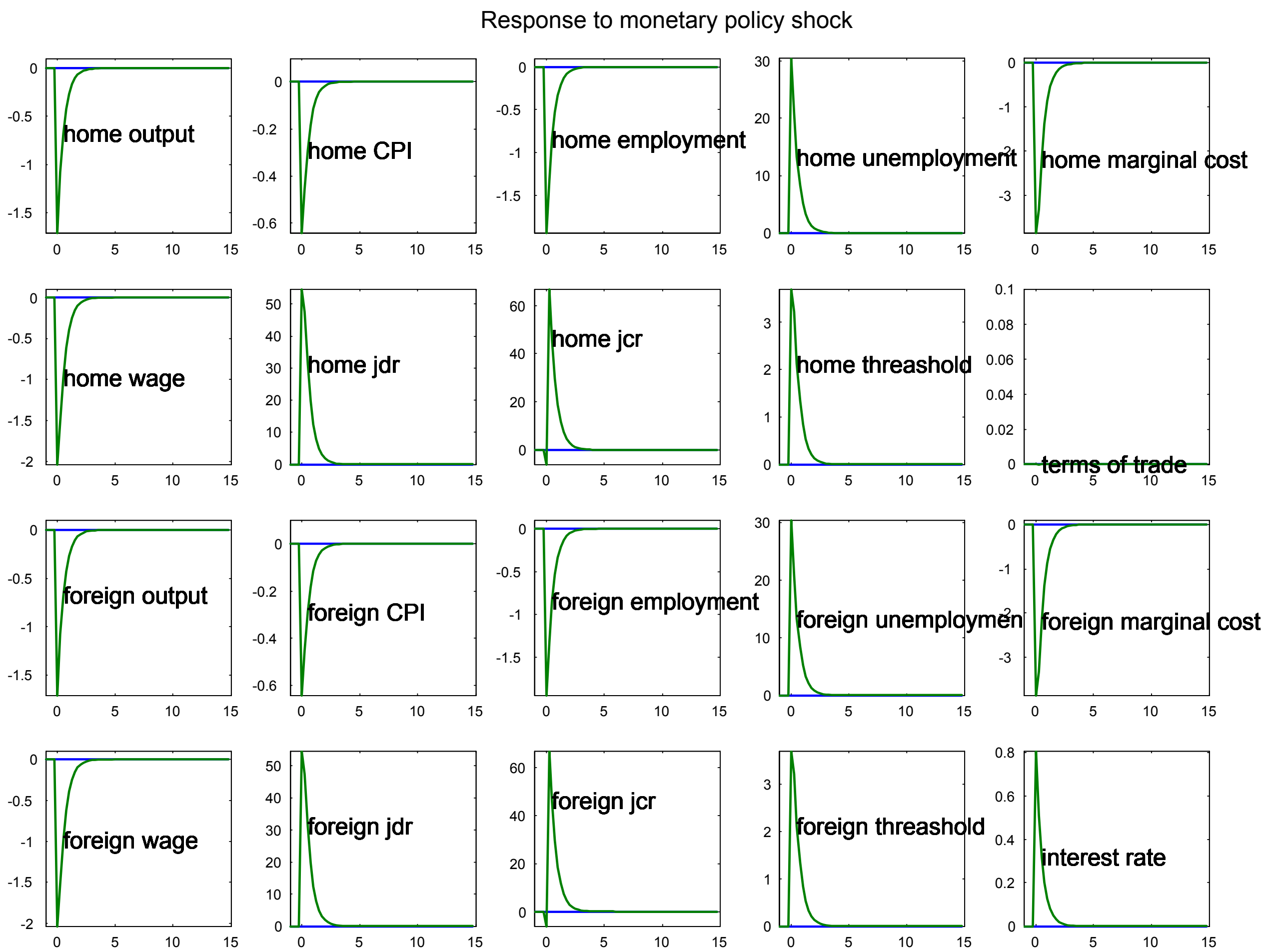

Figure 4: **Impulse responses of domestic and foreign variables to a monetary policy shock. The y-axis reports percentage deviations from the steady state, while the x-axis reports years after the shock.**

