

Merkl, Christian; Schmitz, Tom

**Working Paper**

## Macroeconomic volatilities and the labor market: first results from the euro experiment

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## **Working Papers**

**Kiel Institute  
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### **Macroeconomic Volatilities and the Labor Market: First Results from the Euro Experiment**

by Christian Merkl and Tom Schmitz

**No. 1511** | April 2009

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## **Macroeconomic Volatilities and the Labor Market: First Results from the Euro Experiment\***

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### Abstract:

This paper analyzes the effects of different labor market institutions on inflation and output volatility. The eurozone offers an unprecedented experiment for this exercise: since 1999, no national monetary policies have been implemented that could account for volatility differences across member states, but labor market characteristics have remained very diverse. We use a New Keynesian model with unemployment to predict the effects of different labor market institutions on macroeconomic volatilities. In our subsequent empirical estimations, we find that higher labor turnover costs have a statistically significant negative effect on output volatility, while replacement rates have a positive effect, both of which are in line with theory. Real wage rigidities do not seem to play much of a role. This result is in line with our employed labor market model, but stands in stark contrast to the search and matching model. While labor market institutions have a large effect on output volatility, they do not seem to have much of an effect on inflation volatility. Our estimations indicate that the latter is driven instead to a certain extent by differences in government spending volatility.

**Keywords:** Labor market institutions, macroeconomic volatility, monetary policy, firing costs, unemployment benefits, replacement rate.

**JEL classification:** E24, E32, J64

### **Christian Merkl**

Kiel Institute for the World Economy  
24100 Kiel, Germany  
Telephone: +49 431 8814 260  
E-mail: christian.merkl@ifw-kiel.de

### **Tom Schmitz**

Kiel Institute for the World Economy  
24100 Kiel, Germany  
E-mail: [Tom.Schmitz@mailhec.net](mailto:Tom.Schmitz@mailhec.net)

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# 1 Introduction

What are the effects of different labor market institutions on the volatility of macroeconomic variables (macroeconomic volatilities henceforth), such as inflation and output? With risk averse agents, the answer to this questions has important welfare and policy implications. It is highly relevant both for the (optimal) design of labor market institutions and for (optimal) fiscal and monetary policy.<sup>1</sup> There is a broad theoretical literature that touches this issue indirectly and a very recent empirical cross-country literature dealing with it more directly. However, so far there is no generally accepted view on the effect of labor market institutions on macroeconomic volatilities. We will argue below that the eurozone offers an unprecedented and so far largely unexplored experiment to analyze this question empirically.

The existing macro labor theory, which is centered around the search and matching model, indirectly touches the question how different labor market institutions affect macroeconomic volatilities. Hagedorn and Manovskii (2008) show that a high value of leisure (i.e., more generous unemployment benefits) increases the volatility of labor market variables in the search and matching model. Hall (2005) shows that real wage rigidities<sup>2</sup> also have a positive effect on the volatility of labor market variables.<sup>3</sup> These papers are very insightful from a theoretical point of view, but they do not tackle the empirical question whether labor market institutions actually affect macroeconomic volatilities, as predicted by the models.

There is a recent empirical cross-country literature (Abbritti and Weber (2008), Rumler and Scharler (2009)) that directly analyzes the effects of labor market institutions on macroeconomic volatilities. However, it suffers from two problems. (i) When two countries are hit by different macroeconomic shocks, macroeconomic volatilities would differ, even though they may have exactly the same labor market institutions. (ii) Even when two countries are hit by the same shocks and when they have the same labor market institutions, different monetary policy reactions may lead to completely different macroeconomic volatilities (see, e.g., Blanchard and Galí (2007b), and an illustrative example later in this paper).

We circumvent these two problems by making use of a natural experiment, the eurozone, whose members have substantially different labor market institutions. However, since 1999, the twelve founding states have been subject to the same monetary policy, and thus, differences in macroeconomic volatilities cannot be attributed to this factor. In addition, business cycles within the eurozone have shown a substantial synchronization. While there are countries like Ireland that have had a better growth performance, periods of high and low growth have been very similar in the entire eurozone.<sup>4</sup> Therefore, after 10 years of existence, the Eurozone provides an excellent opportunity, largely unexplored so far<sup>5</sup>, to learn more about the effects of

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<sup>1</sup>Further, it sheds more light on the question which institutions should be integrated into labor market and business cycle models.

<sup>2</sup>While unemployment benefits are clearly part of the labor market institutions of a country, this is not the case for real wage rigidities. However, other labor market institutions, such as unions or collective bargaining agreements, may be the driving force for real wage rigidities (in whichever direction). As there is no general agreement on the link between labor market institutions and real wage rigidities, we directly test for the effects of real wage rigidities on macroeconomic volatilities, thereby including them in our list of labor market institutions.

<sup>3</sup>This literature was initiated by Costain and Reiter (2008) and Shimer (2005). All these papers discuss the ability of the search and matching model to replicate the volatility of labor market variables (e.g., unemployment, vacancies and the job finding rate). In contrast, we focus on output volatility for empirical reasons. The quality of output data in the eurozone is much better than the quality of employment data (due to structural breaks, comparability problems, etc.). It can, however, be shown in our model simulations that labor market institutions have the same qualitative effects on employment and output volatilities.

<sup>4</sup>For instance, Benalal et al. (2006) write that while there remains some dispersion of real GDP growth rates, "the degree of synchronisation of business cycles across the euro area countries seems to have increased since the beginning of the 1990s, [and] the degree of correlation currently appears to be at an historic high" (p. 4).

<sup>5</sup>The only papers analyzing the impact of labor market institutions on macroeconomic fluctuations in a monetary union are Abbritti and Mueller (2007) and Campolmi and Faia (2006). However, the first paper

different labor market institutions. We are well aware that the euro experiment also suffers from some shortcomings, such as the short observation period and the limited number of member states. However, we think that our approach generates interesting new insights that can be tested in a more detailed manner once more data becomes available on both the time dimension and the admission of more countries to the eurozone.

We proceed in two steps: First, we use a New Keynesian model that contains a new type of labor market model (see Lechthaler et al., 2008), which has so far not been used for this type of question, to analyze the effects of labor market institutions on macroeconomic volatilities, namely those of inflation and output. We simulate a model economy to make theoretical predictions on the effects of firing costs (as they are known to be important in Europe<sup>6</sup>), unemployment benefit replacement rates, and real wage rigidities (as the latter two play an important role in the theoretical debate). Second, we show descriptive correlations between labor market institutions and macroeconomic volatilities, and we run cross-country regressions.

Our analysis delivers the following results. As predicted by economic theory, there is a negative and significant correlation between labor turnover costs and output volatility, and there is a positive correlation between the replacement rate and output volatility. However, this latter relationship is not as robust and sometimes depends on the definition used for the replacement rate. Real wage rigidities do not seem to play an important role for output volatility. The picture looks different for inflation volatility, where labor market institutions in general do not have a great explaining power. Our regression results indicate that this may be due to differences in government spending.

These results are important for several reasons: (i) They give us an idea which labor market institutions appear to matter most for macroeconomic volatilities. (ii) They provide important guidance in deciding which labor market institutions should be integrated into the fully fledged dynamic stochastic general equilibrium models that are used for fiscal and monetary policy analysis.

The rest of the paper is structured as follows: Section 2 shortly describes the underlying labor market model, used to analyze macroeconomic volatilities. Section 3 presents the simulation results, Section 4 presents and discusses the empirical strategy, and Section 5 briefly concludes.

## 2 Short Model Description

To illustrate the theoretical effects of labor market institutions on macroeconomic volatilities, we need to choose a model framework that is both suitable for business cycle analysis and rich enough to capture several labor market institutions. Therefore, we choose a standard New Keynesian sticky price model (to capture the business cycle dimension) which is enhanced by a labor market with heterogenous idiosyncratic productivities and labor turnover costs. The model details are laid out in Lechthaler et al. (2008) and Faia et al. (2009).<sup>7</sup> For brevity, we only show the labor market equations below because all other parts correspond to an absolutely standard New Keynesian business cycle model. The entire set of equations can be found in the Technical Appendix.

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does not contain an empirical part, and the second only focuses on the effects of replacement rates on inflation differentials.

<sup>6</sup>Blanchard and Wolfers (2000) show that the evolution of European unemployment can be explained by the interaction of shocks and labor market institutions. Among the latter, employment protection is significant in most of the cases. However, they only consider level effects and not the second moments. The role of labor turnover costs in macroeconomic models has recently been pointed out by Lechthaler et al. (2008) and Faia et al. (2009).

