Exchange rates, employment and labour market rigidity

Fernando Alexandre* Pedro Bação† João Cerejeira‡ Miguel Portela§

July 7, 2010

Abstract

There is increasing evidence that the interaction between shocks and labour market institutions is crucial to understanding the dynamics of employment. In this paper, we show that the inclusion of labour adjustment costs in a trade model affects the impact of exchange rate movements on employment. We also explore how labour market rigidities interact with the degree of exposure to international competition and with the technology level. Our model-based predictions are consistent with estimates obtained using panel data for 23 OECD countries. Namely, our estimates suggest that employment in low-technology sectors that have a very high degree of openness to trade and are located in countries with more flexible labour markets are more sensitive to exchange rate changes. Our model and estimates therefore provide additional evidence on the importance of interacting external shocks and labour market institutions.

Keywords: exchange rates, international trade, job flows, employment protection.

JEL-codes: J23, F16, F41.

*Corresponding author: Escola de Economia e Gestão and NIPE, University of Minho, Campus de Gualtar, 4710-057 Braga, Portugal. Email: falex@eeg.uminho.pt.

†University of Coimbra and GEMF. Email: pmab@fe.uc.pt.

‡University of Minho and NIPE. Email: jccsilva@eeg.uminho.pt.

§University of Minho, NIPE and IZA. Email: mangelo@eeg.uminho.pt.

1 Introduction

Globalization has increased the exposure of open economies to external shocks. The almost instantaneous collapse of international trade in most developed and developing countries in the last quarter of 2008, caused by the international financial crisis, is an instance of how fast the transmission of shocks in the world economy can be. But the world economy has been afflicted by global shocks before. In the 1970s and in the 1980s, when the industrialized countries were hit by oil shocks and by the turbulence in exchange rate markets, following the demise of Bretton Woods, policymakers were vocal about the impact of external shocks on competitiveness. In the 1990s, exchange rates became less volatile and, as a result, exchange rate fluctuations caused only moderate and intermittent concerns. However, the first decade of the 21st century has revived concerns about exchange rate volatility, its effects on global trade and the need for international policy coordination. The rampant US trade deficit and China's surplus raised doubts about the exchange rate between the dollar and the renminbi. US policymakers have been accusing Chinese authorities of managing the exchange rate policy to keep the renminbi undervalued and boost China's exports. This type of argument received more attention following the international financial crisis, as governments sought to use the exchange rate to stimulate the economy (e.g., UK and US).

The political concern with foreign competition, in general, and exchange rates, in particular, may not be dissociated from the evolution of manufacturing employment in advanced economies. Between 1988 and 2006, manufacturing employment in OECD countries decreased from around 20% to 15% of total employment, according to the OECD STAN database. Nevertheless, trends in manufacturing employment have been very diverse across countries and sectors. The decrease in manufacturing employment was more pronounced in the US and in the UK, where it decreased, respectively, from 15.5% to 10.1% and from 18.8% to 10.4%. On the other hand, manufacturing employment in countries like Italy and Germany decreased only slightly, remaining close to 20% of total employment in 2007. When one looks at the evolution of manufacturing employment by technology level, using the OECD technology level classification, the conclusion is that low-technology sectors have been the most affected by the downward trend in manufacturing employment: their share in total manufacturing employment declined from 46.3% in 1988 to 39.7% in 2006.

However, policymakers and scholars — see, e.g., (Nickell 1997), (Nickell, Nunziata, Ochel, and Quintini 2002), (Blanchard 1999), (Blanchard and Wolfers 2000) and (Blanchard and Portugal 2001) — have come to realize that the economic impact of shocks, such as those that work through the exchange rate, depends on labour market institutions, among other factors.[1] This realization, together with a rapidly changing environment, due to increasing competition from emerging countries and to the acceleration in the pace of technological change, has led many to urge industrialized countries to reform labour markets, with a view to making them more flexible — these concerns have been specially strong in European countries. The European Commission, in particular, has rec-

[1](Calmfors and Driffill 1988) were among the first to discuss the implications of different labour market institutions for macroeconomic performance, namely the relationship between employment and the bargaining structure. (Driffill 2006) updates that study and surveys the recent literature on labour market institutions and macroeconomic performance.

