Eurosclerosis and International Business Cycles

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Abstract This paper incorporates search frictions with endogenous job creation and destruction into a two country dynamic stochastic general equilibrium model to explain two macroeconomic facts. First, since the 1980's, European unemployment rates have risen substantially above USA levels. Second, European business cycle have lagged the USA business cycle during the period of the Great Moderation. In the model, more generous unemployment benefits and greater firing costs can endogenously generate higher unemployment. These same policies will also create labor market frictions which slow the response of the economy to business cycle conditions.

Keywords cross-country comovement; firing costs; frictional unemployment

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I. Introduction

During the 1980's, many continental European countries began to display much higher rates of unemployment relative to the United States (see Ljungvist and Sargent, 1998; Bertola and Rogerson, 1997; Blanchard and Wolfers, 2000). Frictional unemployment is a function of the average rate of job finding and separations from employment. Each of these behave very differently in the US and Europe. European workers are less likely to join the ranks of the unemployed than American workers (Elsby, Hobijn, and Sahin, 2011; OECD, 1997; Reichling, 2005). At the same time, unemployed European workers are relatively less likely to find a new position in any period (see Hobijn and Sahin, 2009; Ridder and van den Berg, 2003). The net effect is higher average unemployment in the Eurozone during the period of the Great Moderation[2]. The OECD reports quarterly harmonized unemployment rates for the European Monetary Union from the 3rd quarter of 1990. The mean unemployment rate for the EMU during the period 1990-2007 is 9.1%. Over the same period, the unemployment rate for the United States is 5.44%.

This paper notes a possibly related fact; the Eurozone business cycle lags the USA business cycle during the Great Moderation. Figure 1, Panel A shows the cross-correlogram of harmonized unemployment between the EMU and the USA over the period 1990:3-2007:4. The moderately positive contemporaneous correlation of 0.32 is smaller than the dynamic correlation of US unemployment with EMU unemployment observed one year in the future near 0.6. The correlation of current USA unemployment with EMU unemployment observed one year previously is much lower, near -0.6. Panel B shows the cross-correlogram of the USA and EMU Hodrick-Prescott detrended real GDP over the period 1984:1-2007:4. Panel A and B show a similar pattern with a contemporaneous correlation of the output gap equal .28, the largest positive dynamic correlation above .5 at a lead of 6 periods and a negative correlation below -.35 at a lag of six periods[3].

[2] We focus on the period of the Great Moderation ending the data prior to the financial crisis of 2008 during which contemporaneous co-movment between Europe and the United States was high. During the period of the Great Recession, the US economy moved into a liquidity trap. Cook and Devereux (2010) show that international comovement is quite different at the zero lower bound than at normal times.

[3] Heathcote and Perri (2008) find that in a period characterized by increasing globalization international business cycle co-movement fell substantially. However, even during this period, the *dynamic* correlation between US and EMU GDP was still quite strong with the US economy playing a leading role.

This paper attempts to quantify how much of the business cycle lead-lag relationship between major economies can be explained by the differences in labor market structure. We construct a dynamic general equilibrium model with search frictions in labor markets and endogenous job destruction (following Den Haan, Ramey, and Watson, 2000, and ultimately Mortensen and Pissarides, 1994)[4]. In our model, high frictional European unemployment and the structure of employment flows can be explained by a combination of policy choices: generous European unemployment benefits and greater levels of employment protection which create costs for firms that destroy jobs. The argument that firing costs are higher in the Eurozone is consistent with evidence accumulated by OECD that measures of employment protection are much higher in continental Europe than in the USA (see Venn, 2009). We allow for differences in the income of the unemployed consistent with evidence that unemployment benefits are higher in continental Europe than in the USA (see OECD, 2007).

We incorporate labor market search frictions in a two country international business cycle model in which one economy features a job flow structure similar to the United States and one economy features a structure similar to the Eurozone. Hairault (2002) has previously shown that international business cycle models with symmetric search frictions feature more realistically positive international co-movement in response to technology shocks than do models with Walrasian labor markets. In our model, we find that the more rigid nature of European labor markets cause that economy to lag the more flexible US economy at cyclical frequencies; the correlation between USA and EMU employment is higher at a lag than the contemporaneous correlation in a pattern qualitatively similar to the data. Employment is likely to respond more slowly to business cycle conditions in the sluggish European market.

More severe labor market frictions in Europe explain a substantial fraction of the lead lag relationship between the high unemployment EMU and the low unemployment USA. To help explain the data, we explore additional avenues which might strengthen the lead-lag relationship. If each economy is impacted by independent productivity shocks,

[4] Shimer (2012) presents evidence that endogenous job separations are unimportant to cyclical unemployment volatility in the US. Fujita and Ramey (2007, 2009) argue that cyclical job destruction to macroeconomic shocks should not be ignored. Our model explains the large difference between Europe and the US in job separation rates as the result of policy differences, requiring the modeling of endogenous job destruction.

the lead-lag relationship in output is likely to be smaller than that in employment. Instead, following Rotemberg (2008), we focus on cost-push shocks which drive changes in labor demand without directly impacting technology. Thus, the lead-lag relationship in output closely follows the lead-lag in employment. In another extension, we assume that constructing new vacancies requires planning and call this model the Hiring Inertia model. The Hiring Inertia model is successful in generating a stronger S-shape cross-correlogram of employment and output.

A large literature analyzes the role of labor market policies in driving European unemployment. Nickell, Nunziata and Ochel (2005) catalog the effects of unemployment benefits on long-term unemployment. Layard, Nickell and Jackman (2005) suggest that high levels of employment protection legislation might impact the high level of unemployment in Europe. Lazear (1990) finds that high severance costs are associated with high levels of unemployment. Nickell (2001) argues that the empirical findings on the relationship between employment protection laws are mixed. Bentolila and Bertola (1990) and Ljungvist and Sargent (2006) have illustrated cases where firing costs increase employment. Ljungqvist (2002) argues that if firing costs have an impact on firms bargaining power with existing workers, then these costs can sharply increase steady state unemployment in search-matching models. We follow this guidance and assume that firing costs are deadweight losses for firms (see Mortensen and Pissarides, 2003), thereby increasing unemployment.

Following Backus, Kehoe and Kydland (1992), a large number of models have examined international business cycle comovement in dynamic general equilibrium models. Cook (2002), Baxter and Farr (2004), and Wen (2007) show that time varying factor utilization can act as a channel that increases business cycle comovement. We include time-varying capital utilization to boost this channel.

Hairault (2002) shows that a two country model with labor markets characterized by search and matching (with exogenous job separation such as in Andolfatto, 1996; and Merz, 1995) displays much greater co-movement than in a model featuring only an optimal leisure-labor trade-off. Fonseca, Patureau, and Sopraseuth (2007) with a calibrated search model and empirical analysis find that countries with similar labor market institutions tend to have stronger co-movement. Most of the international comovement literature focuses on contemporaneous comovement. An important recent exception is Kang (2010) which also notes the strong dynamic lead-lag relationship between the US and Europe. Kang (2010) calibrates an equilibrium model with convex labor adjustment costs in the modeled Europe as a general representation of European labor market inflexibility. Wen (2004) also explains the sluggish response to productivity in European countries through the assumption of relatively large labor adjustment costs.

Many papers in the closed economy literature have examined the effect of firing costs on business cycle dynamics in a closed economy setting. Samaniego (2008) and Veracierto (2008) show that firing costs will reduce employment volatility. Using a New Keynesian model developed by Krause and Lubik (2007), Thomas and Zanetti (2009) study the effect of firing costs on inflation dynamics. Campolmi and Faia (2006) study the effect of other labor market institutions in a similar model. Also in a similar model, Ahrens and Wesselbaum (2009) examine the effects of firing costs on business cycle volatility. Costain (1997) examines the effect of unemployment insurance on the level of unemployment in a model of endogenous job separations. Costain and Reiter (2008) study the impact of unemployment benefits on business cycle dynamics. This literature is part of a larger group of papers which examine the role of labor market search in business cycle dynamics including Cole and Rogerson (2000), Mortensen and Nagypal (2007), and Walsh (2005).

This paper is organized as follows. Section II presents the data and cross-correlogram of the USA and EMU output and employment during the Great Moderation period. Section III gives the details of the model with firing cost. The calibration of the model is discussed in Section IV. Section V reports the simulation results of the model under technology shocks. Section VI reports the simulation results of the model under markups shocks. Section VII presents the Hiring Inertia model. Section VIII concludes.

II. Data

Table 1 reports business cycle moments for the European Monetary Union and the United States for the period 1984-2007, or for whichever sub-period that data is available. During this period, the volatility of GDP in the USA and the Eurozone were both approximately equal with a standard deviation of about 1%. In each economy, consumption is slightly less volatile than output and strongly pro-cyclical. Investment in each economy is more volatile than output but again strongly pro-cyclical. The trade balance as a share of GDP is about half as volatile as output but with absorption more volatile than output, the trade balance is negatively correlated with GDP. Note the counter-cyclicality of the trade balance is greater for the United States than for the EMU; the correlation between the EMU trade balance and EMU GDP is about -.12 while the correlation between USA trade balance and USA GDP is about -.44.