<sup>7</sup>For the model in partial equilibrium, see Snower and Merkl (2006).

## 2.1 The Labor Market

### 2.1.1 Idiosyncratic Shocks and Labor Turnover Costs

Intermediate goods firms (which sell their products to wholesale firms<sup>8</sup>) hire labor to produce the intermediate good  $Z$ . Their production function is

$$Z_t = A_t N_t, \quad (1)$$

where  $A$  is the level of technology and  $N$  is the number of employed workers. The parameter  $A$  is subject to temporary technology shocks with an autoregressive component  $\rho_a$ , and the standard deviation  $\mu_a$ . Intermediate goods producers are price takers in a perfectly competitive environment, and sell their products at the relative price  $MC_t = P_{z,t}/P_t$ , where  $P_z$  is the absolute price of the intermediate good and  $P$  is the economy's overall price level.<sup>9</sup>

We assume that every worker (employed or unemployed) is subject to an idiosyncratic operating cost shock,  $\varepsilon_t$ , at the beginning of the period, which can be interpreted as an idiosyncratic shock to workers' productivity or as a firm-specific idiosyncratic cost shock. The firms learn the value of the operating costs of every worker at the beginning of a period and base their employment decisions on this value, i.e., an unemployed worker associated with a sufficiently favorable shock will be employed, while an employed worker associated with a strong enough negative shock will be fired. However, hiring and firing is not costless. Firms have to pay linear hiring costs,  $H$ , and linear firing costs,  $F$ , both measured in terms of the final consumption good. These hiring and firing costs drive a wedge between the hiring decision and the firing decision. In their presence, the retention rate (i.e., 1 minus the firing rate) is always higher than the hiring rate (see Figure 2 in Lechthaler et al. (2008)).

Indeed, each worker generates the following profit:

$$\begin{aligned} \tilde{\Pi}_{I,t}(\varepsilon_t) &= A_t MC_t - W_t/P_t - \varepsilon_t \\ &+ E_t \sum_{i=t+1}^{\infty} \Delta_{t,i} \left[ \begin{array}{c} (1 - \phi_i)^{i-t} \left( \begin{array}{c} A_i MC_i - W_i/P_i - \\ E_t(\varepsilon_i | 1 - \phi_i) \end{array} \right) \\ - \phi_i F (1 - \phi_i)^{i-t-1} \end{array} \right], \end{aligned} \quad (2)$$

where  $\phi$  is the separation probability,  $E_t(\varepsilon_{t+1} | 1 - \phi_{t+1})$  the expected value of operating costs for an insider (i.e., conditional on retention), and  $\Delta_{t,i}$  the stochastic discount factor from period  $t$  to  $i$  (i.e., the subjective discount factor  $\beta$  weighted with the respective periods' marginal consumption utility).  $W/P$  is the real wage, which is determined in a Nash bargain between firm and employed workers (see below).

Unemployed workers are hired whenever their operating cost does not exceed a certain threshold (i.e., their idiosyncratic productivity realization is too small), such that the profitability of a worker is higher than the hiring cost, i.e.,  $\tilde{\Pi}_{I,t}(\varepsilon_t) > H$ . Thus, the hiring threshold,  $v_{h,t}$ , (the value of the operating cost at which the firm is indifferent between hiring and not hiring an unemployed worker) is defined by

$$\tilde{\Pi}_{I,t}(v_{h,t}) = A_t MC_t - W_t/P_t - v_{h,t} + E_t(\Delta_{t,t+1} \tilde{\Pi}_{I,t+1}) = H. \quad (3)$$

Unemployed workers whose operating cost is lower than this value are hired, while those whose operating cost is higher are not. The resulting hiring probability is given by

$$\eta_t = \Gamma(v_{h,t}), \quad (4)$$

<sup>8</sup>The wholesale firms face monopolistic competition and sticky prices (Calvo adjustment scheme).

<sup>9</sup> $MC$  is the marginal cost for the wholesale sector.

where  $\Gamma$  is the cumulative density function of  $\varepsilon$ .

The firm will fire a worker whenever  $\tilde{\Pi}_t(\varepsilon_t) < -F$ , i.e., when the operating costs are so high that it is more profitable for the firm to pay the cost of firing the worker. This defines the firing threshold,  $v_{f,t}$  (the value of the operating cost at which the firm is indifferent between firing and retaining the worker), as

$$\tilde{\Pi}_{I,t}(v_{f,t}) = A_t MC_t - W_t/P_t - v_{f,t} + E_t(\Delta_{t,t+1} \tilde{\Pi}_{I,t+1}) = -F. \quad (5)$$

Thus, the separation rate is

$$\phi_t = 1 - \Gamma(v_{f,t}). \quad (6)$$

We thus obtain the usual employment dynamics curve

$$n_t = n_{t-1}(1 - \phi_t - \eta_t) + \eta_t, \quad (7)$$

where  $n$  is the employment rate.

### 2.1.2 Wage Bargaining

The real wage is the outcome of a Nash bargain between the median worker and her firm, and is renegotiated in each period  $t$ . When both parties agree, the worker receives the real wage  $W_t/P_t$  and the firm receives the expected profit  $A_t MC_t - W_t/P_t - \varepsilon^I$  in each period  $t$ . When they disagree, the worker's fallback income is  $B_t$ , assumed for simplicity to be equal to the real unemployment benefit. The firm's fallback profit assumed to be equal to  $-S$ , which is the cost of not producing.<sup>10</sup> Consequently, the Nash-product is

$$\Lambda = (W_t/P_t - B_t)^\gamma (A_t P_{z,t} + S - W_t/P_t - \varepsilon^I)^{1-\gamma} \quad (8)$$

where  $\gamma$  represents the bargaining strength of the insider relative to the firm. Maximizing the Nash product with respect to the real wage, yields the following equation:

$$W_t/P_t = \gamma (A_t MC_t + S - \varepsilon_t^I) + (1 - \gamma) B_t. \quad (9)$$

Further details on the wage bargaining and the rest of the model can be found in Lechthaler et al. (2008) and Faia et al. (2009).

## 2.2 Monetary Policy

We assume that monetary policy follows a standard Taylor rule:

$$\left( \frac{1 + i_t}{1 + \bar{i}} \right) = \left( \frac{\pi_t}{\bar{\pi}} \right)^{\alpha_\pi} \left( \frac{Y_t}{\bar{Y}} \right)^{\alpha_y}, \quad (10)$$

where  $\pi_t$  is the gross inflation rate,  $\bar{\pi}$  is the central bank inflation target,  $Y_t$  is the actual output,  $\bar{Y}$  is the steady state output level, and  $\bar{i}$  is the steady state interest rate (for a given output and inflation level).

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<sup>10</sup>There may be a fixed cost of production or workers may impose a cost on the firm in case of disagreement.

## 2.3 Calibration

The quarterly probability,  $\theta$ , that prices will not be readjusted in the Calvo model is set to 0.75 (i.e., there is an average price duration of four quarters). The elasticity of substitution,  $\varepsilon$ , in the monopolistic sector is set to 10.

In our standard calibration, we set the values for labor market institutions to represent a typical eurozone country. Bargaining power,  $\zeta$ , is set to 0.5 and unemployment benefits,  $b$ , are set to 64% of a worker's average productivity (her annual productivity,  $A$ , is normalized to 1), i.e., to 70% of the wages. Linear hiring costs are 10% and linear firing costs are 60% of annual productivity (see Bentolila and Bertola (1990), Chen and Funke (2005)). The model is calibrated to represent the labor market flow rates of a typical continental European economy ( $\phi = 0.02$ ,  $\eta = 0.2$ ).<sup>11</sup> In the standard calibration, we assume no real wage rigidities. To illustrate the effects of different labor market institutions, we change the values for the firing costs, the unemployment benefits replacement rate, and real wage rigidities, keeping all other parameters constant.

A summary of all calibration values can be found in Table 1. For further details on the calibration strategy, see Lechthaler et al. (2008).