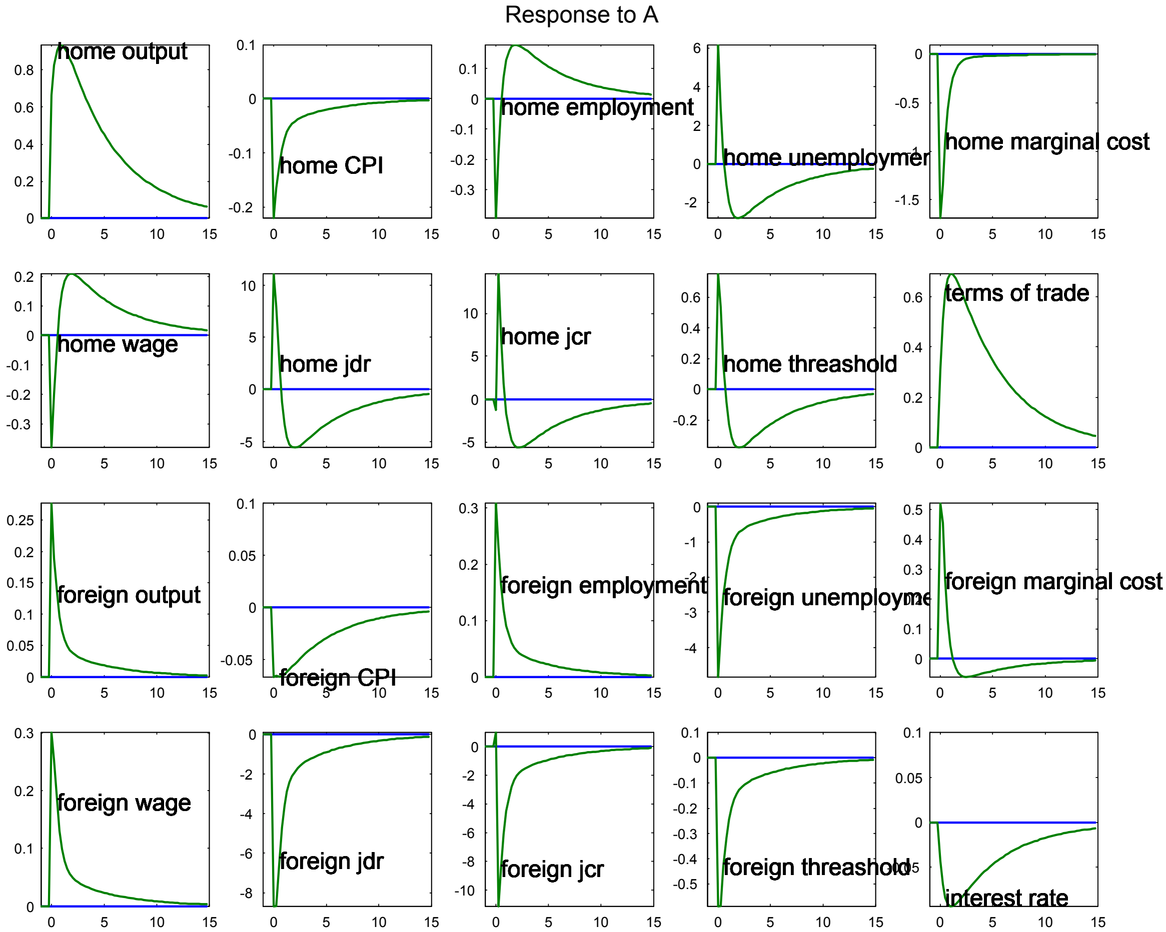

Figure 5: **Impulse responses of domestic and foreign variables to a domestic technology shock. The y-axis reports percentage deviations from the steady state, while the x-axis reports years after the shock.**