Harmonized measures of the unemployment rate are available only from 1991; during this period, the unemployment rate is strongly counter-cyclical with unemployment rising sharply in recessions. Notably, the unemployment rate is approximately twice as volatile in the US as in the EMU. Information on total employment is available from 1992. The level of employment is strongly pro-cyclical but more volatile in the USA than in the EMU. Labor productivity is also less volatile than output and equally volatile in the EMU and the USA. Labor productivity is strongly pro-cyclical, though more so in the EMU than in the USA. The correlation of output with labor productivity in EMU is above .8 while it is near .47 in the USA.

Table 1 also reports the moments of dynamic co-movement, in particular, the cross-correlogram (with up to four leads and lags) for each series in the two. Repeating the findings of Figure 1, we see a strong lead-lag relationship between the USA and the EMU unemployment rate. The two series have a contemporaneous correlation of about .33 while the correlation between USA and EMU unemployment four quarters later is nearly .66. A similar pattern is seen in total employment, though the peak correlation is at .5 with USA leading EMU employment by two quarters. We see that the dynamic lead-lag pattern is replicated in GDP with a contemporaneous correlation of about .28 but a correlation between USA and EMU GDP in four quarters measuring nearly .5. Both the contemporaneous correlation and the lead-lag relationship in the investment data are similar to that observed in the output data. The contemporaneous correlation between consumption across economies is very weak while a USA leader-EMU follower pattern is still visible in the consumption data. The trade balances as a share of GDP in the two economies are basically uncorrelated at all leads and lags. Interestingly, labor productivity is negatively correlated across countries. Further, the correlation between

EMU labor productivity and USA labor productivity is sharpest at a contemporaneous correlation.

Arguably, the high unemployment and the observations in Figure 1 may be explainable by a lack of flexibility in European labor markets. If inflexibility reduces the rates at which European firms hire workers, it could increase unemployment rates. If employment demand responds slowly to economic shocks, then European unemployment might tend to lag that in the United States.

Intriguingly, inter-European differences in the behavior of unemployment vis-à-vis the USA seem to be positively associated with the degree of unemployment. We obtain seasonally adjusted quarterly data on harmonized unemployment rates for j = 1 to 17 European OECD economies[5] from OECD Main Economic Indicators Labor Statistics for the period 1984 through 2007. We calculate the correlation of HP detrended unemployment with its counterpart from the USA two quarters previously, $\rho_j^{ur_t^j, ur_{t-2}^{USA}}$, using whichever sub-period over the period 1984 through 2007 data is available. We define the phase shift of the unemployment rate in country j as the difference between the correlation of unemployment with the USA at two lags and the contemporaneous correlation. We regress the phase shift on the average unemployment rate over the same period. See Figure 2 for a scatter plot. This generates the following regression results

$$\rho_j^{ur_t^j, ur_{t-2}^{USA}} - \rho_j^{ur_t^j, ur_t^{USA}} = \underset{(.070)}{.050} + \underset{(.009)}{.020} \cdot \overline{ur}_j \qquad \hat{R}_{Adj}^2 = .216 \tag{1.1}$$

The coefficient on the unemployment rate is significant at the 5% critical value (or at 1% using a heteroskedasticity consistent standard error). Average unemployment rates explain almost 22% of the variation in the phase shift. These findings are consistent with the idea that labor market rigidities which increase the unemployment rate also lead to a more sluggishly reacting economy.

III. The Model

In this section, we will construct a two country open economy stochastic dynamic general equilibrium model with labor market imperfections. The model economy consists of two

[5] Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom.

countries, labeled as the *US* and the *EZ* where j = *US, EZ*. Firms in each country produce an imperfectly traded good absorbed by households in both countries. Each country is populated by a representative household made up of a large number of risk-sharing workers (as in Andolfatto, 1996; and Merz, 1995). The households accumulate wealth in the form of either domestic physical capital or a risk free, internationally traded bond. Households in each country get utility from consumption of perfectly substitutable of market goods, $C^M_{t,j}$, and household production, $C^H_{t,j}$: $C_{t,j} = C^M_{t,j} + C^H_{t,j}$.

A. Production of Goods

The goods absorbed by each economy j, A_t, are a cost minimizing CES combination of goods produced at home, A_t^{HM}, and imported goods, A_t^{IM}.

$$A_{t,j} = \left[a^{1-\psi} \left(A^{HM}_{t,j} \right)^{\psi} + (1-a)^{1-\psi} \left(A^{IM}_{t,j} \right)^{\psi} \right]^{\frac{1}{\psi}} \tag{1.2}$$

The choice of home and imported goods minimizes the cost of the market basket.

$$a^{1-\psi} \left(A^{HM}_{t,j} \big/ A_{t,j} \right)^{\psi-1} = \frac{p_{t,j}}{cpi_{t,j}} \qquad (1-a)^{1-\psi} \left(A^{IM}_{t,j} \big/ A_{t,j} \right)^{\psi-1} = \frac{p_{t,\neq j}}{cpi_{t,j}} \tag{1.3}$$

where $p_{t,j}$ is the price of the good produced in country j, and $p_{t,\neq j}$ is the price of the good in the trading partner. The consumer price index, $cpi_{t,j}$, is given by

$$cpi_{t,j} = [a(p_{t,j})^{\frac{\psi}{1+\psi}} + (1-a)(p_{t,\neq j})^{\frac{\psi}{1+\psi}}]^{\frac{1+\psi}{\psi}} \quad .$$

Output, $Y_{t,j}$, is retailed by a competitive sector which combines inputs from a set of monopolistically competitive production firms.

$$Y_{t,j} = \left[\int_0^1 Y_{t,j,i}{}^{\eta_{t,j}} di \right]^{1/\eta_{t,j}} \tag{1.4}$$

where the elasticity of substitution between inputs is $\frac{1}{1-\eta}$. Each monopolistic firm combines effective capital and labor using a Cobb-Douglas production function with variable capital utilization as in Burnside, Eichenbaum, and Rebelo (1995),

$$Y_{t,j,i} = Z_{t,j} \cdot (Q_{t,j,i})^{\theta} \cdot H_{t,j,i}{}^{1-\theta} \tag{1.5}$$

where $Z_{t,j}$ is the aggregate stochastic technology; $Q_{t,j}$ is effective capital; and $H_{t,j}$ is effective labor. The cost minimizing marginal cost, $mc_{t,j}$, is given by:

$$rp_{t,j} = \theta mc_{t,j,i} \frac{Y_{t,j,i}}{Q_{t,j,i}} \qquad wp_{t,j} = (1-\theta) mc_{t,j,i} \frac{Y_{t,j,i}}{H_{t,j,i}} \tag{1.6}$$

$rp_{t,j}$ is the capital rental rate and $wp_{t,j}$ is the rental rate of effective labor. In a symmetric equilibrium, $mc_{t,j} = \frac{1}{\eta_{t,j}} \cdot p_{t,j}$, we hide the i subscript (e.g. $Q_{t,j,,i} = Q_{t,j}$, $H_{t,j,,i} = H_{t,j}$, and $Y_{t,j,,i} = Y_{t,j}$).

B. Labor Market

We add firing costs to a model with search frictions in labor markets with endogenous job separation following Den Haan, Ramey, and Watson (2000). Workers match or attempt to match with firms that produce effective labor. A match l will produce a quantity of effective labor, h_t^l, where h is an i.i.d. idiosyncratic technology shock distributed log normally with mean of one and standard deviation, σ. There are N workers in the labor force. The number of employed workers will be $L_{t,j}$, the number of unemployed workers will be $U_{t,j}$: $(1-\rho_{t,j}) \cdot L_{t,j} + U_{t,j} = N$; where $\rho_{t,j}$ is the endogenous time-varying job separation rate.

Firms that produce effective labor must pay a fee, c, to post a vacancy. The number of vacancies is $V_{t,j}$. The number of matches between workers and firms is a function of the number of unemployed people and the number of vacancies: $M_{t,j} = \mu_j \cdot U_{t,j}{}^{\alpha} V_{t,j}{}^{1-\alpha}$. Matches break down with an exogenous probability ρ^X but also may break down endogenously if the realization of the technology is below the reservation level at which it no longer makes sense to continue the relationship, $\bar{h}_{t,j}$. The probability that a match that does not break down exogenously will break down endogenously, $\rho_{t,j}^h$, is:

$$\rho_{t,j}^h = \rho^h(\bar{h}_{t,j}) = \int_0^{\bar{h}_{t,j}} dF(h) = F(\bar{h}_{t,j}) \tag{1.7}$$

The dynamics of labor are:

$$L_{t+1,j} = (1-\rho_{t,j})L_{t,j} + m_{t,j} \tag{1.8}$$

Where $\rho_{t,j}$ is the probability that matches break down, $\rho_{t,j} = \rho_X + (1-\rho_X)\rho_{t,j}^h$; and $m_{t,j}$ is the number of successful matches in period t.

Following Hagedorn and Manovskii (2008), unemployed workers receive a combination of transfers payments and internal benefits. Unemployed workers are able to produce γ home goods on their own time. In addition, they will receive as an unemployment benefit a transfer of consumption goods, f_j, which might differ as a matter of policy across countries. As market and home goods are perfect substitutes, the value of the payment can be expressed as $cpi_{t,j}b_j$ where $b_j = \gamma + f_j$.