**Table 1: Parametrization**

$\beta$	0.99	$S$	0.2879	$\mu_a$	0.01	$\alpha_\pi$	1.5
$\sigma$	2	$F$	0.6	$\rho_a$	0.95	$\alpha_y$	0.125
$\varepsilon$	10	$H$	0.1	$E(\varepsilon)$	0	$\zeta$	0.5
$\theta$	0.75	$b$	0.64	$sd$	0.53	$A$	1

## 3 Simulation Results

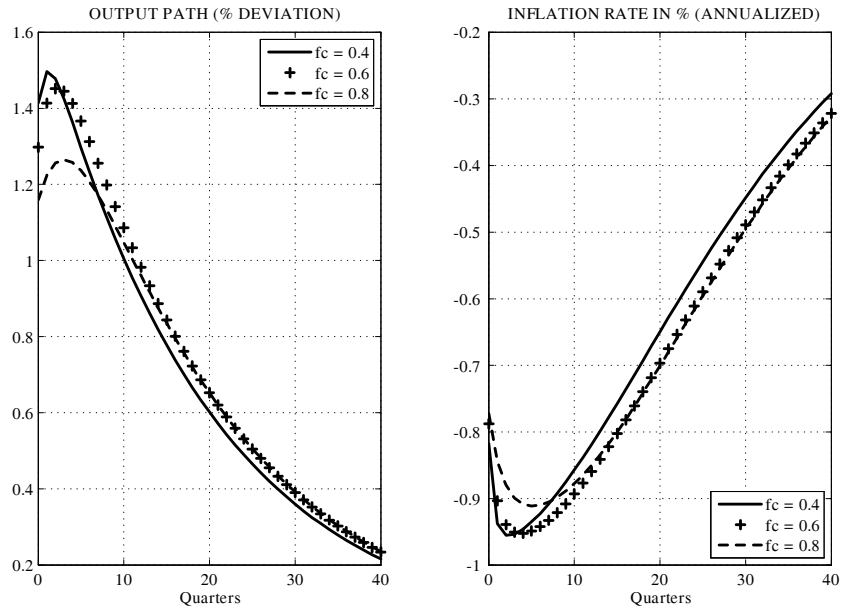
We use our benchmark calibration and conduct *ceteris paribus* analyses for three labor market institutions (firing costs, replacement rates and real wage rigidities) and different conducts of monetary policy. This means that we just vary one parameter, keeping all others constant, and that we analyze how this changes the impulse response functions and the Hodrick-Prescott (HP) filtered volatilities of output and inflation (to make the theoretical exercise comparable to the empirical exercise, we filter the simulated time series using  $\lambda = 1,600$ ). The simulations are based on 200 quarters. The shown volatilities are an average of 2,000 simulations. Standard errors are given in brackets. In all our exercises, the model economy is subject to productivity shocks with an autocorrelation of 0.95.

### 3.1 Different Firing Costs

In addition to our standard calibration, we also set firing costs (FC) to 0.4 and 0.8, keeping all other parameters values constant. Visual inspection of the impulse response functions (see Figure 1) shows that higher firing costs clearly reduce the volatility of output. The mechanism involved is straightforward. Higher firing costs reduce labor market flows (both hiring and

<sup>11</sup>A logistic distribution is chosen for the idiosyncratic operating cost shock. The mean,  $E(\varepsilon)$ , is normalized to zero. The dispersion of the distribution,  $sd$ , and the fall-back option of the firm under disagreement,  $-S$ , are chosen to obtain the desired flow rates (see Wilke (2005) for the labor market flow rates).





**Figure 1: Impulse Response Functions for Different Firing Costs ( $FC = 0.4, 0.6, 0.8$ ).**

firing). Therefore, an economy with higher firing costs reacts in a more sclerotic manner: both the initial job creation in reaction to a positive shock and the rate at which the output path declines slows down. The picture for the inflation rate is less clear. However, the HP filtered volatilities (see Table 2) show that we should expect inflation volatility to decrease as rising firing costs rise.

**Table 2: Volatilities for Different Firing Costs**

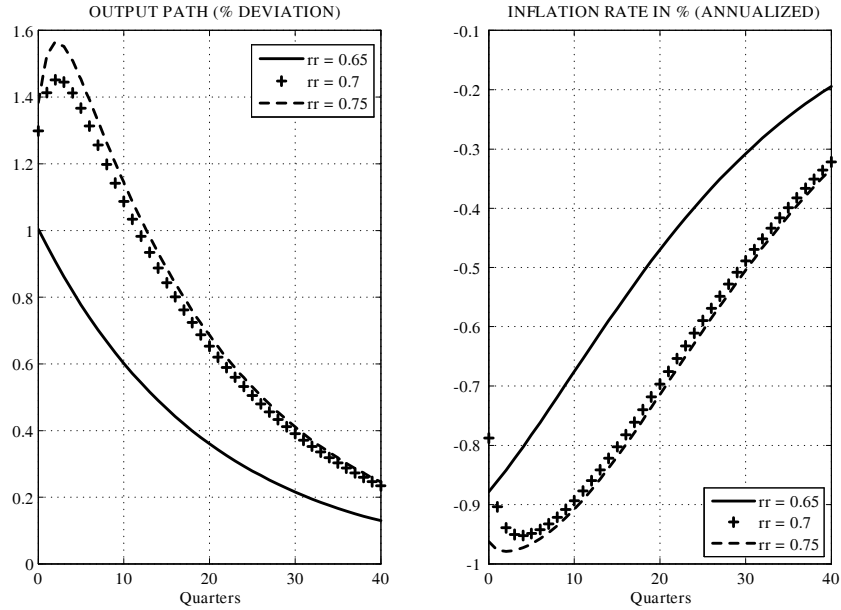
Volatilities	FC=0.4	FC = 0.6	FC = 0.8
$\pi$	0.69 (0.08)	0.65 (0.08)	0.54 (0.07)
$Y$	2.01 (0.22)	1.94 (0.21)	1.58 (0.19)

(All volatilities are reported as logs in deviations from a HP filter ( $\lambda = 1,600$ ). The table shows the averages and, in brackets, the standard deviations across 2,000 model simulations.)

### 3.2 Different Replacement Rates

In addition to our standard calibration, we also set the unemployment replacement rate (RR) to 0.65 and 0.75, keeping all other parameters values constant. As shown in Figure 2, the impulse response functions indicate that higher unemployment benefit replacement rates (measured as the unemployment benefits divided by the wage in the steady state) increase the volatility of inflation and output. This can also be clearly seen in Table 3. In our model, higher unemployment benefits increase workers' fallback position, raising the wage in the economy. Thus, higher unemployment benefits increase job destruction and reduce job creation. These two effects pull in different directions (the former makes the labor market more fluid, while the latter has the opposite effect). Our numerical result, which is based on a typical eurozone country, indicates that we should expect higher volatilities of inflation and output in countries of the eurozone with higher replacement rates.

This is in line with Hagedorn and Manovskii (2008). However, both their model and their calibration strategy are different from ours. They use a search and matching model, and in their



**Figure 2: Impulse Response Functions for Different Replacement Rates ( $RR = 0.65, 0.7, 0.75$ ).**

calibration, they increase the value of leisure while reducing the bargaining power (compared to the standard calibration by Shimer (2005)).<sup>12</sup> As a consequence, wages are less responsive to productivity shocks than under the standard calibration, the firm captures a larger part of the surplus and the job creation becomes more volatile.

**Table 3: Volatilities for Different Unemployment Benefits**

Volatilities	RR = 0.65	RR = 0.7	RR = 0.75
$\pi$	0.52 (0.05)	0.65 (0.08)	0.82 (0.09)
$Y$	1.28 (0.12)	1.94 (0.21)	2.09 (0.23)

(All volatilities are reported as logs in deviations from a HP filter ( $\lambda = 1, 600$ ). The table shows the averages and, in brackets, the standard deviations across 2,000 model simulations.)

### 3.3 Different Degrees of Real Wage Rigidities

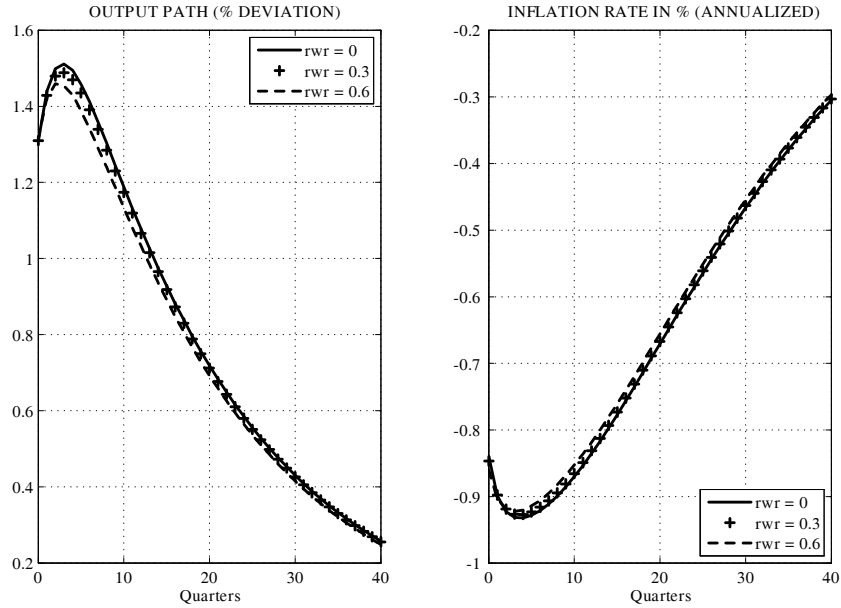
We specify real wage rigidities, as laid out in Blanchard and Galí (2007a):

$$W_t/P_t = \alpha (W_{t-1}/P_{t-1}) + (1 - \alpha) (W_t^B/P_t), \quad (11)$$

where  $W_t^B/P_t$  is the bargaining solution from the Nash bargain. If  $\alpha > 0$ , the wage depends not only on the bargaining solution, but also on its past values. In our simulations, we use three different values for  $\alpha$  (0, 0.3, 0.6).