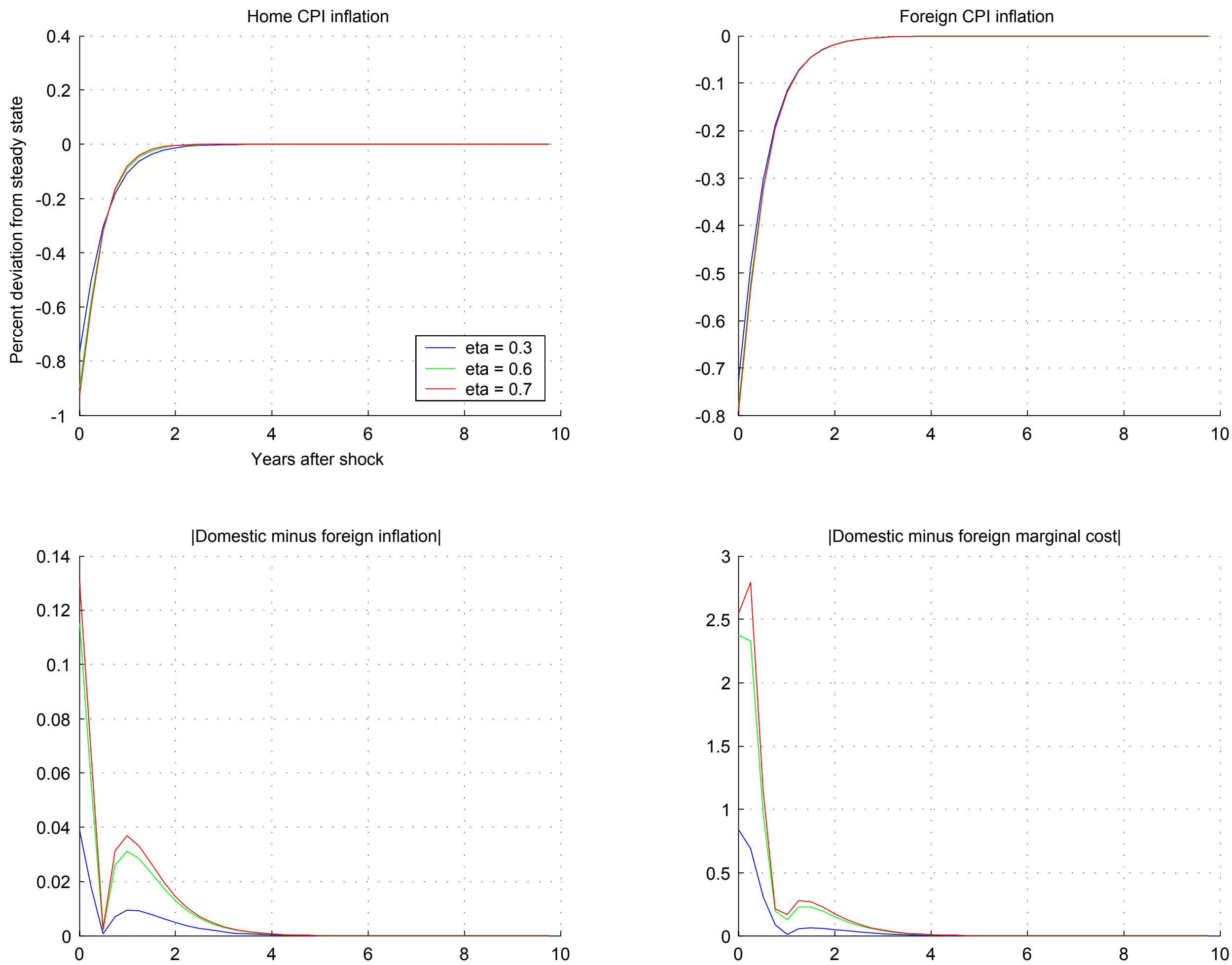

Figure 6: **Impulse responses to a monetary policy shock for different values of the unemployment benefit.**