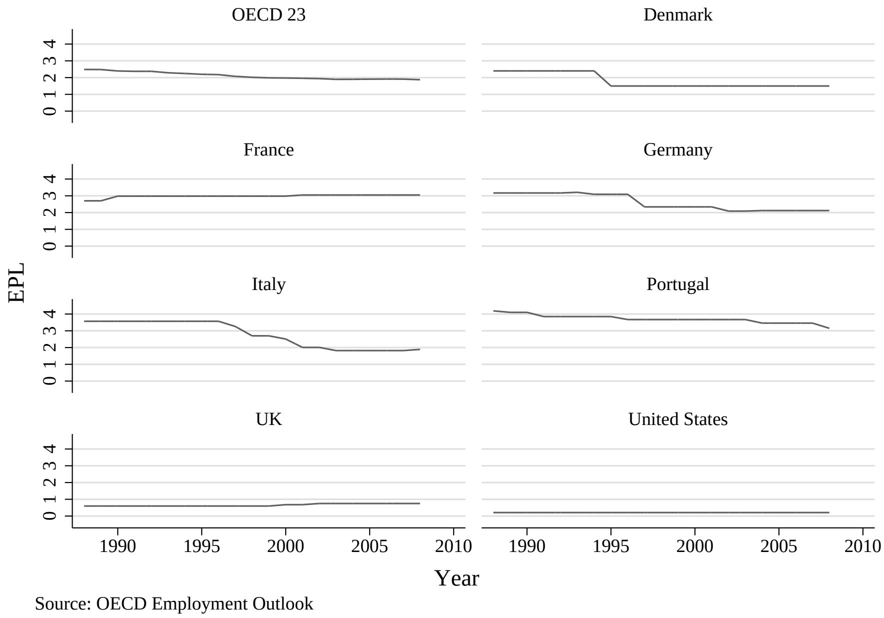

Figure 1: Employment Protection Legislation

ommended on several instances the reform of labour markets, namely of the excessively restrictive employment legislation, as a necessary condition for making the European Union the world's most competitive economy as stated in the Lisbon Strategy (see, for example, (European Commission 2003)). One measure of labour market rigidity is the OECD *EPL* index. As shown in Figure 1, in the last 20 years there has been a downward trend in this index: it decreased from 2.49, in 1988, to 1.91, in 2006, indicating an easing of hiring and/or firing conditions. France and the UK are among the exceptions; in these countries the *EPL* index has increased slightly in the period under analysis. Figure 1 also shows that countries with more stringent labour markets regulations, namely Germany and Denmark, converged to lower *EPL* index levels, from 3.17 and 2.4 in 1988 to 2.12 and 1.5 in 2006, respectively. However, the *EPL* index is still very diverse across countries, and despite the changes mentioned most countries have kept their relative positions, with the US, the UK and Canada appearing as the countries with the most flexible labour markets.[2]

The aim of this paper is thus to investigate, both theoretically and empirically, the impact of exchange rate shocks on employment and the relation between this impact and labour market institutions. Our approach brings together two strands of the literature on international trade. One is composed of the studies, mainly empirical, that find a significant effect, positively related to the degree of openness to trade, of exchange rate movements on employment (e.g., (Branson and Love 1988), (Revenga 1992), (Gourinchas 1999), (Campa and Goldberg 2001), and (Klein, Schuh, and Triest 2003)). The other is the new literature on international trade that builds on the seminal paper by (Melitz

[2]According to (OECD 2004) the regulation of temporary employment is crucial to understanding differences in EPL across countries.

2003) and highlights the relationship between international trade and productivity. A recent example of this literature is (Berman, Martin, and Mayer 2009), who add distribution costs to the Melitz model. By doing that, they are able to show that heterogeneity in productivity across firms produces differentiated price and output responses to exchange rate depreciations. Using the same framework, (Alexandre, Bação, Cerejeira, and Portela 2009b) go one step further and show how the degree of openness to trade and the level of productivity interact to determine the impact of exchange rate movements on employment.

On the theoretical front, the present text provides a link between these international trade models and the analysis of labour market institutions, and shows how labour market rigidities, alongside openness and productivity, mediate the impact of exchange rates movements on employment. The development of our theory rests on the introduction of labour market frictions, in the form of hiring and firing costs, in a trade model with heterogeneous firms and distribution costs of the type developed in (Berman, Martin, and Mayer 2009). Our results suggest that higher labour adjustment costs decrease the employment exchange rate elasticity, i.e., an increase in labour adjustment costs attenuates the impact of exchange rate movements on labour demand. In our model, this result is robust to different degrees of openness to trade, productivity and exchange rate persistence.

The themes of labour market institutions and international trade have already appeared together in the new trade literature following (Melitz 2003). For example, (Felbermayr, Prat, and Schmerer 2008) added wage bargaining and search frictions to the Melitz model. Even more recently, (Helpman and Itskhoki 2010) presented a two-sector version of the Melitz model that also includes wage bargaining and search frictions. However, the focus of these papers is on the comparative statics analysis of the economic implications of trade liberalization. In fact, the exchange rate is not even mentioned in such papers. We aim at filling part of this theory gap.

On the empirical side, we estimate the response of employment to exchange rate movements. We take into account the theoretical results and interact the exchange rate with measures of openness, productivity and labour adjustment costs. Our proxy for labour adjustment costs is the Employment Protection Legislation (EPL) index computed by OECD, which has previously been shown (see, among other, (Cingano, Leonardi, Messina, and Pica 2009)) to be related to labour adjustment costs. We use sector-level data from 23 OECD countries covering the years 1988-2006. The results seem to corroborate the predictions of the theoretical model: very open sectors, using a lower level of technology and facing less labour rigidity are more sensitive to exchange rate movements.

The remainder of the paper is organized as follows. In section 2 we develop a model of firm behavoiur featuring labour market rigidities that take the form of labour adjustment costs. Openness to international trade, technology and labour adjustment costs are shown to be relevant for understanding the relation between the exchange rate and employment. Section 3 presents econometric evidence on the effect of exchange rate changes on employment, in a panel of OECD countries, and its interaction with openness, technology and labour market rigidity. Section 4 concludes.

2 A trade model with labour adjustment costs

It has been shown (e.g., (Bertola 1990), (Bertola 1992)) that labour adjustment costs affect firms' optimal decisions, preempt an efficient allocation of resources and, in particular ((Bertola 1992), and (Hopenhayn and Rogerson 1993)), that labour adjustment costs imply lower job flows.[3] In this section we show that in an international trade model one manifestation of this sort of effect is that higher labour adjustment costs reduce the size of the labour demand elasticity with respect to the exchange rate. Our presentation follows (Melitz 2003) and (Berman, Martin, and Mayer 2009), but we introduce labour adjustment costs into the framework.