As can be seen in Figure 3, the impulse response functions do not show much of a difference under different real wage rigidities. The numerical results (see Table 4) indicate that if there is any effect, macroeconomic volatilities should be dampened by higher real wage rigidities.

<sup>12</sup>We did not reduce the bargaining power because it is unclear whether countries with higher replacement rates have systematically different bargaining power. Thus, our theoretical exercise is more in line with our cross-country estimations below.



**Figure 3: Impulse Response Functions for Different Real Wage Rigidities.**

This stands in stark contrast to Hall (2005) who increases the volatility of employment using a real wage rigidity. The intuition in the search and matching model is straightforward: when the wage reacts in a less volatile way to productivity shocks, a larger part of the surplus goes to the firm. Thus, the job creation is more procyclical and the economy becomes more volatile.

In our model, both current and future wages affect the expected profits a worker generates for the firm (see equation 2) and therefore the current hiring and firing rates (see equations 4 and 6). When the economy faces a positive shock, a real wage rigidity reduces the rise in current wage costs. However, the real wage also returns to the steady state more slowly, and, thus, future wage costs are increased. Therefore, the overall impact of real wage rigidities on macroeconomic volatilities is not clear analytically. Our numerical simulation indicates that it can be expected to be small. When we take the standard errors into account, the different volatilities in the model simulation are not statistically different from one another. Thus, we hypothesize that real wage rigidities have no effect on macroeconomic volatilities.

**Table 4: Volatilities for Different Real Wage Rigidities**

Volatilities	RWR = 0.0	RWR = 0.3	RWR = 0.6
$\pi$	0.65 (0.08)	0.64 (0.08)	0.64 (0.07)
$Y$	1.94 (0.21)	1.91 (0.21)	1.87 (0.20)

(All volatilities are reported as logs in deviations from a HP filter ( $\lambda = 1,600$ ). The table shows the averages and standard deviations across 2,000 model simulations.)

### 3.4 Different Monetary Policy Rules

Table 5 shows the volatility of model economies with the same productivity shocks and the same labor market institutions, but different weights on inflation in the Taylor rule. It shows that different monetary policy rules change volatilities substantially, potentially reversing the impact of different labor market institutions. Therefore, we consider the eurozone to be particularly

suitable for a case study, as all the countries in this case are subject to the same monetary policy.

**Table 5: Volatilities for Different Weights on Inflation**

<b>Volatilities</b>	$\alpha_\pi = 1.5$	$\alpha_\pi = 2.5$	$\alpha_\pi = 3.5$
$\pi$	0.65 (0.08)	0.23 (0.03)	0.15 (0.02)
$Y$	1.94 (0.21)	2.19 (0.25)	2.24 (0.26)

(All volatilities are reported as logs in deviations from a HP filter ( $\lambda = 1, 600$ ). The table shows the averages and in brackets the standard deviations across 2,000 model simulations.)

## 4 Empirical Strategy

### 4.1 Indicators and Data Sources

#### 4.1.1 Macroeconomic variables

Our empirical analysis of the eurozone covers 11 countries<sup>13</sup> and a time span of nearly ten years, from the first quarter of 1999 to the second quarter of 2008. Just like in the simulations above, we focus on the movements of output and inflation<sup>14</sup>, on a quarterly basis.

Output is measured using real GDP, taken from the IFS (Issue 10/2008), and inflation is measured using the GDP deflator<sup>15</sup> from the same database. All time series are seasonally adjusted. To assess the cyclical behavior of output, we consider the output gap, i.e., the percentage deviation of the time series from its trend, calculated using an HP filter (with  $\lambda = 1, 600$ ). For inflation, we simply consider the cyclical component of the series (the difference between the series and its trend, computed using the same filter).<sup>16</sup> Volatility is defined as the standard deviation of these two cyclical measures.

#### 4.1.2 Labor Market Institutions

We use the OECD’s (2004) employment protection legislation measure (EPL) to model labor turnover costs (LTC). This index is calculated as a weighted average of measures for the protection of regular workers against individual dismissals, requirements for collective dismissals, and regulation of temporary employment. Compared with other measures, such as the employment legislation index created by Botero et al. (2004), or the hiring and firing costs calculated in the World Bank’s “Doing Business” studies (2008), the EPL both covers a larger range of relevant aspects of LTC and is computed in a more precise and differentiated way. The OECD published EPL figures only once in our observation period, for the year 2003.

The generosity of unemployment benefits can be measured by replacement rates, which are also established by the OECD (2007). It defines the net replacement rate (NRR) as the ratio between net income while out of work and net income while in work. By taking a simple average of the NRR over 60 months of unemployment, for four different family types, and two different

<sup>13</sup>The 12 founding members, excluding Luxembourg, due to a lack of labor market indicators.

<sup>14</sup>Employment fluctuations have also been considered. However, the data is less reliable due to more structural breaks and changes in the unemployment definitions.

<sup>15</sup>The GDP deflator is more in line with the theoretical framework than the CPI, because the former only includes domestically produced goods, i.e., goods that are subject to domestic price rigidities.

<sup>16</sup>The inflation gap may be indefinite if the trend is equal to zero. Therefore, we do not choose percentage deviations. However, our theoretical predictions would be unaffected by this transformation.

income levels, a “synthetic overall measure of the generosity of benefits relative to net earnings” (OECD (2007), p. 99) is obtained. This measure is calculated in two specifications, (with and without taking into account social assistance) and has been published yearly since 2001. Previously, the OECD had also established a gross replacement rate (GRR), covering a much longer time period (1961–2005). Computed similarly to the NRR, it neglected nevertheless a certain number of elements, such as taxes or family-related benefits, and should therefore be less precise. For our analysis, we thus retain the NRR (including social assistance), but we also consider the GRR, for comparison and robustness purposes.

For the NRR (and the EPL), we use their values in 2003. For the GRR, we use the simple average of its values in the period 1999–2005<sup>17</sup>.

The measures we use to assess real wage rigidities (RWR) are of our own design and based on Eurostat (2008) data on hourly wages and salaries for all industry and service sectors, excluding public administration. These data are seasonally adjusted and deflated. As we can only calculate proxies for real wage rigidity, we calculate two measures to test for robustness. The first measure is completely atheoretical: we compute the volatility of real wages (RWV), defined as the standard deviation of a real wage gap (calculated analogously to the output gap). The second measure (real wage rigidity measure, RWRM) is model-based<sup>18</sup> and computed using the following equation, taking the estimated value of the parameter  $\beta_1$  as a proxy for real wage rigidity.

$$w_t = \beta_0 + \beta_1 w_{t-1} + \beta_2 c_t + \beta_3 u_t + \beta_4 a_t + \varepsilon_t, \quad (12)$$

where  $w$  is the cyclical component of the real wage,  $c$  is the cyclical component of consumption,  $u$  is the cyclical component of unemployment, and  $a$  is the cyclical component of productivity.<sup>19</sup> This measure is based on theory and, unlike RWV, isolates the effects of productivity shocks. However, it has two shortcomings. First, for some countries, the parameter  $\beta_1$  is not significant. Second, the theoretical measure may be misspecified. To address the first issue, we have also conducted all the estimations below when setting RWRM in all countries with a non-significant parameter<sup>20</sup> equal to zero. This did not affect our results. The second issue is the reason why we also use the purely atheoretical RWV.

### 4.1.3 Control variables

As labor market institutions are of course not the only possible source of differences in macroeconomic volatilities, we choose a set of control variables. Following the choices made by Rumler and Scharler (2009), we choose the average real GDP per capita, the volatility of government expenditure, the volatility of terms of trade, the volatility of import prices, union density and the coordination of the wage-setting process. Additionally, we also take into account the average quarterly growth rate, the average real GDP (to control for size effects), and the average quarterly inflation rate.