The effective labor match, indexed by *l*, will sell its labor in a competitive market at rental rate $wp_{t,j}$. If either exogenous or endogenous separation occurs, then there is no match in period *t.* In this case, the worker obtains a payoff of $cpi_{t,j}b_j + \omega_{t,j}$, which can be considered as payoff from opportunities outside of the match where ω_t denotes the shadow value to the worker of being unemployed at the end of period *t*. For the firm, there is a country-specific tax in terms of goods, d_j, placed on firms that break-up the match which is constant in terms of the consumption good. The free entry condition implies that the value to the firm of breaking up a match, or the outside payoff for firm is $-cpi_{t,j}d_j$ in equilibrium. Hence, in period *t*, the match creates a joint surplus, $s_{t,j}^l$, net of workers and firms outside pay-off. The joint surplus is equal to

$$s_{t,j}^l = wp_{t,j}h_t^l + g_{t,j} - (cpi_{t,j}b_j + \omega_{t,j}) + cpi_{t,j}d_j \qquad (1.9)$$

where g_t is the value of a continuing match which is equal across firms (within a country) due to the i.i.d. nature of idiosyncratic shock.

If the surplus drops below 0, the match will not last. A firm and worker can endogenously choose to break up the match. There will be a technology level, $\overline{h}_{t,j}$, below which the match will be shut down, defined by:

$$0 = wp_{t,j}\overline{h}_{t,j} + g_{t,j} - (cpi_{t,j}b_j - cpi_{t,j}d_j + \omega_{t,j}) \qquad (1.10)$$

Firms and workers will Nash bargain over surplus and will split it with a fraction π going to firms and the remaining fraction, *(1-π)*, going to workers. Workers' value of the match will be $cpi_{t.j}b_j + \omega_{t,j} + (1-\pi)s_{t.j}^l$. Firms receive $-cpi_{t.j}d_j + \pi s_{t.j}^l$.

Define the fraction of unemployed workers finding a match as $\lambda_{t,j}^{U} \equiv {m_{t,j}}/{U_{t,j}}$ and fraction of firms with vacancies making matches as $\lambda_{t,j}^{F} \equiv {m_{t,j}}/{V_{t,j}}$. Define the shadow value of income of the household as $\Omega_{t,j}$. The recursive equation defining the value of being unemployed at the end of the period is:

$$\omega_{t,j} = E_t\left[\beta\frac{\Omega_{t+1,j}}{\Omega_{t,j}}\left\{\left[\lambda_{t,j}^{U}(1-\rho^X)\int_{\bar{h}_{t+1,j}}^{\infty}(1-\pi)s_{t+1,j}^{l}dF(h)\right]+cpi_{t+1,j}b_j+\omega_{t+1,j}\right\}\right] \quad (1.11)$$

From (1.11), the worker obtains $(1-\pi)s_{t+1.j}^{l}$ with probability $\lambda_{t,j}^{U}(1-\rho^X)(1-\rho_{t+1.j}^{h}),$ which is the fraction of workers matched in *t* whose match survives to *t+1*.

Firms create vacancies at cost, *c*, in goods. The free entry criteria implies that

$$cpi_{t,j}c = \lambda_{t,j}^{F}E_t\left[\beta\frac{\Omega_{t+1,j}}{\Omega_{t,j}}\left\{\left[(1-\rho^X)\int_{\bar{h}_{t+1,j}}^{\infty}\pi s_{t+1,j}^{l}dF(h)\right]-cpi_{t+1,j}d_j\right\}\right] \quad (1.12)$$

Where the firm obtains $\pi\cdot s_{t+1.j}^{l}$ with probability $\lambda_{t,j}^{F}(1-\rho^X)(1-\rho_{t+1.j}^{h})$. For a worker and a firm who remain matched in period *t*, the value of the continuing match is:

$$g_{t,j} = E_t\left[\beta\frac{\Omega_{t+1,j}}{\Omega_{t,j}}\left\{\left[(1-\rho^X)\int_{\bar{h}_{t+1,j}}^{\infty}s_{t+1,j}^{l}dF(h)\right]+cpi_{t+1,j}(b_j-d_j)+\omega_{t+1,j}\right\}\right] \quad (1.13)$$

Note (1.13) assumes the partners in a continuing match do not need to be matched again. So they receive the joint surplus with probability $(1-\rho^X)(1-\rho_{t+1.j}^{h})$.

Total efficient labor is given by:

$$H_{t,j} = (1-\rho_X)L_{t,j}\cdot\int_{\bar{h}_{t,j}}^{\infty}h_t^l dF(h) \quad (1.14)$$

C. Effective Capital

Effective capital is the product of physical capital, $K_{t,j}$, and utilization, $E_{t,j}$: $Q_{t,j} = E_{t,j}\cdot K_{t,j}$. Households in each country own that country's capital stock and consume and invest to maximize expected utility.

$$K_{t+1,j} = (1-\delta_{t,j})\cdot K_{t,j} + I_{t,j} \quad (1.15)$$

where δ_t is a time-varying capital utilization rate following Burnside, Eichenbaum and Rebelo (1995): $\delta_{t,j} = \delta_0 E_{t,j}^{\xi}$. The first order conditions for capital utilization and investment.

$$\xi\delta_{t,j} = rp_{t,j} \cdot E_{t,j} \tag{1.16}$$

$$1 = E_t\left[\beta\frac{\Omega_{t+1,j}}{\Omega_{t,j}}\left\{\left(1-\delta_{t+1,j}\right) + rp_{t+1,j}E_{t+1,j}\right\}\right] \tag{1.17}$$

D. Equilibrium

There is a single risk-free bond with interest rate, $1+r_t$, traded by families in both countries:

$$E_t\left[\beta\frac{\Omega_{t+1,j}}{\Omega_{t,j}}\cdot\left\{1+r_t\right\}\right] = 1 \tag{1.18}$$

Total household production is $C_{t,j}^H = \gamma \cdot U_{t,j}$. Assuming logarithmic utility,

$$cpi_{t,j}\Omega_{t,j} = u'(C_{t,j}) = {}^{1}\!/_{C_{t,j}} = \frac{1}{\left(C_{t,j}^M + C_{t,j}^H\right)} = \frac{1}{\left(C_{t,j}^M + \gamma\cdot U_{t,j}\right)} \tag{1.19}$$

The equilibrium in final goods markets is:

$$C_{t,j}^M + I_{t,j} + G_{t,j} + c\cdot V_{t,j} + \rho_{t,j}d_j = A_{t,j} \tag{1.20}$$

The equilibrium in intermediate goods market is

$$A_{t,j}^{HM} + A_{t,\neq j}^{IM} = Y_{t,j} \tag{1.21}$$

The net quantity of the risk free bond must be zero, so the quantity of bonds held by agents in country j are:

$$B_{t+1,j} = (1+r_{t-1})B_{t,j} + (p_{t,j}A_{t,\neq j}^{IM} - p_{t,\neq j}A_{t,j}^{IM}) \tag{1.22}$$

Finally, we set $p_{t,US}$ =1, as the numeraire.

IV. Calibration

We numerically solve a linear approximation to the model near a symmetric steady state with zero current account balances. The subjective discount factor is set at $\beta = .99$ indicating a quarterly frequency to match the business cycle data. The capital utilization elasticity parameter, $\xi \approx .4$, is set so that steady state depreciation rate is $\delta = .025$; the parameter δ_0 is set to normalize steady state utilization, $E=1$.

We set the steady state of the markup parameter, η, so that there is a small 5% markup of price over marginal cost. We set capital intensity of production at $\theta = .285$ so steady state share of output paid to labor (estimated as $\frac{(1-\pi)wp_{t,j}+\pi b_j}{Y_{t,j}} \cdot H_{t,j}$) is approximately ⅔. In all experiments, we normalize the US technology level equal to $Z_{SS} = 1$ and set the *EZ* technology level so that the steady state price of *EZ* goods is one at the trade balance steady state. Matching OECD data, we set the steady state level of government consumption equal to 16% of GDP in the steady state of the simulated *US* economy and equal to 20.5% of GDP in the simulated *EZ* economy. The degree of home bias, a, is set so that when the price of *EZ* produced goods equals *US* produced goods, the home country will consume a market basket that is 85% home goods. We set ψ =-1, so the elasticity of substitution between domestic and foreign goods is 0.5.

We set the matching parameter, α = .5, following Pissarides (2009) and Petrongolo and Pissarides (2001) and the bargaining power, π = .5, so the Hosios (1990) condition holds. We set the standard deviation of the idiosyncratic technology, σ = .075, and the probability $\rho_X = 0.015$, to roughly match the cyclical volatility of unemployment in the Benchmark parameterization.

Elsby, Hobijn, and Sahin (2011) provide comparable estimates of the monthly probability of entering and exiting unemployment for the United States and several Eurozone countries. For the United States, we use these to construct a monthly transition matrix, AM_{US}, of the month to month probability of moving into and out of unemployment (where the diagonal elements represent the probability of remaining in the current state). We then use $AQ_{US} = [AM_{US}]^3$ as a quarter to quarter transition matrix. The off diagonal elements of *AQ* are used for the steady state probability of moving out of unemployment, λ_{US}^U =.8804, and the probability of moving out of employment, ρ_{US} = .0561. We use the equally weighted average of the monthly transition probabilities of France, Germany, Italy, and Spain to construct AM_{EZ}. We then use the off diagonal element of AQ_{EZ} to calibrate the steady state EMU model, λ_{EZ}^U =.1748, and the probability of moving out of employment, ρ_{EZ} = .0189.