We start by describing the behaviour of the demand for the good that is exported. To simplify, we assume that the exporting firm only sells in market i. An alternative interpretation is that the revenues and costs associated with exporting to country i are separable from the rest of the firm's activities. We also assume, as is common in the related literature — namely, (Melitz 2003) and (Berman, Martin, and Mayer 2009) — and, more generally, in modern macroeconomics, that the firm is a monopolistic competitor. Therefore, the price and quantity the firm will set will depend on the size of a finite price-elasticity of demand for the good that the firm produces. In our interpretation of the model's implications, this elasticity will also represent the degree of openness of country i. The motivation for this interpretation is that, in a more open market, competition from similar goods produced by other exporters to market i will be more intense, i.e., the price-elasticity will be higher. Another paper that also makes this assumption explicitly is (Klein, Schuh, and Triest 2003).

2.1 Demand

We assume that the representative consumer in country i maximizes a standard intertemporal utility function:

$$U = E_0 \sum_{t=0}^{\infty} \theta^t u(C_{it}) \tag{1}$$

where θ is the discount factor.

The period utility flow is given by the Dixit-Stiglitz functional:

$$u\left(C_{it}\right) = C_{it} = \left[\int_{\Phi} x_{it}\left(\varphi\right)^{1-\frac{1}{\sigma}} \mathrm{d}\varphi\right]^{\frac{1}{1-\frac{1}{\sigma}}} \tag{2}$$

where σ is the elasticity of substitution between any two varieties (besides being the symmetric of the own price-elasticity) and $x_{it}(\varphi)$ is the consumption of variety φ, i.e., φ indexes, over the set Φ, the goods available to the consumer. Below, we will also use φ to represent the level of productivity of the firm that produces variety φ. Given the form of the utility function, the demand for variety φ will be given by:

$$x_{it}(\varphi) = C_{it}\left[\frac{p_{it}(\varphi)}{P_{it}}\right]^{-\sigma} \tag{3}$$

[3] These theoretical predictions have found empirical support in several studies — see, e.g., (Haltiwanger, Scarpeta, and Schweiger 2006) and (Gómez-Salvador, Messina, and Vallanti 2004).

For our purposes, we do not need to detail any more the behaviour of the representative consumer in country i. We will assume C_{it} to be an exogenous element in the firm's problem, to which we now turn.

2.2 Exporting firm

As we said before, the firm that produces variety φ, and exports it to country i, is a monopolistic competitor in country i, the sole destination of its output. The price that it charges in country i's currency ($p_{it}(\varphi)$) is given by:

$$p_{it}(\varphi) = \frac{p_t}{\varepsilon_{it}} + \eta_i w_{it} \tag{4}$$

where p_t is the period t price of the good in the domestic currency, ε_{it} is the period t price of a foreign unit of currency in units of the domestic currency, η_i are the distribution costs in country i, measured in units of country i's labour, and w_{it} is the wage in country i, in period t. The introduction of these distribution costs is the main innovation in (Berman, Martin, and Mayer 2009) relatively to the trade model proposed by (Melitz 2003). The presence of distribution costs makes the elasticities of demand for variety φ with respect to the price (p_t) and with respect to the exchange rate functions of σ and of other parameters in the model, as we shall see below.

As in the related literature, the production function is assumed to be linear in the labour input:

$$y_t(\varphi) = \varphi L_t \tag{5}$$

where φ, as mentioned above, is a measure of productivity. The production costs include labour costs (given the wage in the firm's country, w_t), fixed costs and labour adjustment costs:

$$c_t(\varphi) = w_t L_t + F_t(\varphi) + w_t A(\Delta L_t) \tag{6}$$

The focus of this paper is on labour adjustment costs, $w_t A(\Delta L_t)$. For $A(\Delta L_t)$ — labour adjustment costs measured in units of labour — we adopt the formulation proposed by (Pfann and Verspagen 1989):

$$A(\Delta L_t) = -1 + \exp(\beta \Delta L_t) - \beta \Delta L_t + \frac{\gamma}{2}(\Delta L_t)^2 \tag{7}$$

In this formulation, when $\beta \neq 0$, labour adjustment costs are asymmetric: if $\beta > 0$, then hiring costs are higher than firing costs; if $\beta < 0$, then the opposite is true. The other parameter, γ, reflects the symmetric component of the costs of adjusting labour.

The firm chooses how much to produce and sets the price so as to maximize its present value:

$$\max E_0 \sum_{t=0}^{\infty} \tilde{\delta}_t \left[p_t y_t(\varphi) - c_t(\varphi) \right] \tag{8}$$

where $\tilde{\delta}_t$ is the current period discount factor for the cash flow in period t. To simplify the derivations below, we shall assume that $\tilde{\delta}_t = \delta^t$.

Given our setup, the optimal choices for price and quantity are given by:

$$p_t = \frac{\sigma}{\sigma - 1} \left(1 + \frac{q_{it} \eta_i \varphi}{\sigma} + B_t \right) \frac{w_t}{\varphi} \tag{9}$$

and

$$y_t = C_{it} P_i^{\sigma} w_{it}^{-\sigma} \left(\frac{\sigma - 1}{\sigma} \right)^{\sigma} \left(\frac{1 + B_t}{q_{it}\varphi} + \eta_i \right)^{-\sigma} \tag{10}$$

where

$$q_{it} = \frac{\varepsilon_{it} w_{it}}{w_t} \tag{11}$$

denotes the real exchange rate and B_t includes current and future marginal costs of adjusting labour:

$$B_t = M_t - \delta E_t \left[\frac{w_{t+1}}{w_t} M_{t+1} \right] \tag{12}$$

with

$$M_t = \beta \left[\exp\left(\beta \Delta L_t\right) - 1 \right] + \gamma \Delta L_t \tag{13}$$

The non-linear nature of the model and the fact that B_t includes current and future marginal costs of adjusting labour make the analysis of the relation between firm behaviour and exchange rate movements more complex. To proceed we resort to log-linearization of equation (10).