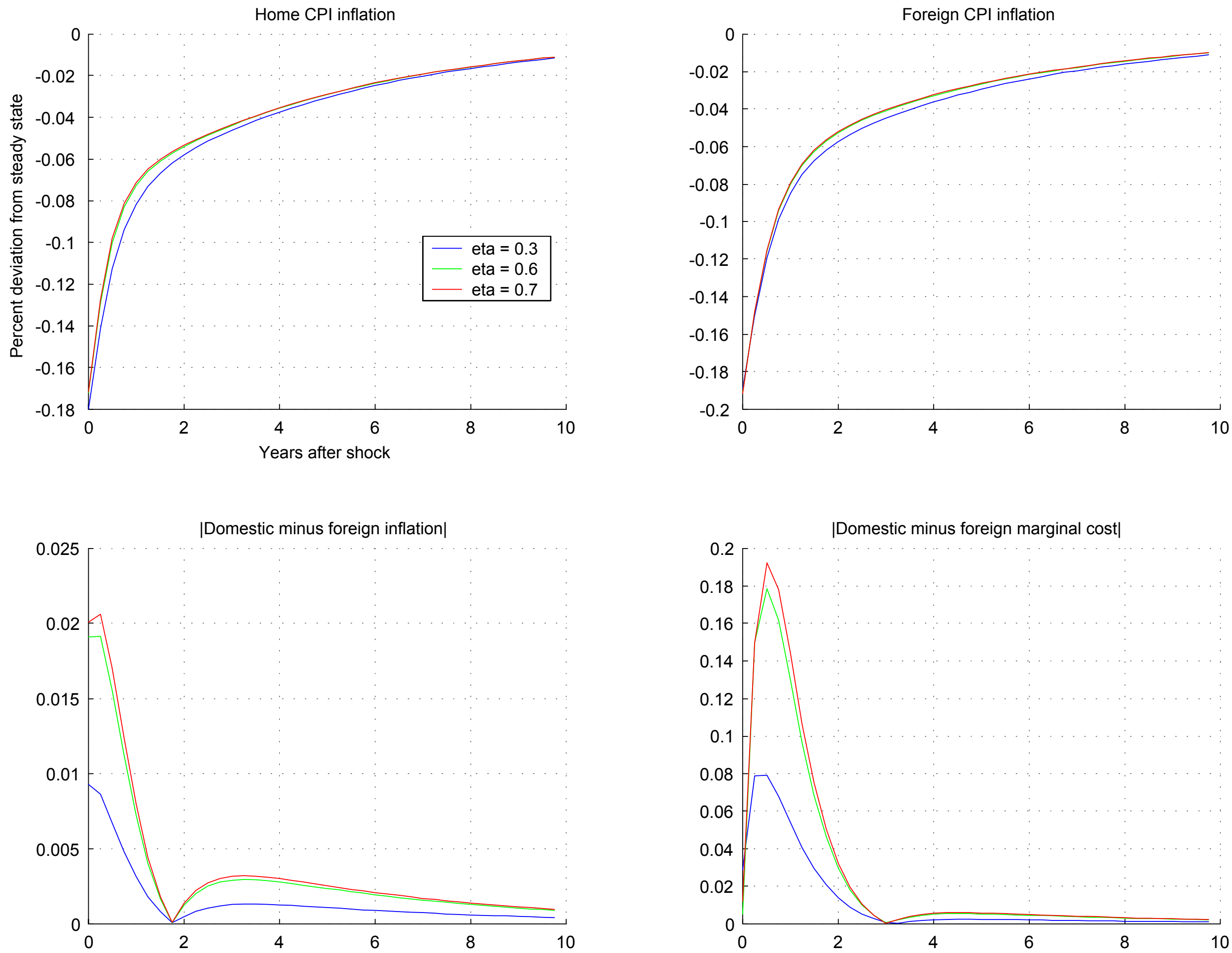

Figure 7: **Impulse responses to a technology shock for different values of the unemployment benefit.**