We follow den Haan, Ramey and Watson (2000) in assuming, $\lambda^F = .71$, in both countries. We assume that the cost of firing a worker in the *US* is twice as costly as posting a vacancy posting, $c = .5d_{US}$. We then calibrate, c, μ_{US}, and b_{US} to exactly match the labor market transition probabilities for the United States (λ_{US}^U =.8804, ρ_{US} = .0561, λ^F = .71). We assume equal costs of posting vacancies, c, in both countries. We then calibrate d_{EU}, μ_{EU}, and b_{EU} to exactly match the transition probabilities from the EMU (λ_{EZ}^U =.1748, ρ_{EZ} = .0189, $\lambda^F = .71$). These transition probabilities translate into a steady state unemployment rate of 6.3% in the *US* and 9.9% in the *EZ*, not far from data estimates. We calibrate γ to be 75% of b_{US}.

Table 2 shows the parameters identified for each economy. Steady state job posting costs are less than .1% of GDP in both economies. Firing costs constitute less than .2% of GDP as well. It is straightforward to see that firing costs, represented by *d,* will reduce the likelihood of separations from jobs. Given a job match, a lower idiosyncratic match productivity, *h*, must be realized to make it worthwhile to incur high firing costs; this will be less likely. Firing costs can also increase steady state unemployment by reducing the rate at which new jobs are created. Intuitively, as there is a positive probability that any worker hired will ultimately be terminated, a tax on job destruction is also a tax on job creation. Differences in unemployment benefits, *b*, also affect steady state unemployment rates. When unemployed workers receive relatively high benefits, the surplus available to firms will be relatively small, giving firms less incentive to create vacancies. As a result, the ability of workers to find positions will be limited.

We see that the replacement income relative to returns to working b^{US}/MPL^{US} is almost 0.95 while b^{EZ}/MPL^{EZ} is slightly above 0.98 so that most of labor productivity accrues to workers. Matching technology in the *EZ* economy is calibrated as substantially worse than in the *US* economy. This is consistent with the idea that low cross-country labor mobility in Europe (see Jung and Kuhn, 2011) might lead to low levels of matching efficiency.

Table 2: Calibrated Parameter for Labor Market

Parameter: Calibration Strategy		*US*	*EZ*
Job Posting Cost: Half of US Firing Costs	c	.0291	.0291
Firing Cost: Job Separation Rate	d	.0581	.1096
Replacement Income: Job Finding Rate	b	1.511	1.636
Matching Technology: Vacancy Filling Rate	μ	0.790	0.352
Production Technology: Relative Price Normalization	Z	1	1.033

V. Technology Shocks

In this section, we consider the simulated behavior of the model, focusing on persistent shocks to technology and markups. We assume technology shocks which follow an independent AR(1) processes as in Hansen (1985):

$$\begin{matrix} \ln Z_{t,US} \\ \ln Z_{t,EZ} \end{matrix} = \begin{matrix} z_{SS,US} \\ z_{SS,EZ} \end{matrix} + \begin{bmatrix} .95 & .00 \\ .00 & .95 \end{bmatrix} \cdot \begin{matrix} \ln Z_{t-1,US} \\ \ln Z_{t-1,EZ} \end{matrix} + \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \cdot \begin{matrix} \omega_{t,US} \\ \omega_{t,EZ} \end{matrix} \tag{1.23}$$

where $\omega_{t,j}$ is a set of normally distributed, $N(0,\sigma_Z^2)$ i.i.d. shocks with zero cross country correlation.

A. Impulse Response Functions

We consider the response of employment and output to technology shocks in the model under the Benchmark calibration. For comparison, we show the response under a Symmetric calibration in which all parameters in both economies are set as in the benchmark *US* economy[6]. Figure 3, Row 1 reports the response of *US* and *EZ* output and employment to a 1% shock to *US* technology at time 0 (i.e. $\omega_{0,US} = .01$); Figure 3, Row 2 reports the response of *US* and *EZ* output and employment to an *EZ* technology shock at time 0 (i.e. $\omega_{0,EZ} = .01$).

A *US* technology shock leads immediately to an increase in the level of *US* output and the productivity of labor. Higher labor productivity at every firm will shift the distribution of productivity levels upward, reducing the fraction of employee matches that are low enough to lead to an endogenous break-up; the endogenous separation rate will fall persistently. *US* employment will rise persistently increasing to a peak in the second period in both the Symmetric and Benchmark model.

[6] Note that there is one asymmetry in the model: international debt is denominated in the numeraire US production good. This has limited asymmetric effects near a zero trade balance steady state.

The *US* technology shock increases the relative price of the imperfectly substitutable *EZ* goods increasing the marginal product of *EZ* labor. In both the Benchmark and Symmetric cases, the persistent rise in the price of *EZ* goods relative to the cost of creating *EZ* vacancies leads to a persistent rise in *EZ* hiring rates. The price rise also reduces the cut-off level of idiosyncratic technology necessary to continue the match between firms and employees and the *EZ* firing rate will fall. In the Benchmark case, firing costs keep endogenous separation rates low and there is only a small initial impact on *EZ* employment. In the Symmetric case, a change in separation rates has a larger immediate impact on *EZ* employment. Once *EZ* employment rises, though, it stays high more persistently in the Benchmark case as the separation rate is so low in the *EZ* economy.

Similar effects can be seen when considering the impact of an *EZ* productivity shock (as seen in Row 2). In the Symmetric case, the effect of an *EZ* technology shock on *EZ* and *US* output and employment is the reverse of the already discussed effect of a *US* technology shock on *US* and *EZ* (respectively) output and employment. In the Benchmark case, the rise in *EZ* technology will have less initial effect on *EZ* separation rates so employment will rise only slowly. This result is in line with results of Messina and Valenti (2007) who analyze firm level data and find that high levels of employment protection amongst European countries are associated with a reduced response of job destruction to business cycle shocks. Indeed, the initial increase in *US* employment (due to rising *US* relative prices) will exceed the increase in *EZ* employment. Therefore, *EZ* output jumps immediately upon the shock but *EZ* employment begins to rise only slowly. This is in line with the empirical findings of Balakrishnan and Michelacci (1999) who find, using VAR techniques that European unemployment responds more slowly to business cycle shocks than American unemployment. Again, the rise in *EZ* output is more persistent, eventually exceeding that seen in the model *US* economy. Changes in *US* employment lead changes in *EZ* employment. However, following an *EZ* technology shock there is immediate contemporaneous movement between *US* and *EZ* output.

B. Second Moments

Table 1 reports the simulated moments of the model under the assumption $\sigma_Z = .0035$ to roughly match the standard deviation of Hodrick-Prescott filtered *US* GDP in the

Benchmark model to the data. In each case, we simulate the economy for 200 periods, drop the first 100 periods, and calculate the moments of the last 100 periods after Hodrick-Prescott filtering. Table 1 reports the average of key moments of the *EZ* and *US* economies from 1000 simulations.

We first examine the moments of the Symmetric model. By construction, the variation in technology is set so that the volatility of output is close to the data. We see that consumption expenditure is less volatile than output and slightly less than in the USA data[7]. Investment is more volatile than output. The volatility of the trade balance is also a bit smaller than in the data. Both consumption and investment are strongly correlated with output while the trade balance as a share of output is negatively correlated with output as in the data.

The volatility of unemployment in the symmetric model is in between the relatively larger volatility in the USA data and the smaller volatility in the Eurozone data. We also see that employment is less volatile than output (as is true in the data). As expected and as in the data, employment is strongly pro-cyclical while unemployment is counter-cyclical. Labor productivity is less volatile than output but strongly pro-cyclical. The correlation of labor productivity with output is very large in the model while the correlation is moderate (about .4 in the *US*) in the data.

We also show the cross-country, cross-correlogram of the variables with four leads and lags. Despite the fact that there is no exogenous co-movement between technology levels in the two economies, we see that there is considerable comovement between many of the series. The cross-country correlation in output in the Symmetric model (0.29) is similar in size to that observed in the data (about 0.28).

The complementarity between *US* and *EZ* goods in demand is a key channel for co-movement. Capital utilization is proportional to the physical capital rental rate which is equalized in expectation across countries through financial markets; this augments the cross-country comovement of output. The complementarity of goods and the comovement of effective capital lead to a comovement in marginal product of labor and

[7] Note however, that the OECD data on personal consumption expenditure includes consumer durables while the model concept more closely adheres to non-durables consumption.

the willingness of firms to hire labor. Employment is reasonably positively correlated across countries.

There is a moderately positive cross-country correlation of market consumption. Changes in the level of unemployment/home production have a direct impact on the marginal utility of consumption of market goods. When employment is temporarily high during a boom, home goods production will be reduced and marginal utility of consumption of market goods will increase. Comovement in the unemployment rate across economies translates into comovement in consumption across countries.

There is essentially no cross-country comovement in investment in the Symmetric model. A positive technology shock in one country increases the marginal product of capital which increases investment in that country. The spillovers to the relative price in the trading partner will also increase the partner's marginal product. At the same time, the strong temporary response of consumption in both countries raises the interest rate, *r*, which has a negative impact on investment in the partner. Quantitatively, these two effects offset in the model.

Labor productivity is also uncorrelated across economies in the model. A positive technology shock in one country increases both employment and capital utilization in the other country; these have offsetting impacts on labor productivity in the second country. By definition, the trade balance in one country is perfectly negatively correlated with the trade balance in the other country of the model. This is an important deviation from the data in which each country has many trading partners.