Data sources and details on the computation of the control variables, as well as more precise information on all macroeconomic and labor market variables can be found in the Appendix.

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<sup>17</sup>Using the GRR’s value in 2003 does not affect the results. In fact, with the exception of the Netherlands, countries’ GRR is almost stable during the period under consideration.

<sup>18</sup>We take the typical labor supply equation in Real Business Cycle models or New Keynesian models as our reference point.

<sup>19</sup>Consumption data was taken from the IFS, while unemployment and productivity were taken from Eurostat. All cyclical measures are expressed as percentage deviations from the trend.

<sup>20</sup>At a 10% significance level,  $\beta_1$  is not significant for Italy, Portugal, and the Netherlands.

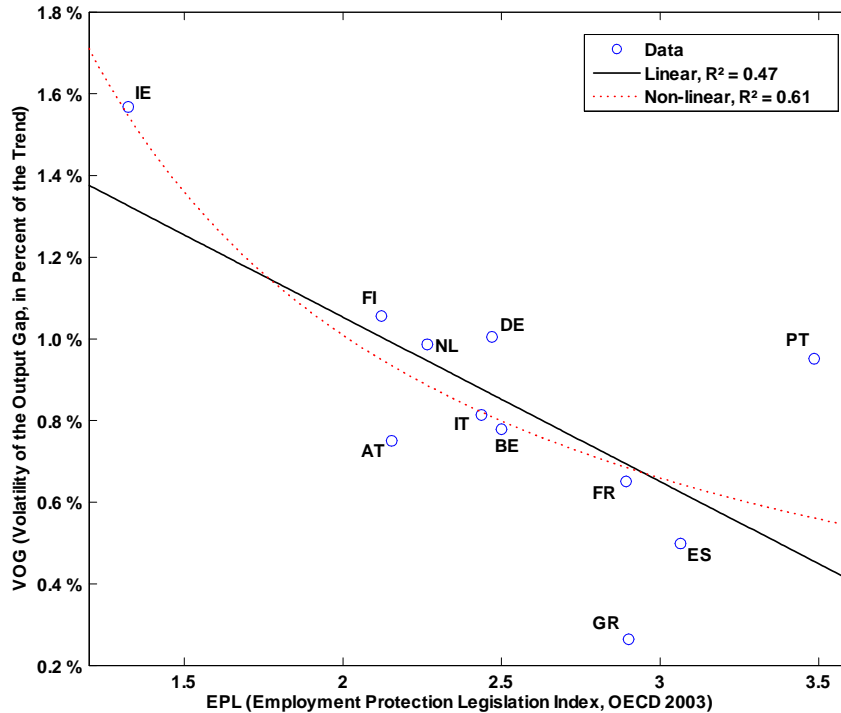


Figure 4: EPL and the Volatility of the Output Gap

## 4.2 Descriptive Statistics

### 4.2.1 Output Volatility

Before looking at the joint impact of labor market institutions on output volatility, individual correlations may already yield some indications of their explaining power.

As Figure 4 shows, we find that there is a negative correlation between the EPL index and the volatility of the output gap (VOG). Member states with stronger employment protection (and thus, with higher labor turnover costs) have less volatile output fluctuations, a finding that is in line with the theoretical model. Indeed, when estimating a linear model via ordinary least squares, we find a negative coefficient, significant at the 5 % level. Further, we examine whether there is a nonlinear relationship between the two variables, by also testing a quadratic and a hyperbolic relationship (i.e., using  $EPL^2$  or  $\frac{1}{EPL}$  as explaining variable). We find that the latter performs considerably better than the linear model: its explanatory power is greater, and the significance increases to 1%. This functional form is also more realistic, as volatility now approaches a lower bound when the EPL becomes very high, and does not become zero or even negative, as it would be the case with a linear relation.

Figure 5 shows that there is a positive, but relatively weak (significant only at the 10% level) linear relationship between NRR and VOG. Again, this result is in line with theoretical expectations. Here also, there may be a case for using a nonlinear model: we use a quadratic and a hyperbolic model, as for the EPL above, and find that the quadratic one performs best, yielding a significant relationship at the 5% level. This model would again reflect that volatility could not fall beneath a certain lower bound. When using the alternative replacement rate measure, the GRR, there is no significant relationship with VOG at all (neither linear nor nonlinear).<sup>21</sup>

<sup>21</sup>Figures for GRR and RWV are available on request.

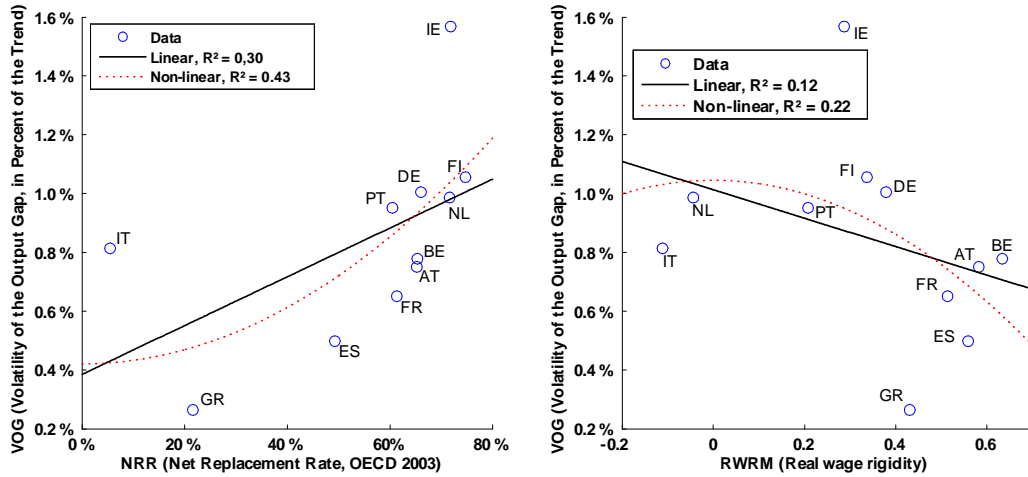


Figure 5: NRR, RWRM and the Volatility of the Output Gap

Figure 5 also shows that real wage rigidities do not seem to be able to explain output volatility. Indeed, both RWV and RWRM are insignificant in a linear and in a nonlinear model.

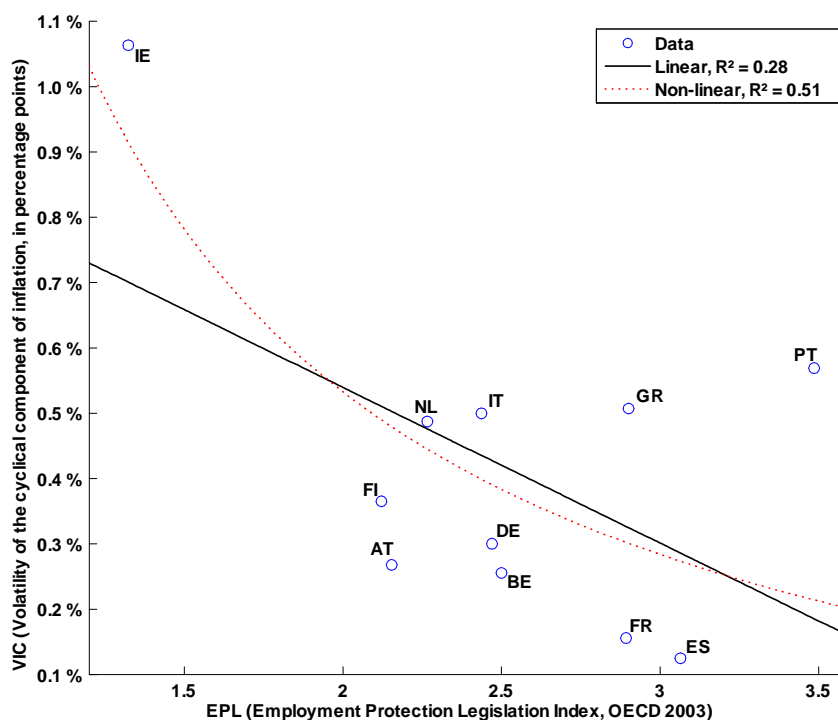
Finally, almost all the control variables are insignificant. The only exception is GDP per capita, which is significant at a 10% level and shows a positive correlation with VOG. This is contrary to conventional predictions, as in Beck et al. (2006), where the authors expect a negative sign.