2.3 Log-linearization

We begin by writing (10) as:

$$y_t = X_t \left(\frac{1 + B_t}{q_{it}\varphi} + \eta_i \right)^{-\sigma}, \tag{14}$$

i.e., we collect in X_t the exogenous variables that are not directly related to the focus of our study.[4] We then log-linearize the resulting equation, obtaining:

$$\begin{aligned} \hat{y}_t \quad \approx \quad & \hat{X}_t + \frac{\sigma}{zq}\hat{q}_{it} - \frac{\sigma}{zq}\frac{(1+\delta)y}{\varphi}(\beta^2 + \gamma)\hat{y}_t \\ & + \frac{\sigma}{zq}\frac{y}{\varphi}(\beta^2 + \gamma)\hat{y}_{t-1} + \frac{\sigma}{zq}\frac{\delta y}{\varphi}(\beta^2 + \gamma)E_t\hat{y}_{t+1} \end{aligned} \tag{15}$$

where the hats denote log-deviations from the steady-state. Note that the parameters related to labour adjustment costs appear together in the factor $\beta^2 + \gamma$. Therefore, in the log-linearized version of the model, one of them is irrelevant: we chose to set $\beta = 0$.

We assume that the exogenous variables ($\hat{X}_t$ and $\hat{q}_{it}$) follow first-order autoregressive processes:

$$\hat{X}_t = \rho_X \hat{X}_{t-1} + \epsilon_t^X \tag{16}$$

$$\hat{q}_{it} = \rho_q \hat{q}_{it-1} + \epsilon_t^q \tag{17}$$

With these assumptions, the solution of the model is of the form:

$$\hat{y}_t = \alpha_0 \hat{X}_t + \alpha_1 \hat{q}_{it} + \alpha_3 \hat{y}_{t-1} \tag{18}$$

[4] One simplification we shall make is that the growth rate of wages is zero, which allows us to ignore the ratio w_{t+1}/w_t in equation (12) and to delete a constant slightly different from 1 multiplying γ in the results presented below. It also saves us from having to assume a stochastic process for wages, which would, in any case, end up merged with the corresponding process for X_t.

The parameter that we are interested in is α_1, which measures the sensitivity of output and labour demand to exchange rate movements. It is given by:

$$\alpha_1 = \frac{\alpha_3}{\left[1 + \alpha_3 \frac{\gamma y(1+\delta)}{\varphi}\right]\left[1 - \kappa(\alpha_2 + \rho_q)\right]} \tag{19}$$

where

$$\alpha_3 = \frac{\sigma}{1 + \eta\varphi q} \tag{20}$$

$$\kappa = \frac{\alpha_3 \frac{\delta\gamma y}{\varphi}}{1 + \alpha_3 \frac{(1+\delta)\gamma y}{\varphi}} \tag{21}$$

$$\alpha_2 = \frac{1 - \sqrt{1 - 4\kappa^2\delta^{-1}}}{2\kappa} \tag{22}$$

Though not immediately visible, these formulas lead to four conclusions that interest us:

1. an increase in labour adjustment costs (parameters β and γ) reduces the reaction of labour demand to exchange rate movements;

2. an increase in openness (σ) increases the reaction of labour demand to exchange rate movements;

3. an increase in productivity (φ) reduces the reaction of labour demand to exchange rate movements;

4. an increase in exchange rate persistence (ρ_q) increases the reaction of labour demand to exchange rate movements.

These conclusions may be gleaned from Figure 2.[5] In these figures we plot the value of α_1 for different parameterizations and using different variables in the axis so that the robustness of the patterns enumerated above may be verified. The model parameters were calibrated assuming $\delta = 0.96$, $\beta = 0$ and $s = 0.3$, as do (Berman, Martin, and Mayer 2009) in one version of their computations. s represents the share of distribution costs in the good's price. This share has been estimated to represent between 40% and 60% of goods' prices — see, e.g., (Burstein, Neves, and Rebelo 2003) and (Campa and Goldberg 2008). Setting $s = 0.5$ would not change the plots, only the scale: increasing the share of distribution costs would reduce the size of the elasticity α_1.

Our model suggests that empirical analyses of the reaction of employment to exchange rate movements should find that low-productivity firms, very open to trade and less affected by labour market rigidities should be more sensitive to the exchange rate. In the empirical section of this paper we will use sector-level data. One of the drawbacks

[5]Figures with additional calibrations are shown in the Appendix, Figures 4, 5 and 6. The plots are organized in three figures in order to facilitate the evaluation of the effect of labour adjustment costs (γ) on the labour demand elasticity with respect to the exchange rate. In each figure the patterns are similar regardless of the calibration. The plots reveal that adjustment costs have a larger effect on the value of α_1 when the persistence of exchange rate shocks is low and when productivity is high.