A key finding of the Symmetric model, however, is that the two economies business cycles are synchronized. The strongest cross-country correlation of employment and other series in the model is contemporaneous. This contrasts with the data in which the strongest correlation is between *US* unemployment and *EZ* unemployment several periods later. The cross-correlogram in the data is S-shaped with much stronger correlation of the *US* with *future EZ* unemployment and output being much larger than the correlation with *past EZ* unemployment and output. By contrast, the correlogram in the Symmetric model is hill shaped with correlation between *US* production variables and their *EZ* counterparts diminishing equally at both leads and lags.

The asymmetric Benchmark model with a more sclerotic *EZ* is more successful on both counts. As shown in the impulse response functions, *EZ* unemployment lags *US* unemployment after shocks to technology in either the *EZ* or the *US*. This can be observed in the cross-correlogram of unemployment. In the Benchmark model, the contemporaneous cross-country correlation between *US* and *EZ* variables is positive though slightly smaller than in the Symmetric model. The correlation between current *US* and *EZ* unemployment one quarter later is larger than the contemporaneous correlation between the two variables. This is also (marginally) true for the relationship between *US* output and *EZ* output. The unemployment cross-correlograms are S-shaped with substantially larger correlations between *US* variables and future *EZ* counterparts than the corresponding correlations with past *EZ* counterparts. The cross-country output correlogram displays a weaker S-shape.

In the Benchmark model, the contemporaneous cross-country correlation of investment is somewhat negative. However, there is a more positive lead-lag relationship with the correlation between current *US* and future *EZ* investment becoming positive after several periods. The cross-country correlogram of consumption also displays an S shape in the Benchmark model. Since unemployment directly shifts the marginal utility, market consumption directly follows the dynamics of unemployment.

VI. Markups Shocks

In the previous section, we found that the phase shift between economies in the Benchmark model was stronger in the employment series than in the series for output. The labor market frictions in *EZ* cause employment there to adjust slowly in response to productivity shocks in either country, but a shock to *EZ* technology has a strong contemporaneous impact on output in both countries. In this section, we examine the cross-correlogram when there are persistent shocks to the markups of the monopolistic production firms

$$\begin{matrix} \ln \eta_{t,US} \\ \ln \eta_{t,EZ} \end{matrix} = \begin{matrix} e_{SS,US} \\ e_{SS,EZ} \end{matrix} + \begin{bmatrix} .99 & .00 \\ .00 & .99 \end{bmatrix} \cdot \begin{matrix} \ln \eta_{t-1,US} \\ \ln \eta_{t-1,EZ} \end{matrix} + \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \cdot \begin{matrix} \varepsilon_{t,US} \\ \varepsilon_{t,EZ} \end{matrix} \tag{1.24}$$

where $\varepsilon_{t,j}$ is a set of normally distributed, $N(0,\sigma_\eta^2)$ i.i.d. shocks with zero cross country correlation with $\sigma_\eta = .005$.

Shocks to market power can directly affect the demand for capital and labor inputs. An increase in η reduces the market power of the monopolists and leads them to increase production. There is a direct increase in the demand for labor; in equilibrium, *wp* will rise. The rising marginal product of labor will lead to a decline in separation and an increase in vacancy posting. Employment will rise. The decline in market power will also increase the demand for effective capital. Capital utilization will also rise in response.

Figure 4, Row 1 shows the response of *US* and *EZ* output and employment to a 1% shock to *US* markups at time 0 (i.e. $\varepsilon_{0,US} = .01$). For comparison, we also show the response of the Symmetric model to markup shocks. Upon realization of the shock, employment expands persistently: immediately, due to a decline in endogenous separation rates; and subsequently, due to an increase in vacancies posted by employers. Output increases by almost exactly the same amount as employment since capital utilization increases proportionally to labor. The decline in *US* markups raises the equilibrium relative price of *EZ* goods, increasing demand for labor and effective capital in *EZ*. Due to the already small separation rates, the endogenous decline in this rate leads only to a limited immediate expansion in output; due to the small job finding rate, a given increase in vacancies generates only a very slow expansion in *EZ* employment. Figure 4, Row 2 reports the response of *US* and *EZ* output and employment to an *EZ* markup shock at time 0 (i.e. $\varepsilon_{0,EZ} = .01$). The decline in *EZ* markups leads to an expansion in employment in both the *EZ* and *US* economy. Again, employment responds more slowly in the *EZ* than the *US*, but eventually the *EZ* labor response is larger and more persistent.

Table 3, Panel A and B shows the second moments of the Benchmark and Symmetric models driven by only markups shocks. Employment drives output in the wake of markup shocks; employment volatility is larger relative to output volatility when the exogenous forces are markup shocks as opposed to technology shocks. The cross-country correlation between output (like unemployment) is strongest between the current *US* level and the *EZ* level at one period lead. As in the data, the correlation between *US* output and subsequent *EZ* output is notably stronger than either contemporaneous or previous levels of *EZ* output (i.e. the cross-correlogram is S shaped).

There is stronger investment comovement in the model with markups shocks because of the assumed persistence of these shocks. In the Benchmark model, the contemporaneous comovement is small, but there is a very strong lead-lag between *US* and *EZ* investment due to the impact of the dynamics of employment on the marginal product of capital. The cross-correlogram of consumption also displays a strong S –shape. Counter-factually, productivity is counter-cyclical. However, markup shocks have very small effects on productivity. A mix of mostly markup and some technology shocks would lead to pro-cyclical productivity.

VII. Hiring Inertia

Fujita and Ramey (2007) show that the creation of vacancies and hiring respond only slowly to macroeconomic shocks. Hagedorn and Manovskii (2011) show that a time to build constraint on vacancy creation helps to match the correlations of *US* labor market variables with productivity. We consider an additional labor market friction in which hiring, or creation of new vacancies, only responds slowly to economic shocks. We assume that the costs for posting vacancies must be paid in advance. At time *t*, households in both countries can use absorption goods to create a capacity for vacancies, $V_{t+1,j}$, in the next period[8]. Investment in each economy is done with absorption goods.

$$C_{t,j} + I_{t,j} + G_{t,j} + cV_{t+1,j} + \rho_{t,j} d_j = A_{t,j} \tag{1.25}$$

Any firm can hire that capacity at rate *pv*. In this model, the free-entry criteria for firms produce effective labor will be:

$$pv_{t,j}c = \lambda^F_{t,j} E_t \left[\beta \frac{\Omega_{t+1,j}}{\Omega_{t,j}} \left\{ \left[(1-\rho^X) \int_{\bar{h}_{t+1,j}}^{\infty} \pi s^l_{t+1,j} dF(h) \right] - cpi_{t+1,j} d_j \right\} \right] \tag{1.28}$$

$$cpi_{t,j} = E_t \left[\beta \frac{\Omega_{t+1,j}}{\Omega_{t,j}} pv_{t+1,j} \right] \tag{1.27}$$

Figure 4 shows the response of the Hiring Inertia model to markups shocks in the *US* and *EZ* economies for an easy comparison to the Benchmark model. In Row 1, we show the response to a *US* markups shock. In the period of the shock, *US* and *EZ* employment increases due to declines in separations. Note that employment rises more in the period of the shock than in the models without hiring inertia; hiring inertia increases the continuation value of an existing worker in the period of the shock and endogenous

[8] Yashiv (2004) conjectures polynomial adjustment of vacancies.

separation declines by a greater amount. This response is more notable in the more flexible *US* economy. However, the inability of the employers to immediately adjust vacancies means that both the *EZ* and *US* employment expansion in the period following the shock is relatively small compared to the Benchmark model. The *EZ* economy, with its relatively low separation rate, is very slow to respond until period 3 following the shock. A similar pattern can be observed in Row 2 which shows the response of the model to an *EZ* markups shock. Employment responds in the period of the shock due to a reduction in endogenous separations, more sharply in the *US* than the *EZ*, but plateaus for an additional period until firms can ramp up hiring. Regardless of the source of the shock, the output expansion in each country in every period is very similar in size to the employment expansion.

Table 3, Panel C shows the moments of the Hiring Inertia model. Fluctuations in employment are smaller than in the Benchmark model particularly in the *EZ*, as are fluctuations in output. The main difference appears in the cross-country correlogram in which the S-shape is much more visible. Here we see that the strongest cross-country correlation is that between *US* unemployment/output and *EZ* unemployment/output is at a two period lag. This dynamic correlation is substantially stronger than the contemporaneous correlation (for unemployment, .51 at two lags vs. .36 contemporaneously). The contemporaneous cross-country correlation in investment is slightly negative but there is a strong S-shape to the cross-correlogram to both consumption and investment.

Table 4 reports some labor market moments for the Hiring Inertia model. We find that Job Finding rates are significantly more volatile in the *EZ*. Gartner, Merkl and Rothe (2009) find evidence from West German labor surveys that German job finding rates are indeed more volatile at cyclical frequencies than American job finding rates. We also find that job separation rates are slightly less volatile in *EZ* than in the *US* again matching evidence from Gartner et al (2009) for the largest Eurozone economy. Job separations are counter-cyclical and job finding rates are pro-cyclical as in the data (though this is somewhat weaker in the *EZ* economy).

Table 4: Labor Market Moments for Hiring Inertia Model

	Volatility (Std)		Correlation with GDP	
Hiring Inertia ***X***	US	EZ	US	EZ
Job Finding Rates	7.54%	15.90%	0.99	0.55
Job Separation Rates	10.19%	9.26%	-0.86	-0.21
Vacancies V	1.98%	27.85%	0.37	0.29

We find that in this model, vacancies *V*, are weakly pro-cyclical. Evidence from Blanchard and Diamond (1989) suggests that measured vacancies are strongly pro-cyclical in the data. We also find much smaller volatility of vacancies in the *US* economy than in the *EZ* economy. Modeling on the job search (Krause and Lubik, 2010, Menzio and Shi, 2011) may be necessary to match the cyclical behavior of vacancies.