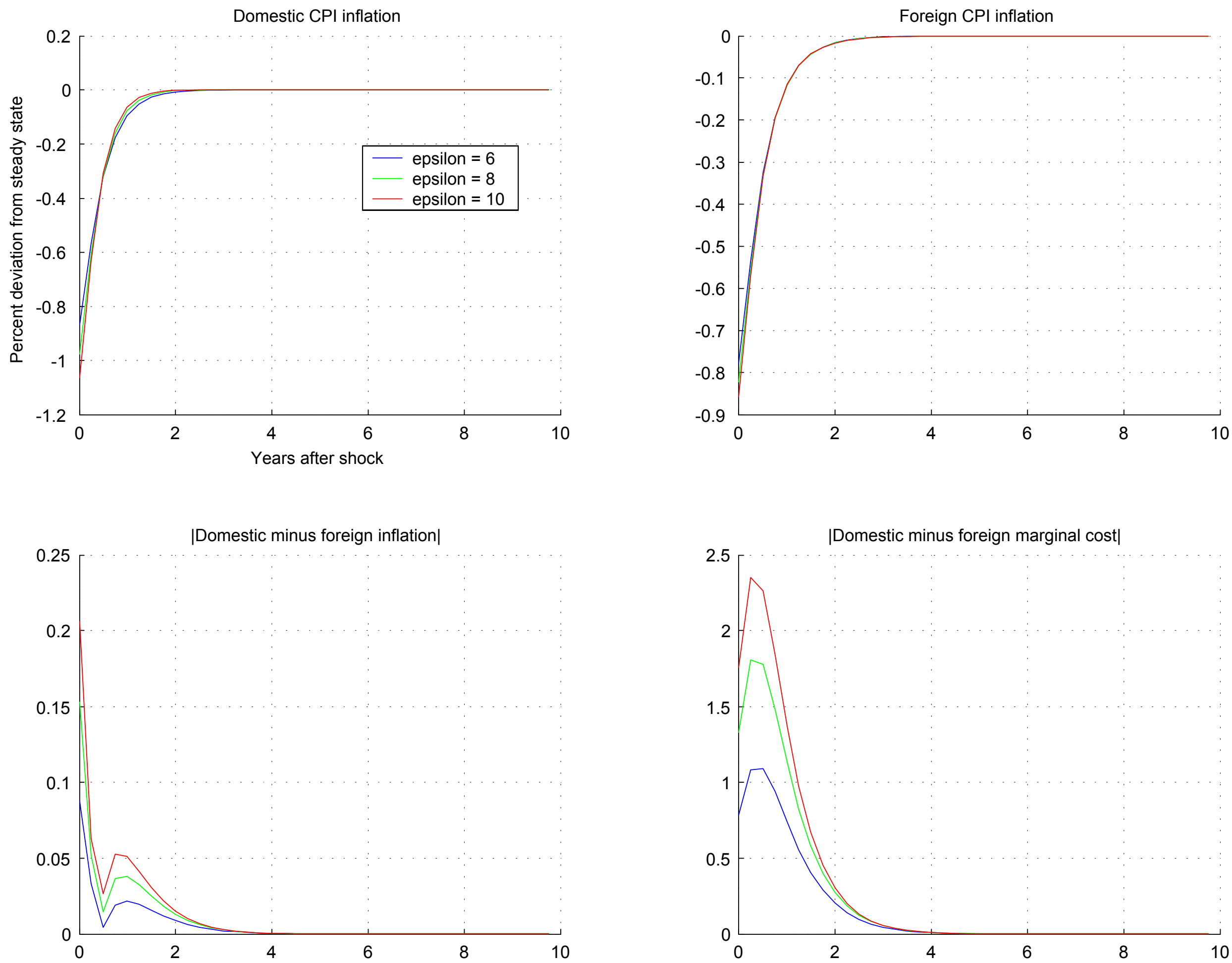

Figure 8: **Impulse responses to a monetary policy shock for different values of the demand elasticity.**