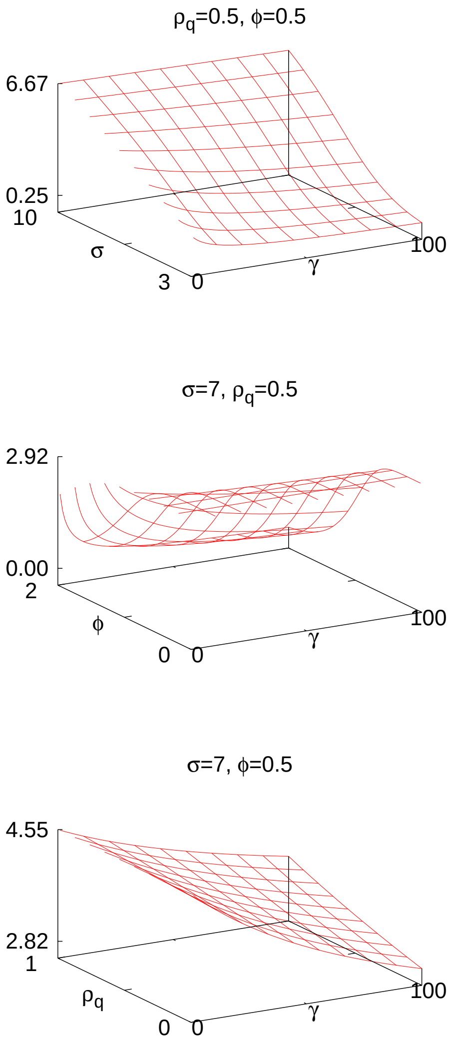

Figure 2: Employment exchange rate elasticity

of using this dataset is that it does not allow us to distinguish between firms that do and do not export. However, a similar model for non-exporting firms would also lead to the conclusion that the size of the impact of exchange rate movements on labour demand declines when labour adjustment costs increase. Therefore, we expect that the same will happen at the sector level. Note that we do not address the issue of firm entry and exit (the "extensive margin"). In (Berman, Martin, and Mayer 2009) fixed costs — $F_t(\varphi)$ in equation (6), assumed to depend on the productivity level — are viewed as a payment that allows the firm to export to country i. Thus, in that setup fixed costs are important for the study of firms' entry and exit decisions concerning the destination market. (Berman, Martin, and Mayer 2009) show that at the aggregate level these costs will influence the extensive margin elasticity of exports with respect to the exchange rate. This is estimated to represent around 20% of the elasticity of French exports with respect to the exchange rate. We therefore believe that our model should be able to explain the bulk of the effect of exchange rate changes on employment.

3 Empirical evidence

3.1 Model and data

As shown in the previous section, our theoretical model implies that the sensitivity of employment to exchange rate changes should increase with the degree of openness and decrease with labour adjustment costs and productivity. In order to test these implications we use the following empirical specification:

$$\begin{aligned}\Delta y_{jct} = \ & \beta_0 + \beta_1 \Delta ExRate_{jc,t-1} + \beta_2 Open_{jc,t-1} + \beta_3 EPL_{c,t-1} \\ & + \beta_4 \Delta ExRate_{jc,t-1} \times Open_{jc,t-1} + \beta_5 \Delta ExRate_{jc,t-1} \times EPL_{c,t-1} \\ & + \beta_6 \Delta ShareChina_{jc,t-1} + \beta_7 \Delta ShareChinaW_{jc,t-1} + \beta_8 \Delta ULC_{c,t-1} \\ & + \beta_9 \Delta GDP_{c,t-1} + \beta_{10} \Delta IntRate_{c,t-1} + \lambda_t + u_{jct}, \qquad (23)\end{aligned}$$

where Δ is the first-difference operator, y_{jct} is log employment, measured as total workers, in sector j and country c in year t, and $ExRate_{jc,t-1}$ is the lagged sectoral real effective exchange rate (in logs) smoothed by the Hodrick-Prescott filter,[6] which filters out the transitory component of the exchange rate.[7]

$Open_{jc,t-1}$ is the openness of sector j in country c, measured as the ratio of exports plus imports to gross output plus exports and imports. Figure 3 presents the evolution of openness, in a group of countries, measured as the ratio of exports plus imports to gross output plus exports and imports. It shows that between 1988 and 2006 the openness to trade has increased steadily.

$EPL_{c,t-1}$ stands for the OECD's Employment Protection Legislation (*EPL*) index regarding country c. One feature of labour market rigidities is employment protection, that is, the legislation and collective bargaining agreements that regulate the hiring and firing — for a survey of the literature on employment protection see, for example, (Addison and Teixeira 2003). This employment protection represents an additional labour

[6] The smoothing parameter was set equal to 6.25 following (Ravn and Uhlig 2002).

[7] According to our theoretical model, the sensitivity of employment to exchange rate movements increases with the persistence of exchange rate shocks.