VIII. Conclusion

Labor market policies, including heavy employment protection and generous unemployment benefits, that can lead to high long-term unemployment rates can also lead to an economy that responds more sluggishly to business cycle shocks. We model an international business cycle model in which a high unemployment economy lags a low unemployment economy in that 1) the contemporaneous cross-country correlation between employment or the output gap is weaker than the correlation between production aggregates in the low unemployment economy and the counterpart in the high unemployment economy at several lags; and 2) the correlation between the high unemployment economy and lags of the low unemployment economy are reasonably strongly positive while correlation with leads of the low unemployment economy are zero or even negative.

One discrepancy between the model and the data comes in terms of the sheer size of the phase shift between European and USA business cycles during the period of the Great Moderation. In terms of detrended output data, we find that the strongest correlation occurs between the USA economy and the Eurozone economy at least four quarters later as compared to a strongest dynamic correlation at a two period lag in the model. Further refining the model to include greater persistence in unemployment through modeling skill loss (see Ljungqvist and Sargent, 2008) might lead to a stronger lead-lag relationship.

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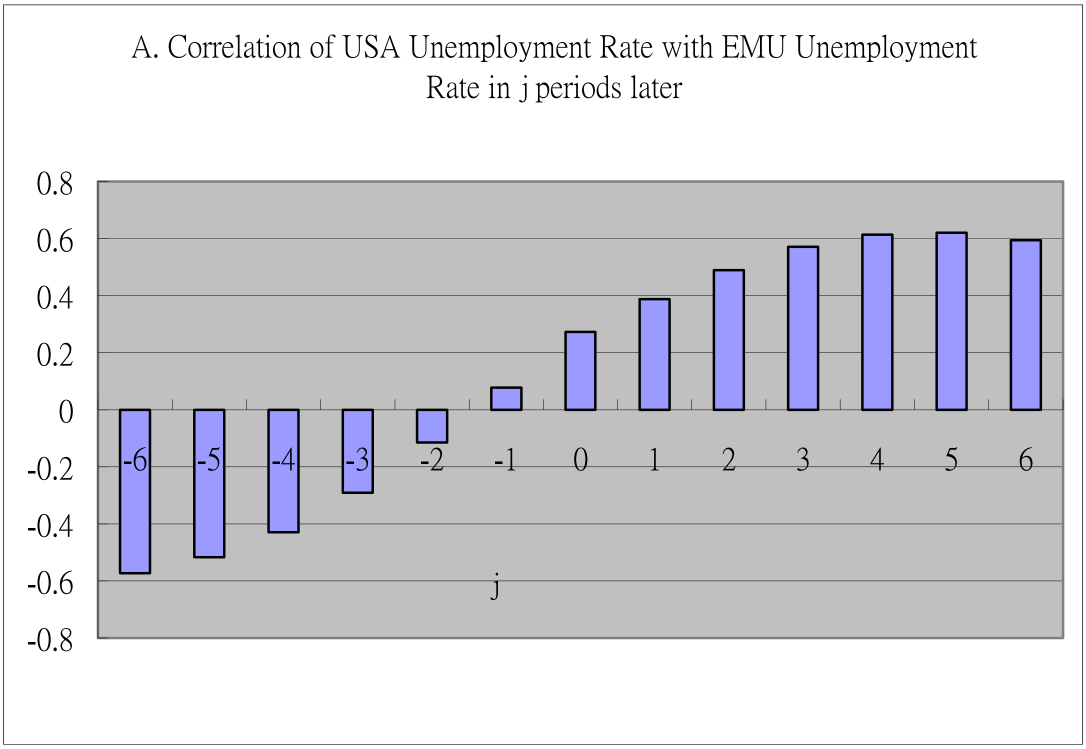
Appendix

Data on economy level GDP and expenditure components is VPVOBARSA: Millions of US dollars, volume estimates, fixed PPPs, OECD reference year, annual levels, seasonally adjusted from the Quarterly National Accounts database at the OECD. Data for the EMU-12 from 1970 to the first quarter of 2005 is from QNA 2003 with year 2000 as the base year. This data is extended through 2007 using a series from the current OECD Historical National Accounts for the EMU-16 by assuming that the quarter-by-quarter growth of the EMU-12 series is identical to the measured quarterly growth of the EMU series. GDP data from the US is constructed using an identical procedure. The level of employment used to construct labor productivity for the US is from OECD Main Economics Indicators Labor Force Statistics is in thousands of persons. The EMU-12 employment series, also in thousands of persons is from Eurostat. The EMU series is seasonally adjusted by the X12 package in Eviews 7.0.

Additional Parameters

β	.99	*Subjective Discount Factor*
δ_0	.025	*Steady State Depreciation Rate*
ξ	.4	*Elasticity of Capital Utilization*
θ	.285	*Capital Intensity of Production*
η	$1/1.05$	*Small Markup*
ψ	$-1/2$	*Elasticity of Substitution between International Goods*
π	$1/2$	*Bargaining Power of Workers*
α	$1/2$	*Weight on Unemployment in Matching Function*
σ	.075	*Volatility of Idiosyncratic Technology*
ρ^X	.015	*Exogenous Separation Rate*
c	.0291	*Job Separation Rate USA*
a	.85	*Home Bias in Demand*
G/Y^{US}	.16	*Share of Government Spending USA*
G/Y^{EZ}	.205	*Share of Government Spending EU*

Figure 1 shows the Cross-correlogram of the detrended US and EMU unemployment rate (Panel A, 1990:3 2007:4) and the US and EMU output gap (Panel B).



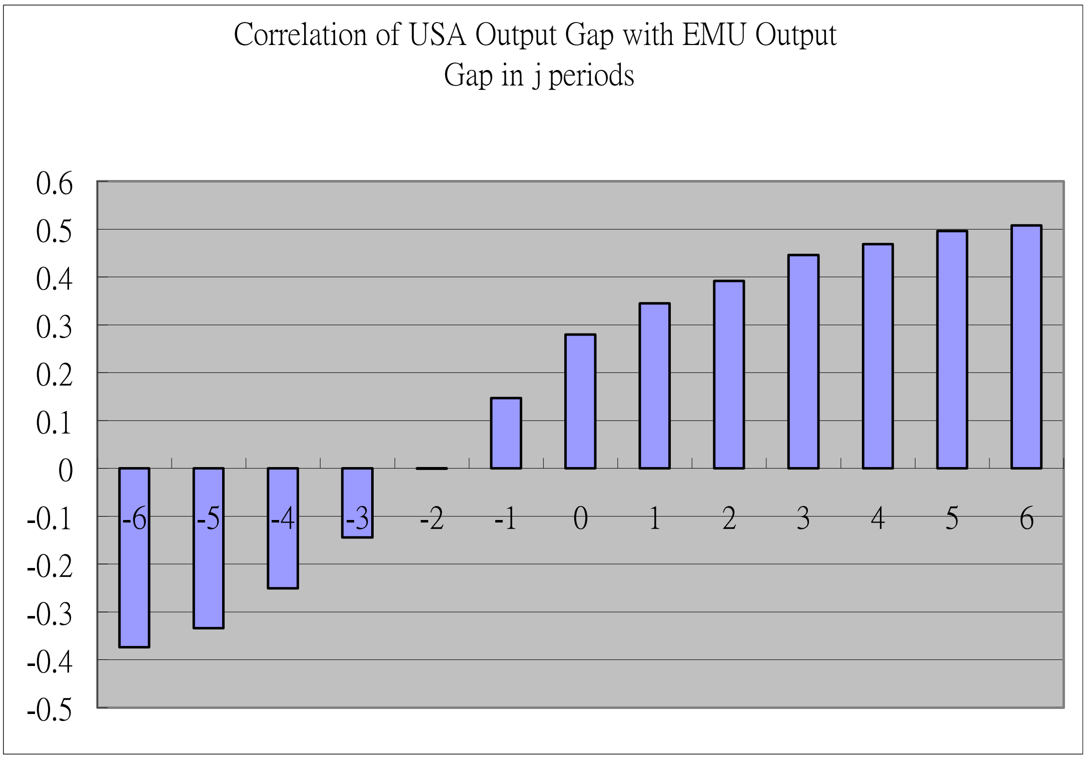


Figure 2 shows a scatter plot of the average unemployment rate for seventeen European economies over the period 1984-2007 (or whichever sub-period for which data is available) alongside the phase shift with US unemployment (defined as the difference between the cross country correlation at two lags and the contemporaneous correlations) from the same period.