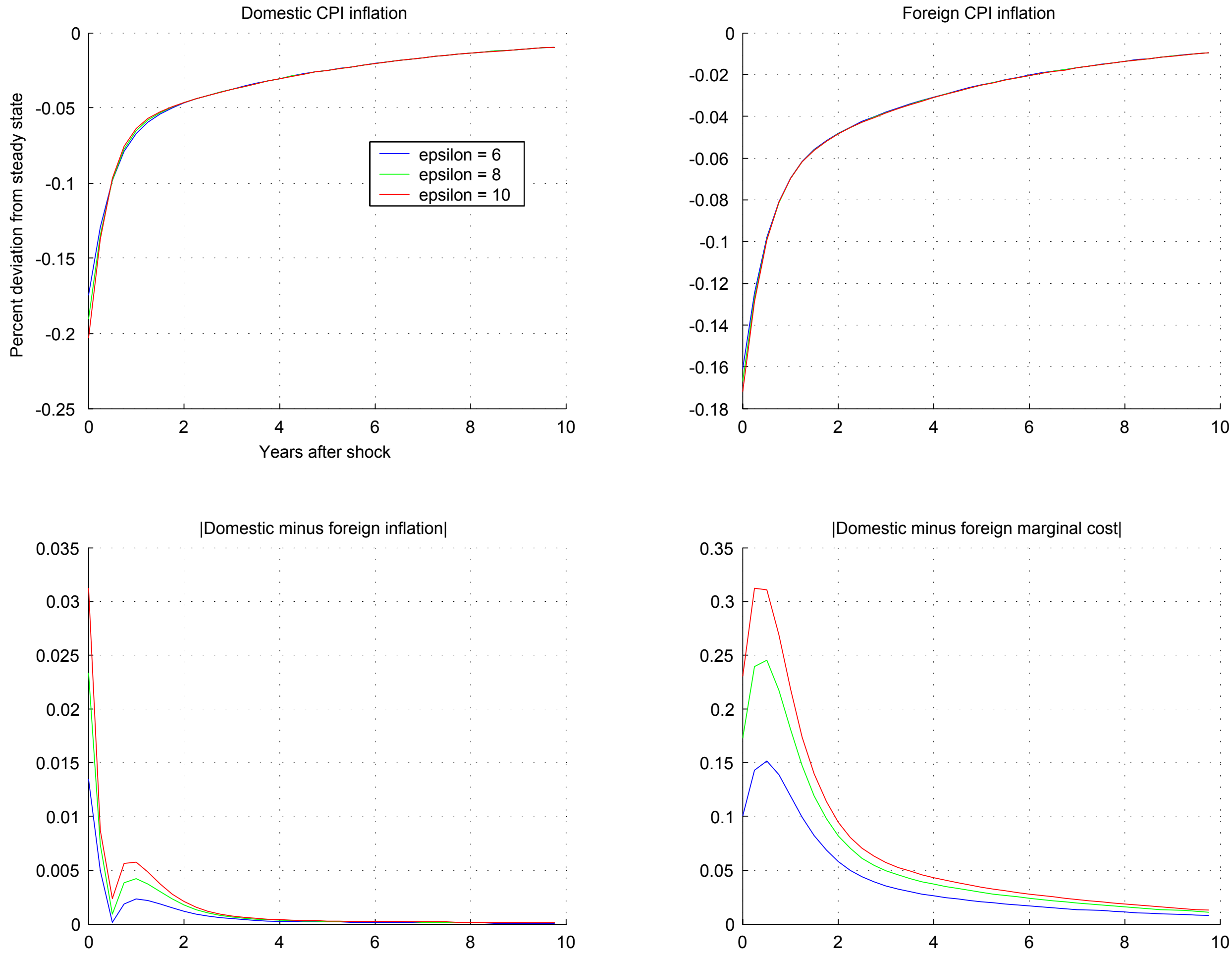

Figure 9: **Impulse responses to a technology shock for different values of the demand elasticity.**

Figure 10. VARS for Germany, France, Italy and Spain for the period 1998-2004.