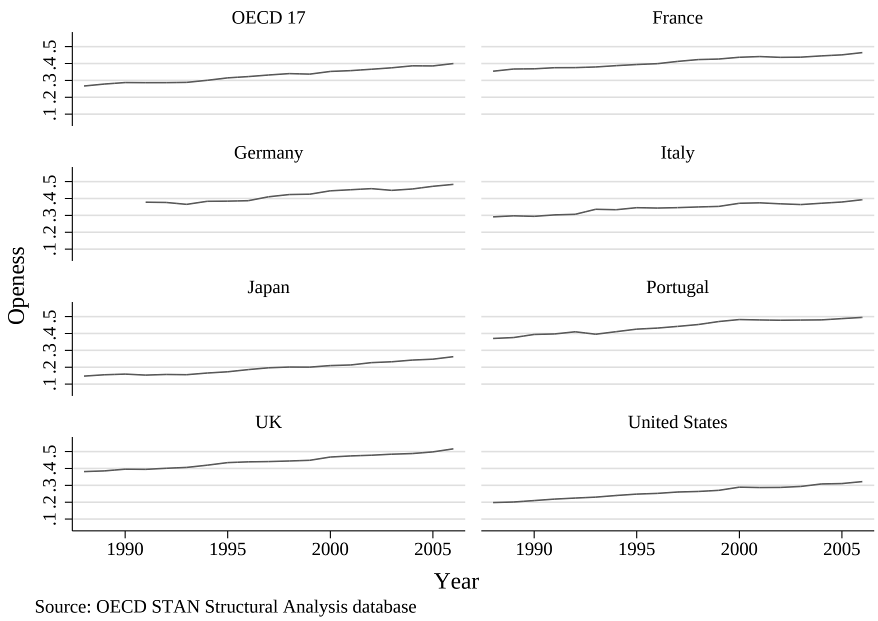

Figure 3: Openness to international trade

cost for employers of the type that the model described in section 2 attempts to capture in the term $A(\Delta L_t)$. As a proxy for this, in our empirical analysis, we use the EPL index, which allows us to compare the labour market rigidities over time and across the 23 OECD countries. This measure of employment protection gathers three different types of indicators: indicators on the protection of regular workers against individual dismissal; indicators of specific requirements for collective dismissals; and indicators of the regulation of temporary forms of employment — for more details see (OECD 1999) and (OECD 2004).

We include as additional control regressors the share of China in country c imports of goods belonging to sector j ($ShareChina_{jc,t-1}$). Similarly, exporters from country c to another OECD country i face competition from Chinese exporters to country i. This type of competition is proxied by the $ShareChinaW_{j,c,t-1}$ variable, which is an weighted average of the share of Chinese imports in OECD countries, where the weights are defined as the share of each country i in country c exports (the formula is given in Table 8 in the Appendix). In order to control for possible correlation between sectoral exchange rates and aggregate variables that are likely to influence employment growth we include additional controls for production costs such as real unit labour costs, $ULC_{c,t-1}$, for labour, and the long-term real interest rate, $IntRate_{c,t-1}$, for capital costs. Aggregate real shocks are captured by the real Gross Domestic Product, $GDP_{c,t-1}$, measured in logs.[8] The composite error term is defined as $u_{jct} = \theta_{jc} + \varepsilon_{jct}$, where θ_{jc} is a set of sector/country specific dummies. Finally, equation (23) also includes time dummies, λ_t, to account for common technology shocks that affect all sectors and countries.

Summary statistics and a description of the variables used in our analysis are presented

[8] Further details on the data are given in Table 8 in the Appendix.

in Table 5 in the Appendix. Table 6 in the Appendix provides the list of 23 countries used in our analysis, as well as the number of observations within countries by technology level. Overall, we have 3295 observations for medium-low- and low-technology industries and 2428 observations for high- and medium-high-technology industries. For some countries, the number of observations is relatively low, particularly for Slovakia, Poland, South Korea, Hungary, Czech Republic and Switzerland.

In the next section we report our main results. Our estimation strategy is the following. We begin by estimating equation (23) without including the EPL index, either alone or interacting with the exchange rate, and without allowing for different behaviour according to the sectors' technology level — in this first estimation, the exchange rate effect depends only on the degree of openness. The next step is to estimate the model separately for low- and high-technology sectors. These sectors are defined according to the OECD technology classification. The OECD technology classification ranks industries according to indicators of technology intensity based on R&D expenditures ((OECD 2005)). We use the OECD technology classification as a proxy for the productivity parameter in the production function of our theoretical model, φ, which can be understood as a total productivity factor (or a Solow residual). In fact, a simple OLS regression of labour productivity, measured as sectoral value added per employee, on OECD's technology classes and capital per employee, shows that high-technology sectors are more productive than low technology sectors.[9] Given that data on value added and on the stock of capital are available just for a small sample of countries and years, we develop our analysis using the OECD's technology classification.

Finally, we estimate equation (23) separately for low- and high-technology sectors including the EPL index, both alone and interacting with the exchange rate. The goal is to test the predictions of the theoretical model concerning the role of openness, technology and labour market rigidity in the determination of the effect of exchange rate movements on employment.

3.2 Main results

Equation (23) was estimated by the within estimator, with sector/country fixed-effects. Table 1 shows the results of our estimations. We report robust standard errors, clustered within sectors/countries pairs in order to allow for intra-group correlation. We begin our review of the results by the additional control regressors. The first noticeable result is that competition from China ($ShareChina$) seems to have a negative impact on employment, but the coefficient is not always significant: it is significant only in the model for low-technology sectors that includes EPL. Second, increases in unit labour costs seem to

[9]We ran the following regression:

$$\log(A_{it}) = \beta_0 + \beta_1 MHT_{it} + \beta_2 MLT_{it} + \beta_3 LT_{it} + \beta_4 \log(K_{it}) + \theta_i + \gamma_t + \varepsilon_{it}$$

where A is labour productivity, K is the capital stock, MHT, MLT and LT are dummies that indicate medium-high, medium-low and low technology sectors, respectively, whereas θ_i and γ_t are sector/country and time dummies, respectively. We concluded that high-technology sectors are the ones with highest productivity and that productivity decreases for lower levels of technology. Furthermore, the estimated coefficient on capital is about 0.41, with a standard error of 0.01. This implies that higher levels of capital are associated with higher levels of productivity. The R^2 is 0.78.

cost jobs in low-technology sectors (columns (2) and (4)). Third, increases in GDP lead to employment growth, but again low-technology sectors seem to be more dependent on this variable than high-technology sectors, for which this coefficient is not statistically significant. Finally, interest rate changes, though displaying the expected negative sign, do not exhibit statistical significance.