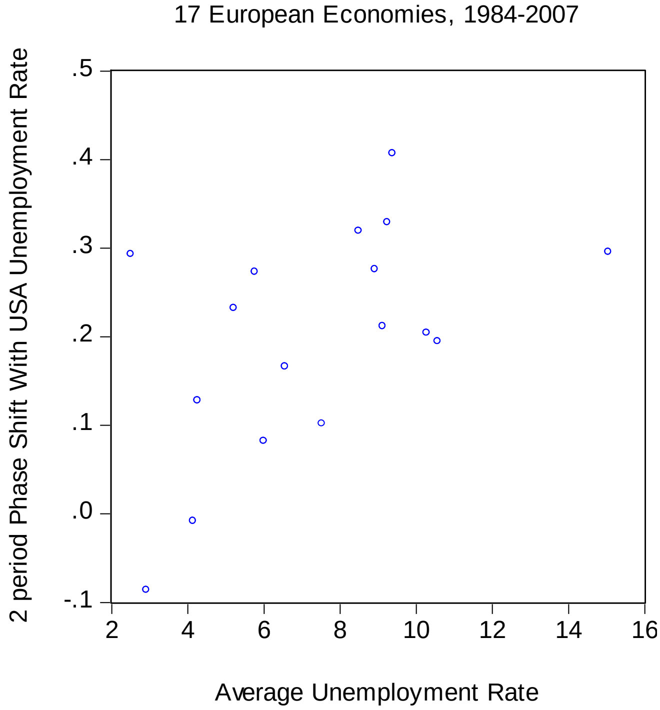


Figure 3 shows the dynamic response of output, Y_j, and employment, E_j, in each of the modeled US and EZ economies to a one standard deviation shock to the US and EZ technology level in period 1. The figure compares the response in the 1) Symmetric model with no firing cost in either economy; 2) Firing Costs model with higher deadweight losses from job separation in the EZ than in the US.

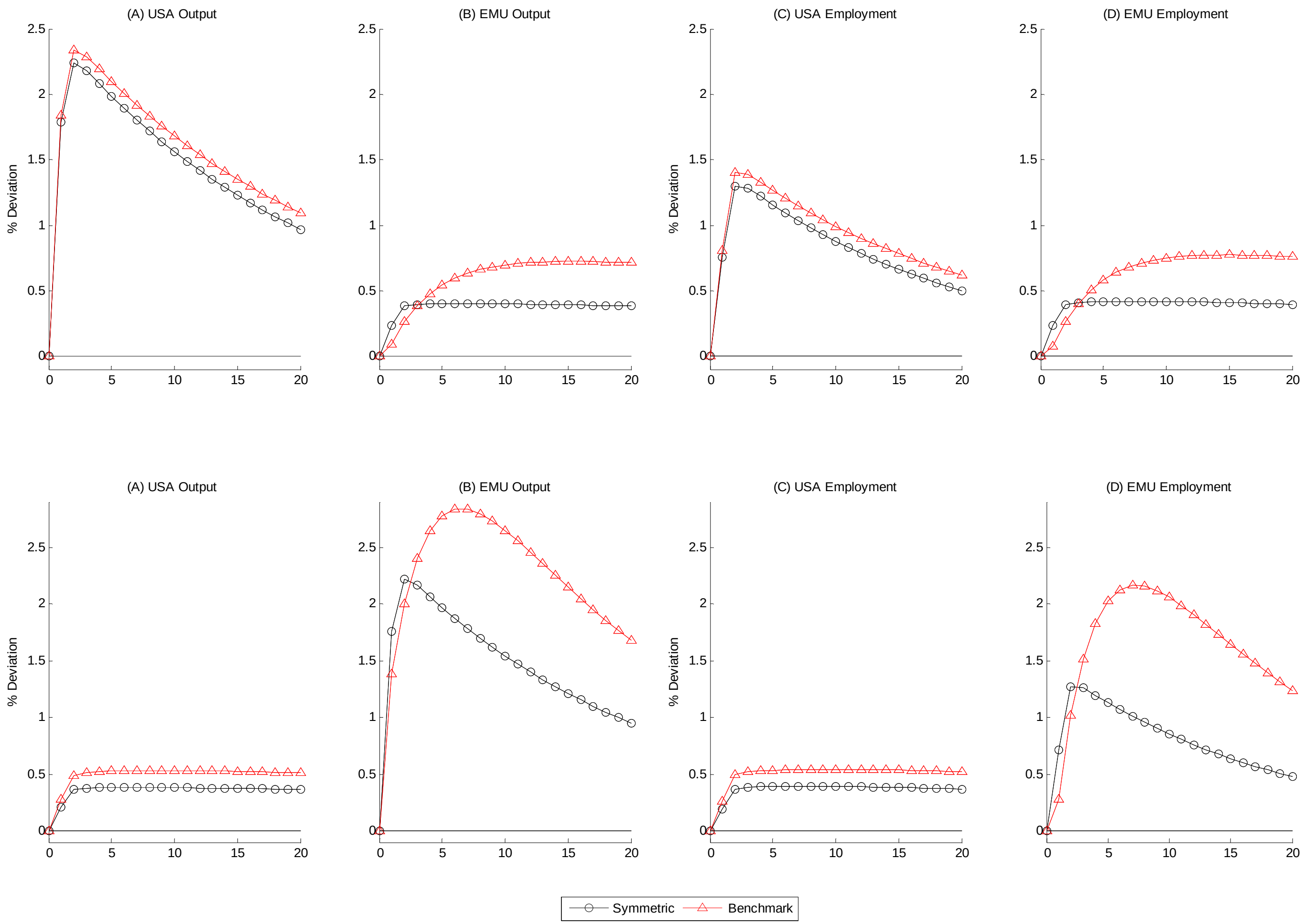


Figure 4 shows the dynamic response of output, Y_j, and employment, E_j, in each of the modeled *US* and *EZ* economies to a one standard deviation shock to the US and *EZ* markup level in period 1. The figure compares the response in the 1) Symmetric model with no firing cost in either economy; 2) Firing Costs model with higher deadweight losses from job separation in the *EZ* than in the US; 3) Hiring Inertia model with higher firing costs in the EMU and slow vacancy creation in both economies

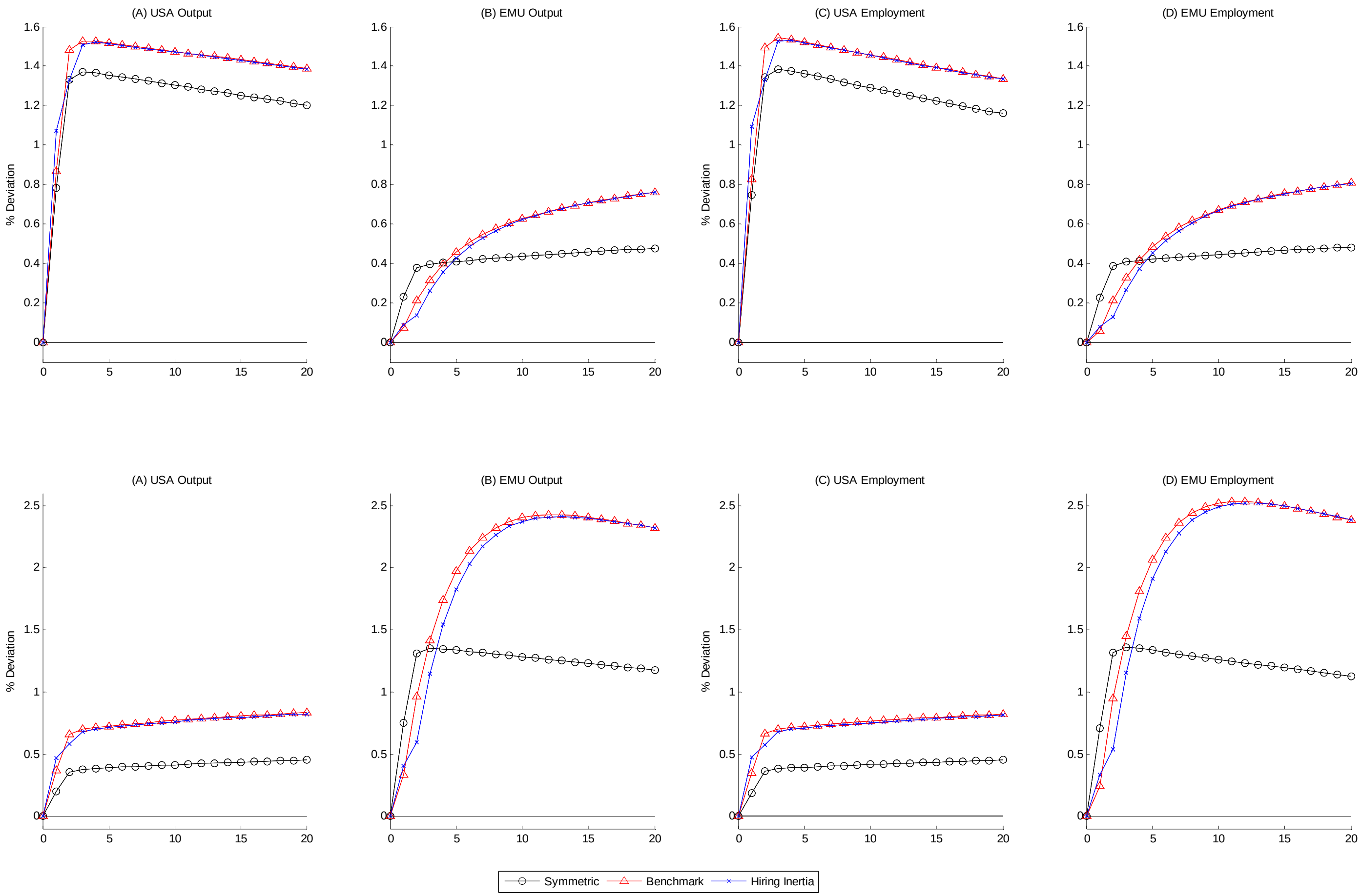


Table 1 Empirical Moments and Technology Shocks. This table describes the business cycle moments of the natural logarithm of quarterly, Hodrick Prescott filtered time series (generically X) from the USA and European Monetary Union including output (GDP), consumption (personal consumption expenditure), investment (gross fixed capital formation), unemployment (the Harmonized Unemployment rate), employment (thousands of persons), labor productivity (GDP per person employed) along with the trade balance as a share of GDP. Moments reported include the % standard deviation, the correlation of the variable with domestic GDP, and the cross-correlation of each variable of the EMU with its counterpart in the US. Data is measured over the period 1984-2007. The table also reports the corresponding simulated moments of % deviations from the steady state for the modeled *US* and *EZ* economies in the Symmetric and Benchmark model under technology shocks. Moments are averages over 1000 simulations of 100 periods each.