All the individual results are summarized in Table 6 below. They indicate that labor turnover costs seem to have the best power to explain the differences in output volatility in the eurozone, while replacement rates have less power, and real wage rigidities appear to have no explaining power at all. However, these results need to be verified in a model with several explaining variables, that can take possible interactions into account.

Table 6

		Linear model				Nonlinear model				
Category	Variable	Const.	Coeff.	R <sup>2</sup>	R <sup>2</sup> (adj.)	Specific.	Const.	Coeff.	R <sup>2</sup>	R <sup>2</sup> (adj.)
LTC	EPL	1.859	-0.403**	0.47	0.42	$\frac{1}{EPL}$	-0.042	2.103***	0.61	0.56
RR	NRR	0.385	0.830*	0.30	0.22	NRR <sup>2</sup>	0.421	1.199**	0.43	0.37
	GRR	0.449	1.156	0.09	-0.01	$\frac{1}{GRR}$	1.214	-0.115	0.21	0.13
RWR	RWV	1.002	0.167	0.04	-0.07	RWV <sup>2</sup>	0.964	0.116	0.11	0.01
	RWRM	1.013	-0.483	0.12	0.03	RWRM <sup>2</sup>	1.045	-1.144	0.22	0.14
Controls	GDPPC	-0.238	0.042*	0.29	0.21	GDPPC <sup>2</sup>	0.209	0.001*	0.35	0.27

Explanations: \*\*\* significant at 1%, \*\* significant at 5%, \* significant at 10%. We tested a linear ( $VOG_i = \beta_0 + \beta_1 X_i + \varepsilon_i$ ), a quadratic ( $VOG_i = \beta_0 + \beta_1 X_i^2 + \varepsilon_i$ ) and a hyperbolic ( $VOG_i = \beta_0 + \beta_1 \frac{1}{X_i} + \varepsilon_i$ ) model for all variables. We only show the results for the more significant of the two nonlinear specifications. The coefficient of RWV has been multiplied by -1, so that it can be interpreted in the same way than the one of RWRM : both an increase in RWRM and in -RWV mean increasing real wage rigidity. Non-significant control variables are not shown.



**Figure 6: EPL and the Volatility of the Cyclical Component of Inflation**

#### 4.2.2 Inflation Volatility

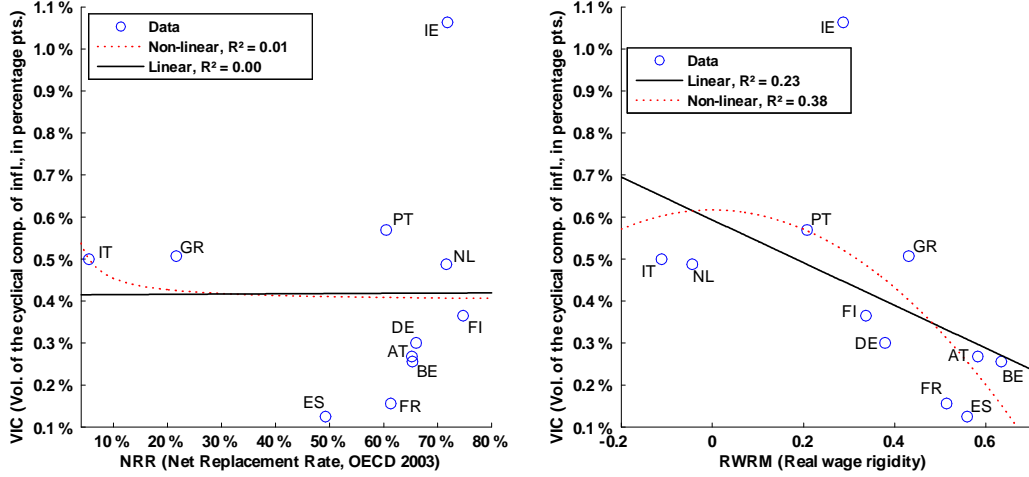
Analyzing the relationship between the EPL index and the volatility of the cyclical component of inflation (VIC), we find a negative correlation, as suggested by theory (see Figure 6). However, this result is weaker than the one found in the section above: in a simple linear model, EPL is only significant at the 10% level. Again, we find that a hyperbolic model performs considerably better, being significant at the 5% level. All in all, there is thus some evidence that a higher EPL lowers inflation volatility, even though the impact is probably less important than the one on output volatility.

When looking at replacement rates, there seems to be no viable relationship between them and inflation volatility. Both measures used are indeed highly insignificant, for linear and nonlinear models. Real wage rigidities, too, do not seem to be strongly correlated with VIC: the linear models for RWV and RWRM do not show significant results. In the nonlinear one, RWRM is however significant, at the 5% level: if this variable has any effect, it thus seems to lower inflation volatility (see Figure 7).

Finally, control variables seem to play a more important role than in the previous analysis: a higher average growth rate and a smaller size of the economy (as measured by real GDP) seem to be associated with higher inflation volatility, even if these correlations are generally not that strong. More importantly, volatility of government expenditure (VGE) seems to matter, a highly volatile fiscal policy being linked with higher inflation volatility. This relationship is significant at the 1% level, whether one considers a linear or a nonlinear model.

All the results are shown in Table 7. When considering these individual correlations, we may think of EPL as being the most important labor market variable for explaining inflation volatility differences, as it was already the case for output. As predicted by theory, the sense of the relation is identical: EPL lowers the volatility of both output and inflation, but its explaining power is lower for the latter. The other two labor market institutions, replacement





**Figure 7: NRR, RWRM and the Volatility of the Cyclical Component of Inflation**

rates and real wage rigidities, always never matter. Instead, inflation volatility seems to depend in an important way on the volatility of government spending. This last result thus appears to confirm similar findings in the literature, for instance in Rother (2004).

**Table 7**

Category	Variable	Linear model				Nonlinear model				
		Const.	Coeff.	R <sup>2</sup>	R <sup>2</sup> (adj.)	Specific.	Const.	Coeff.	R <sup>2</sup>	R <sup>2</sup> (adj.)
LTC	EPL	1.016	-0.238*	0.28	0.20	$\frac{1}{EPL}$	-0.214	1.495**	0.51	0.46
RR	NRR	0.415	0.006	0.00	-0.11	$\frac{1}{NRR}$	0.399	0.553	0.01	-0.10
	GRR	0.586	-0.487	0.03	-0.08	$\frac{1}{GRR}$	0.323	0.030	0.02	-0.08
RWR	RWV	0.231	-0.202	0.10	0.00	$\frac{1}{RWV}$	0.727	0.247	0.19	0.10
	RWRM	0.593	-0.509	0.23	0.15	RWRM <sup>2</sup>	0.617	-1.156**	0.38	0.31
Controls	GROWTH	0.131	0.422*	0.31	0.23	GROWTH <sup>2</sup>	0.248	0.300**	0.46	0.40
	GDP	0.522	-0.145	0.16	0.07	$\frac{1}{GDP}$	0.204	0.064*	0.41	0.34
	VGE	-0.042	0.350***	0.60	0.55	VGE <sup>2</sup>	0.172	0.121***	0.62	0.58

Explanations: \*\*\* significant at 1%, \*\* significant at 5%, \* significant at 10%. We tested a linear ( $VIC_i = \beta_0 + \beta_1 X_i + \varepsilon_i$ ), a quadratic ( $VIC_i = \beta_0 + \beta_1 X_i^2 + \varepsilon_i$ ) and a hyperbolic ( $VIC_i = \beta_0 + \beta_1 \frac{1}{X_i} + \varepsilon_i$ ) model for all variables. We only show the results for the more significant of the two nonlinear specifications. The coefficient of RWV has been multiplied by -1 (see Table 6), and non-significant control variables are not shown.

## 4.3 Estimations

### 4.3.1 Output Gap Volatility

In this section, we look at a more complete model, considering the joint impact of labor turnover costs, replacement rates, real wage rigidities, and control variables on the volatility of the output gap. This model has thus the form:

$$VOG_i = \beta_0 + \beta_1 LTC_i + \beta_2 RR_i + \beta_3 RWR_i + \beta_4 Control_i + \varepsilon_i \quad (13)$$

As we have two different measures for replacement rates (NRR and GRR), and two different measures for real wage rigidities (RWV and RWRM), this gives us four different models to

estimate. The limited amount of observations does not allow a large number of control variables. Thus, we choose to integrate only the variable that was significant in the individual analysis, i.e., GDP per capita (GDPPC).