However, what we are interested in is the interplay between technology, openness and labour market rigidity. The main focus of our analysis is the employment exchange rate elasticity, which, in the model of equation (23), is given by:

$$\xi = \beta_1 + \beta_4 Open + \beta_5 EPL \tag{24}$$

Clearly, the elasticity will depend on the levels of $Open$ and EPL chosen for the computation. Below, we shall use the 90^{th}, 50^{th} and 10^{th} percentiles of these variables in the computation of the employment elasticity.

Our first estimation, column (1), did not allow for different behaviours of sectors/countries according to the level of technology or labour market rigidity, so that the final term in equation (24) drops out. The estimates imply that the employment exchange rate elasticity in this case increases with the degree of openness. The interaction coefficient (β_4) is 0.8851 and statistically significant at the 5% level. The employment exchange rate elasticity for "closed" sectors, evaluated at the 10^{th} percentile of the distribution of the openness measure, is not statistically different from zero: the elasticity is -0.032; the joint significance F-test has a p-value of 0.591.[10] In the case of "open" sectors, for which we take as reference the 90^{th} percentile of the openness distribution, we obtain an elasticity of 0.404, with a corresponding p-value for the joint significance test of 0.028; i.e., a 1% exchange rate depreciation is associated with a 0.4% increase in employment in open sectors. Our results also suggest that more open sectors, on average, create more employment: a 1 point increase in the openness index is associated with an employment increase of 0.23%.

Table 1: Employment regressions

	No-EPL	No-EPL		EPL	
	No-Tech	Low-Tech	High-Tech	Low-Tech	High-Tech
Model	(1)	(2)	(3)	(4)	(5)
$\Delta ExRate_{t-1}$	-.2316*	-.2531**	-.4782	-.0920	-.2613
	(.1255)	(.1071)	(.3396)	(.1255)	(.3595)
$\Delta ExRate \times Open_{t-1}$	.8851**	1.2085***	1.1815	1.0611***	1.0035
	(.3999)	(.3981)	(.7586)	(.3910)	(.7655)
$\Delta ExRate \times EPL_{t-1}$				-.0697	-.0792
				(.0428)	(.0986)
$Open_{t-1}$	.2257***	.0995*	.3426**	.0993*	.3435**
	(.0815)	(.0570)	(.1389)	(.0562)	(.1377)
EPL_{t-1}				-.0158***	-.0227**
				(.0043)	(.0091)

Continued on next page...

[10] The null hypothesis under analysis is $H_0 : \beta_1 + \beta_4 Open^{10} = 0$, where $Open^{10}$ is the 10^{th} percentile of $Open$.

... Table 1 continued

	No-EPL			EPL	
	No-Tech	Low-Tech	High-Tech	Low-Tech	High-Tech
Model	(1)	(2)	(3)	(4)	(5)
$\Delta ShareChinaW_{t-1}$	.0141	-.0626	.2435	-.0638	.2178
	(.2000)	(.1636)	(.4529)	(.1652)	(.4487)
$\Delta ShareChina_{t-1}$	-.1243**	-.0815	-.3486	-.0820*	-.3237
	(.0606)	(.0498)	(.2276)	(.0498)	(.2242)
ΔULC_{t-1}	.0163	-.1323**	.2003	-.1211*	.2128
	(.0879)	(.0626)	(.1786)	(.0627)	(.1750)
ΔGDP_{t-1}	.5959***	.7599***	.3965	.7800***	.4123
	(.1269)	(.0958)	(.2569)	(.0939)	(.2606)
$\Delta IntRate_{t-1}$	-.0010	-.0013	-.0008	-.0012	-.0005
	(.0012)	(.0009)	(.0026)	(.0009)	(.0026)
Countries	23	23	23	23	23
Observations	5723	3295	2428	3295	2428
Adj. R^2	.0504	.1068	.0422	.1137	.0444
LogLikelihood	6421.615	5417.503	1975.572	5431.425	1979.432

Notes: Significance levels: $*$: 10% $**$: 5% $***$: 1%. Robust standard errors in parentheses. All regressions are estimated by fixed-effects at the sector/country level, and include time dummies. The dependent variable is Δy_{jct} (change in log employment).

The estimations reported in columns (2) and (3) account for different levels of technology by estimating different sets of coefficients according to whether the sector is classified as a low-technology or as a high-technology sector. The estimations reported in columns (4) and (5) include in addition the labour market rigidity measure (EPL). We used these results to quantify, separately for low- and high-technology sectors, the effects of exchange rate movements on employment in sectors with different degrees of openness and labour market rigidity. The resulting employment exchange rate elasticities are presented in Table 2. In columns (1) and (3) of this Table, we evaluate the elasticity of employment with respect to the exchange rate at the 90^{th} and 10^{th} percentiles of openness, denoted by Open(+) and Open(-), respectively. For each degree of openness, and for the models that include the employment protection legislation index (*EPL*, columns (4) and (5) in Table 1), we further computed the elasticity at high, median and low levels of *EPL*, i.e., at the 90^{th}, 50^{th} and 10^{th} percentiles of EPL — these are the values reported in columns (2) and (4) of Table 2.