		Volatility		Correlation		Correlation between ($X_{t,US}$, X_{t+j})								
		(Std)		with GDP		Cross-Correlogram								
A. Data	***X***	*USA*	*EMU*	*USA*	*EMU*	*-4*	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*4*
Output	*Y*	0.97%	0.95%	1.00	1.00	-0.25	-0.14	0.00	0.15	0.28	0.34	0.39	0.45	0.47
Consumption	*C*	0.85%	0.80%	0.84	0.87	-0.13	-0.10	-0.05	0.06	0.11	0.14	0.18	0.24	0.24
Investment	*I*	3.07%	2.80%	0.93	0.94	-0.20	-0.10	0.00	0.12	0.24	0.30	0.35	0.37	0.42
Unemployment	*U*	9.61%	4.94%	-0.85	-0.88	-0.44	-0.29	-0.10	0.11	0.32	0.45	0.55	0.62	0.66
Employment	*E*	0.84%	0.69%	0.80	0.72	-0.09	-0.01	0.13	0.25	0.33	0.43	0.51	0.50	0.44
Productivity	Y/*E*	0.55%	0.54%	0.48	0.83	-0.13	-0.16	-0.24	-0.25	-0.26	-0.16	-0.10	-0.06	0.00
Trade Balance	% of Y	0.31%	0.44%	-0.44	-0.12	-0.11	-0.09	-0.05	-0.04	-0.02	-0.02	0.01	-0.02	-0.06
B. Symmetric		*US*	*EZ*	*USA*	*EZ*	*-4*	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*4*
Output	*Y*	0.99%	0.98%	1.00	1.00	0.02	0.07	0.14	0.23	0.29	0.24	0.15	0.08	0.03
Consumption	*C*	0.63%	0.62%	0.99	0.99	0.03	0.12	0.23	0.36	0.45	0.37	0.24	0.13	0.04
Investment	*I*	3.16%	3.13%	0.98	0.98	-0.01	-0.01	-0.01	-0.02	-0.01	-0.01	0.00	0.00	0.01
Unemployment	*U*	8.61%	8.47%	-0.98	-0.97	0.04	0.13	0.26	0.42	0.51	0.42	0.27	0.14	0.04
Employment	*E*	0.58%	0.57%	0.98	0.97	0.04	0.13	0.26	0.42	0.51	0.42	0.27	0.14	0.04
Productivity	Y/*E*	0.44%	0.44%	0.96	0.96	-0.01	-0.02	-0.02	-0.02	-0.01	-0.01	-0.01	0.00	0.00
Trade Balance	% of Y	0.22%	0.22%	-0.59	-0.58	-0.07	-0.25	-0.48	-0.77	-1.00	-0.77	-0.48	-0.25	-0.07
C. Benchmark		*US*	*EZ*	*US*	*EZ*	*-4*	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*4*
Output	*Y*	1.04%	1.12%	1.00	1.00	-0.03	0.03	0.11	0.20	0.29	0.30	0.27	0.22	0.16
Consumption	*C*	0.70%	0.86%	0.99	0.98	-0.03	0.04	0.14	0.27	0.38	0.41	0.37	0.30	0.22
Investment	*I*	3.45%	3.25%	0.98	0.98	-0.12	-0.14	-0.14	-0.11	-0.05	0.03	0.11	0.14	0.14
Unemployment	*U*	9.45%	7.70%	-0.98	-0.93	-0.07	0.01	0.12	0.26	0.41	0.48	0.46	0.38	0.29
Employment	*E*	0.64%	0.85%	0.98	0.93	-0.07	0.01	0.12	0.26	0.41	0.48	0.46	0.38	0.29
Productivity	Y/*E*	0.44%	0.45%	0.95	0.73	0.02	0.02	0.01	0.00	0.01	-0.02	-0.03	-0.03	-0.03
Trade Balance	% of Y	0.25%	0.25%	-0.57	-0.59	-0.14	-0.34	-0.57	-0.82	-1.00	-0.82	-0.57	-0.34	-0.14

Table 3. Markups Shocks. This table reports the moments of % deviations from the steady state for simulated time series (generically X) for the modeled *US* and *EZ* economies in the Symmetric and Benchmark model under markups shocks. Moments are averages over 1000 simulations of 100 periods each. The series includes output (*Y*), consumption (*C*), investment (*I*), unemployment (*U*), employment (*E*), labor productivity (*Y/E*) along with the trade balance as a share of GDP. Moments reported include the % standard deviation, the correlation of the variable with domestic GDP, and the cross-correlation of each variable of the model *EZ* economy with its counterpart in the *US*. The table also reports the associated simulated moments of % deviations from the steady state the Hiring Inertia model.

		Volatility (Std)		Correlation with GDP		Correlation between $(X_{t,US}, X_{t+j})$ Cross-Correlogram								
A. Symmetric	***X***	*US*	*EZ*	*US*	*EZ*	*-4*	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*4*
Output	*Y*	0.82%	0.82%	1.00	1.00	0.05	0.15	0.27	0.42	0.51	0.41	0.27	0.14	0.05
Consumption	*C*	0.46%	0.46%	0.90	0.89	0.10	0.27	0.49	0.75	0.85	0.74	0.48	0.26	0.10
Investment	*I*	2.59%	2.60%	0.99	0.99	0.03	0.08	0.15	0.24	0.30	0.23	0.15	0.08	0.03
Unemployment	*U*	12.28%	12.22%	-1.00	-1.00	0.05	0.15	0.27	0.43	0.51	0.42	0.27	0.14	0.05
Employment	*E*	0.83%	0.83%	1.00	1.00	0.05	0.15	0.27	0.43	0.51	0.42	0.27	0.14	0.05
Productivity	Y/*E*	0.03%	0.03%	-0.44	-0.33	-0.02	0.00	0.05	0.13	0.47	0.06	0.01	0.00	0.00
Trade Balance	% of Y	0.14%	0.14%	-0.48	-0.48	-0.08	-0.27	-0.52	-0.83	-1.00	-0.83	-0.52	-0.27	-0.08
B. Benchmark		*US*	*EZ*	*US*	*EZ*	*-4*	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*4*
Output	*Y*	0.95%	1.05%	1.00	1.00	-0.07	0.02	0.14	0.30	0.46	0.52	0.49	0.41	0.30
Consumption	*C*	0.69%	0.82%	0.93	0.91	-0.16	-0.06	0.07	0.26	0.49	0.70	0.73	0.66	0.53
Investment	*I*	3.37%	2.81%	0.96	0.97	-0.22	-0.21	-0.17	-0.09	0.06	0.27	0.39	0.41	0.38
Unemployment	*U*	14.28%	10.24%	-1.00	-1.00	-0.08	0.01	0.12	0.28	0.44	0.52	0.49	0.42	0.31
Employment	*E*	0.96%	1.13%	1.00	1.00	-0.08	0.01	0.12	0.28	0.44	0.52	0.49	0.42	0.31
Productivity	Y/*E*	0.03%	0.09%	-0.37	-0.77	-0.11	-0.12	-0.12	-0.08	0.26	0.15	0.09	0.05	0.02
Trade Balance	% of Y	0.20%	0.21%	-0.51	-0.49	-0.10	-0.29	-0.53	-0.81	-1.00	-0.81	-0.53	-0.29	-0.10
C. Hiring Inertia		*US*	*EMU*	*US*	*EZ*	*-4*	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*4*
Output	*Y*	0.94%	1.01%	1.00	1.00	-0.11	-0.03	0.09	0.23	0.38	0.46	0.51	0.46	0.38
Consumption	*C*	0.68%	0.81%	0.93	0.90	-0.21	-0.13	-0.01	0.15	0.34	0.56	0.72	0.72	0.62
Investment	*I*	3.44%	2.79%	0.96	0.96	-0.26	-0.26	-0.24	-0.17	-0.05	0.15	0.35	0.44	0.44
Unemployment	*U*	14.09%	9.82%	-1.00	-1.00	-0.12	-0.04	0.07	0.20	0.36	0.45	0.51	0.47	0.39
Employment	*E*	0.95%	1.08%	1.00	1.00	-0.12	-0.04	0.07	0.20	0.36	0.45	0.51	0.47	0.39
Productivity	Y/*E*	0.02%	0.10%	-0.60	-0.78	-0.20	-0.24	-0.28	-0.20	-0.23	-0.17	-0.03	0.07	0.13
Trade Balance	% of Y	0.22%	0.22%	-0.56	-0.50	-0.10	-0.29	-0.54	-0.81	-1.00	-0.81	-0.54	-0.29	-0.09