The results for a linear specification of the explaining variables, and OLS estimation<sup>22</sup>, are shown in Table 8. All equations have been tested for heteroskedasticity (White test), which could always be rejected at the 1% level. The results show a significant overall fit for all four models, indicated by both the F-Statistic and the adjusted R<sup>2</sup>, the latter also showing that the fully specified models have greater explaining power than the individual ones.

EPL is the most important explanatory variable, being highly significant in all four specifications. As in the individual analysis, it is negatively correlated with VOG. An increase of the EPL by one standard deviation would lower output volatility by between 0.34 and 0.68 percentage points, showing that the variable is not only significant from a statistical, but also from an economic point of view.

The replacement rates, which were only moderately significant individually, are found to be significant in the overall model, and as predicted by theory, higher replacement rates are correlated with higher output volatility. Raising them by one standard deviation would imply an increase in output volatility by about 0.17 to 0.21 percentage points (for NRR) or 0.20 to 0.24 percentage points (for GRR). While lower than the one for EPL, this is still a significant economic impact.

**Table 8: Linear Results**

		<b>Model 1</b>	<b>Model 2</b>	<b>Model 3</b>	<b>Model 4</b>
	Constant	6.031532	6.171713	3.331385	5.581484
<b>LTC</b>	EPL	-1.017202***	-1.197825***	-0.596631**	-1.164796**
<b>RR</b>	NRR	0.782115**		0.960726**	
	GRR		2.284071**		2.706740**
<b>RWR</b>	RWV	0.374360*	0.176743		
	RWRM			-0.582518*	0.089063
<b>Control</b>	GDPPC	-0.104213**	-0.112663**	-0.050627	-0.106235**
	R <sup>2</sup>	0.84	0.85	0.85	0.82
	R <sup>2</sup> (adj)	0.73	0.74	0.74	0.70
	F-Stat.	7.93**	8.22**	8.19**	6.82**

Explanations: \*\*\* significant at 1%, \*\* significant at 5%, \* significant at 10%. The coefficient of RWV has been multiplied with -1 (see Table 6).

Real wage rigidity appears to have the least explaining power: it is only significant in half of the models, and only at a low level. Furthermore, when significant, the signs of RWV and RWRM are contradictory.

Finally, the control variable GDP per capita is significant in three out of four models. Interestingly, its sign is not the same as in the individual analysis. Here, we find instead that higher GDP per capita seems to be correlated with lower output volatility, a result that is in line with Beck et al. (2006).

However, even though those four models seem to be significant, we have seen above that a linear relationship between the explaining variables and VOG may not always be the most

<sup>22</sup>For robustness reasons, we also estimated all specifications (linear and nonlinear) with bootstrapping methods, namely, the residual bootstrap. We obtain qualitatively and quantitatively similar results (in terms of the estimated coefficients and significance levels). They are available on request.

appropriate specification. Therefore, we estimate all four equations again, for the nonlinear transformations of the explanatory variables used in 4.2.1. The results are shown in Table 9.

To a large extent, they confirm those of the linear models, indicating their robustness. EPL is again the most important variable, being highly significant in all four models, as a volatility-reducing factor.<sup>23</sup> Its economic impact is somewhat smaller than in the linear models (raising EPL by one standard deviation, starting from its mean value, lowers the volatility by between 0.13 and 0.22 percentage points). The results for replacement rates are statistically weaker, as the two measures are only borderline significant in half of the cases, but the sense of the relationship remains unchanged. The measures for real wage rigidities and the control variable are now insignificant in the majority of the models. In its only significant case, RWRM is negatively correlated with VOG.

**Table 9: Nonlinear Results**

		<b>Model 1</b>	<b>Model 2</b>	<b>Model 3</b>	<b>Model 4</b>
	Constant	0.133174	0.505444	0.149768	0.578383
<b>LTC</b>	$\frac{1}{EPL}$	2.759416***	2.947530***	1.691383*	2.453893**
<b>RR</b>	NRR <sup>2</sup>	0.812554*		0.892718**	
	$\frac{1}{GRR}$		-0.141537*		-0.116144**
<b>RWR</b>	RWV <sup>2</sup>	0.116198	-0.023336		
	RWRM <sup>2</sup>			-0.855410*	-0.608248
<b>Control</b>	GDPPC <sup>2</sup>	-0.000894*	-0.000680	-0.000268	-0.000418
	R <sup>2</sup>	0.86	0.84	0.88	0.89
	R <sup>2</sup> (adj)	0.77	0.73	0.79	0.81
	F-Stat.	9.21***	7.72**	10.57***	11.67***

Explanations: \*\*\* significant at 1%, \*\* significant at 5%, \* significant at 10%. The coefficient of RWV has been multiplied by -1 (see Table 6). The nonlinear specification used is the one found to be more significant in part 4.2.1. There was always at least one of the two nonlinear forms that was more significant than the linear one.

Before summing up these results, one should obviously have in mind that the available dataset is limited, both regarding the number of cross-sections included and the number of years considered for the volatility calculations. Therefore, our results should be seen as giving a first insight of the relative importance of the different variables, rather than a definitive conclusion. This first insight we obtain from our data suggests the following analysis: labor turnover costs, such as modeled by the EPL index, appear to be the most important labor market friction explaining the differences in output volatility in the eurozone. Indeed, in all the specifications of our model, EPL is statistically significant, and has a significant economic impact, higher EPL being correlated with lower volatility. Replacement rates also seem to have a (positive) impact on output volatility, even though it is weaker. Real wage rigidities do not seem to matter much.

These first empirical results from the eurozone offer important lessons also for the recent debate on the ability of labor market models to replicate labor market volatilities. Our empirical results on replacement rates would in principal be in line with Hagedorn and Manovskii's (2008) small surplus calibration, as higher replacement rates seem to increase macroeconomic volatilities. However, the results are at odds with real wage rigidities à la Hall (2005), as they do not seem to matter much in our setting (in line with the labor market framework we use). Furthermore, our analysis shows that labor turnover costs matter a lot within the eurozone.

<sup>23</sup>In the only equation in which EPL is not significant at 5%, its significance level is 5.3%.

Thus, business cycle models should take them into account when analyzing member states or the entire area.

### 4.3.2 Inflation Volatility

As in the previous section, we estimate a model of the following form:

$$VIC_i = \beta_0 + \beta_1 LTC_i + \beta_2 RR_i + \beta_3 RWR_i + \beta_4 Control_i + \varepsilon_i \quad (14)$$

As seen in the individual analysis, there are three control variables that show some significance, but because of the limited sample, we cannot integrate all three into the estimated equations. As volatility of government expenditure (VGE) is most significant individually, and dominates the other control variables in a joint regression<sup>24</sup>, we choose to use only this control variable.

The results for these equations are generally weak: replacement rate and real wage rigidity measures stay as insignificant as they were in the individual analysis, while the EPL index also becomes insignificant. Therefore, we do not show the results table.<sup>25</sup> In all equations, volatility of government expenditure remains the most important explaining variable, even though its significance level also drops. Regarding labor market institutions, we can thus say that the empirical evidence for the interaction between them and inflation volatility is quite weak. LTC seem to play some role, but while significant individually, their impact is quickly dominated by other variables in a regression with more explaining variables. Replacement rates and real wage rigidities do not seem to matter at all.

Indeed, our cross-country relationships point to the importance of the government spending volatility. Obviously, theory would predict that different government spending rules (or shocks) affect the volatility of output and inflation.<sup>26</sup> Similar to different monetary policy rules (see Section 3.4), there may be a larger effect of government spending on inflation volatilities than on output volatilities (the insignificance of the relation between government spending volatility and output volatility points into this direction). Therefore, it may be the case that different government spending behaviors reverse the effects of labor market institutions. This is an interesting issue, both theoretically and empirically, which we leave for future research.

## 5 Conclusion

This paper shows theoretically and empirically that labor turnover costs and replacement rates matter for output volatilities within the eurozone. The former has a dampening effect, while the latter increases output volatility. Real wage rigidities do not play an important role at all. Although the empirical results are based on a small dataset, they offer first insights into how heterogeneous labor market institutions act in a monetary union. This has important implications for the ability of labor market models to replicate macroeconomic volatilities and for the type of labor market institutions that should be integrated into business cycle models.

<sup>24</sup>When estimating the model  $VIC_i = \beta_0 + \beta_1 GROWTH_i + \beta_2 GDP_i + \beta_3 VGE_i + \varepsilon_i$ , only VGE is significant (at a 10% level), while the two other variables become clearly insignificant.

<sup>25</sup>Results are available on request.

<sup>26</sup>See Rother (2004) for the effect of government spending on inflation volatility.

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## 6 Technical Appendix

### 6.1 Theoretical Model

The model consists of the following equations:

$$\frac{1}{C_t^\sigma} = \beta E_t \left[ \left( \frac{P_t}{P_{t+1}} \right) (1 + i_t) \left( \frac{1}{C_{t+1}^\sigma} \right) \right], \quad (15)$$

$$W_t/P_t = \gamma (A_t MC_t - \varepsilon_t^I) + (1 - \gamma) B_t, \quad (16)$$

$$H_t = A_t MC_t - W_t/P_t - v_{h,t} + E_t(\Delta_{t,t+1} \tilde{\Pi}_{I,t+1}), \quad (17)$$

$$\eta_t = \Gamma(v_{h,t}), \quad (18)$$

$$-F_t = A_t MC_t - W_t/P_t - v_{f,t} + E_t(\Delta_{t,t+1} \tilde{\Pi}_{I,t+1}), \quad (19)$$

$$\phi_t = 1 - \Gamma(v_{f,t}), \quad (20)$$

$$E_t(\tilde{\Pi}_{I,t+1}) = E_t \left( \begin{array}{l} (1 - \phi_{t+1})(MC_{t+1}A_{t+1} - W_{t+1}/P_{t+1} - E_t(\varepsilon_{t+1}|1 - \phi_{t+1})) \\ + (1 - \phi_{t+1})\Delta_{t+1,t+2}E_{t+1}(\tilde{\Pi}_{I,t+2}) - \phi_{t+1}F_{t+1} \end{array} \right), \quad (21)$$

$$n_t = n_{t-1}(1 - \phi_t - \eta_t) + \eta_t, \quad (22)$$

$$\Xi_t^e = \frac{\int_{-\infty}^{v_h} \epsilon_t f(\epsilon_t) d\epsilon_t}{\eta_t}, \quad (23)$$

$$\Xi_t^i = \frac{\int_{-\infty}^{v_f} \epsilon_t f(\epsilon_t) d\epsilon_t}{1 - \phi_t}, \quad (24)$$

$$\frac{P_{i,t}}{P_t} = \left( \frac{\varepsilon}{\varepsilon - 1} \right) \left( \frac{\psi_t}{\phi_t} \right), \quad (25)$$

$$\psi_t = u_c(t) Y_t MC_t + \theta \beta E_t(\pi_{t+1}^\varepsilon \psi_{t+1}), \quad (26)$$

$$\varkappa_t = u_c(t) Y_t + \theta \beta E_t[\pi_{t+1}^{\varepsilon-1} \varkappa_{t+1}], \quad (27)$$

$$1 = \left[ \theta \pi_t^{\varepsilon-1} + (1 - \theta) \left( \frac{P_{i,t}}{P_t} \right)^{1-\varepsilon} \right]^{\frac{1}{1-\varepsilon}}, \quad (28)$$

$$C_t = Y_t - n_t \phi_t F_t - (1 - n_t) \eta_t H_t - (1 - \phi_t) n_t \Xi_t^i - (1 - n_t) \eta_t \Xi_t^e, \quad (29)$$

$$n_t A_t = s_t Y_t, \quad (30)$$

$$s_t = (1 - \theta) \left[ \frac{P_{i,t}}{P_t} \right]^{-\varepsilon} + \theta \pi_t^\varepsilon s_{t-1}, \quad (31)$$

$$\left( \frac{1 + i_t}{1 + \bar{i}} \right) = \left( \frac{\pi_t}{\bar{\pi}} \right)^{\alpha_\pi} \left( \frac{Y_t}{\bar{Y}_t} \right)^{\alpha_y}, \quad (32)$$

$$A_t = A_{ss}^{1-\rho_a} A_{t-1}^{\rho_a} e^{\mu t}. \quad (33)$$

## 6.2 Empirical Details

### 6.2.1 Macroeconomic Variables

There are two breaks in the IFS time series for real GDP and the GDP deflator. In Austria, a break in the first quarter of 2000 is notified in the database. In Belgium, there is no such indication, but in the first quarter of 2008, the time series evolve in a peculiar way (quarterly growth rate of over 13%, quarterly deflation rate of 9%) that is not matched by other data sources. Because of these breaks, our Austrian time series does not begin until the first quarter of 2000, and the Belgian one stops in the fourth quarter of 2007. Additionally, some countries did not report data for all the quarters of the observation period: thus, the year 1999 is missing for Greece, the second quarter of 2008 is missing for Portugal and the Dutch GDP Deflator, and the two first quarters of 2008 are missing for Ireland.

### 6.2.2 Labor Market Institutions

For the computation of the OECD's EPL index, the sub-indicator for the regulation of individual dismissals takes into account the associated procedural inconveniences, notice periods and severance pay for workers with a different number of years of service, and their possibilities for contesting dismissal and obtaining compensation and reinstatement. Collective dismissals are assessed by the scope of their legal definition and the additional requirements and costs they cause for employers. Finally, regulation of temporary contracts is measured by the range of jobs for which such contracts are legal, the restrictions on their renewal and their maximum cumulated duration<sup>27</sup>. Further information on the EPL indicators can be found in OECD (1999), where the index was first established.

Because it covers a large number of relevant aspects, the NRR appears to be the best indicator of the generosity of unemployment benefits. Nevertheless, Italy seems to be an outlier with this measure: even when including social assistance, replacement rates are extremely low (only 5.4% in 2003, driven by the long-term unemployed, who according to the OECD do not receive benefits at all). There is some evidence, laid out for example in Dhont and Heylen (2008)<sup>28</sup> that this figure does not capture the entire nature of the Italian social protection system. Thus, this is an additional reason for using the GRR as a robustness control. However, as results for the NRR and the GRR, at least in a model with several explaining variables, are very similar, the Italian case does not affect our main conclusions.

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<sup>27</sup>The associated weights are 5/12 for protection against individual dismissals and regulation of temporary employment, and 1/6 for protection against collective dismissals.

<sup>28</sup>Dhont and Heylen point out that "the gap between Italy and the other European countries is much smaller than it seems. Although unemployment benefits barely exist in Italy, this does not imply a zero fall-back position. Reyneri (1994) points to the importance of family support as an alternative to unemployment benefits. Furthermore, he emphasizes the existence of invalidity benefits as an additional mechanism of public transfers that the unemployed could receive."



### 6.2.3 Control Variables

Variable	Computation	Source
Average quarterly growth rate (GROWTH)	Simple average of the quarterly growth rates of real GDP, over the observation period.	IFS, Issue 10/2008 (i.e., the same series used to compute output volatility)
Average quarterly inflation rate (MEAN_INFL)	Simple average of the quarterly inflation rates, over the observation period.	IFS, Issue 10/2008 (i.e., the same series used to compute inflation volatility)
Average real GDP (GDP)	Simple average of the yearly real GDP, in US dollars and constant PPP, over the observation period. (1999–2007, except for Austria and Greece, where the observation period is 2000–2007 )	OECD (2008) (As the IFS figures are indexed to 100, they could not be used as size indicators)
Average GDP per capita (GDPPC)	Simple average of the yearly GDP per capita, in US dollars and constant PPP, over the observation period.	OECD (2008)
Volatility of Government Expenditure (VGE)	Standard deviation of a “government expenditure gap,” computed similarly to the output gap. Quarterly government expenditure is defined as the ratio real government expenditure/real GDP. The data covers the period from the first quarter of 1999 to the second quarter of 2008 and is seasonally adjusted. Two breaks (Ireland, first quarter 2000, and Austria, first quarter 2008) are left out.	Eurostat (2008), Quarterly National Accounts
Volatility of Terms of Trade (VOLTOT)	Standard deviation of a “terms of trade gap”, computed similarly to the output gap. Quarterly terms of trade are defined as the ratio between the deflator for exports and the deflator for imports of goods and services. Figures are seasonally adjusted and indexed to 100 in 2000. Data missing for Austria and Greece.	OECD (2009a)
Volatility of Import Prices (VOLIMP)	Standard deviation of the cyclical component of import prices. Quarterly import prices were calculated using the deflator for imports of goods and services, (seasonally adjusted, indexed to 100 in 2000) and detrended using a HP Filter, with $\lambda = 1,600$ . Data missing for Austria and Greece.	OECD (2009a)
Union Density (UNDENS)	Ratio of Union Membership relative to Total Employment, in 2001 (latest time point available for all Eurozone Countries).	OECD (2009b)
Wage-Setting Coordination (WSCOORD)	Index established by the OECD, increasing in the degree of coordination of wage negotiations. The exact definition and scales can be found in OECD (2004).	OECD (2004)