For open, low-technology sectors, the results in column (1) of Table 2 show that the employment exchange rate elasticity is positive and statistically significant. In these sectors, a depreciation induces employment growth: a 1% depreciation induces a 0.61% employment change. However, for closed sectors, bottom half of column (1) in Table 2, although we obtain a positive elasticity, it is not statistically significant: the joint significance F-statistic is 9.72, with a p-value about 0.7.

The results in column (3) of Table 1, suggest that for high-technology sectors the employment exchange rate does not vary with the degree of openness: the interaction term is estimated to be about 1.18, with a standard error of 0.76. In fact, altogether, the employment exchange rate elasticity is not statistically significant (Table 2, column (3), top

Table 2: Employment exchange rate elasticities

<table>
<tr><td></td><td></td><td colspan="2">Low-Tech</td><td colspan="2">High-Tech</td></tr>
<tr><td></td><td></td><td>(1)</td><td>(2)</td><td>(3)</td><td>(4)</td></tr>
<tr><td rowspan="3">Open(+)</td><td>EPL(+)</td><td rowspan="3">0.6148*** (0.0020)</td><td>0.4259** (0.0499)</td><td rowspan="3">0.3703 (0.1596)</td><td>0.1820 (0.6152)</td></tr>
<tr><td></td><td>0.5221*** (0.0084)</td><td>0.2914 (0.2971)</td></tr>
<tr><td>EPL(-)</td><td>0.6177*** (0.0016)</td><td>0.3999 (0.1089)</td></tr>
<tr><td rowspan="3">Open(-)</td><td>EPL(+)</td><td rowspan="3">0.0193 (0.6981)</td><td>-0.0969 (0.3399)</td><td rowspan="3">-0.2118 (0.2707)</td><td>-0.3124 (0.3119)</td></tr>
<tr><td></td><td>-0.0006 (0.9904)</td><td>-0.2031 (0.3493)</td></tr>
<tr><td>EPL(-)</td><td>0.0949 (0.1030)</td><td>-0.0945 (0.6174)</td></tr>
</table>

Notes: p-values in parentheses. Significance levels: $*$: 10% $**$: 5% $***$: 1%.

half), with an estimated magnitude of 0.37. Therefore, exchange rate movements seem to play a role in the determination of employment in open, low productivity industries. On the contrary, they appear to be less important for employment in high productivity sectors, a conclusion that is in line with the evidence provided in (Alexandre, Bação, Cerejeira, and Portela 2009b) for the particular case of Portugal. It should also be noticed that, although not all of them are statistically significant, the coefficients presented in columns (1) and (3) of Table 2 obey the patterns predicted by the theoretical model discussed in section 2: the elasticity decreases from left to right and from top to bottom, i.e., low-technology sectors are more sensitive to exchange rate movements and closed sectors are less sensitive.

The inclusion of the *EPL* index in our regressions provides additional corroboration of the predictions of the theoretical model. First, for low-technology sectors, the effect of the exchange rate on employment is higher for open industries that face higher flexibility in the labour market: the coefficient on $\Delta ExRate_{jc,t-1} \times EPL_{c,t-1}$ in column (4) of Table 1 has a magnitude of -0.0697 (it is only marginally non-significant, with a standard error of 0.0428). Second, the result discussed above that exchange rate effects are enhanced for higher degrees of openness is now reinforced. On its own, openness is associated with employment growth (a 1 point increase in openness increases employment by 0.1%), while labour market rigidity (higher *EPL*) relates to negative employment variations (a 1 point increase in *EPL* implies a 1.6% employment decrease).[11] The corresponding employment exchange rate elasticities reported in column (2) of Table 2 reveal the following: in the case of open sectors (top half), the elasticity is positive, statistically significant and decreases with labour market rigidity. It goes from 0.62, for low-technology sectors with a degree of openness equal to its 90^{th} percentile and an *EPL* evaluated at its 10^{th} percentile, to 0.43

[11] The annual average change in EPL is -0.023, with a standard deviation of 0.137. The induced employment change would be $-0.023 * (-0.0158) \simeq 0.036\%$.

for low-technology sectors with the same degree of openness and an EPL evaluated at the 90^{th} percentile. Turning our attention to closed sectors, we observe that with flexible labour markets the employment exchange rate elasticity is 0.0949, which is marginally non-significant (the standard error is 0.1030). With the increase in the degree of labour market rigidity the estimated effect of exchange rate movements on employment decreases and becomes clearly insignificant.

For high-technology industries, both openness and labour market rigidities appear not to influence the effect of exchange rate innovations on employment variations (column (5) of Table 1). At the same time, the employment exchange rate elasticity is not significant (column (4) of Table 2). An interesting result is that, in very open high-technology industries with flexible labour markets, the employment exchange rate elasticity is about 0.4 and marginally non-significant at the 10% level (the associated p-value is 0.1089). Such elasticity is still about 2/3 of the one obtained for low-technology industries. These results lend support to the view that exchange rate movements are particularly relevant for employment determination in low-productivity sectors and that these effects decrease monotonically with labour market rigidity. Nevertheless, on their own, openness and labour market rigidity have important effects on employment in high-technology sectors: a 1 percentage point increase in the openness index implies an increase of about 0.34% in employment (Table 1, column (5)); a 1 point increase in EPL decreases employment by 2.3%.

Finally, looking at the overall significance of the regressions presented in Table 1, we conclude that our model is more successful in explaining employment movements for low-technology industries: the adjusted R^2 is 11% for low-technology sectors (columns (2) and (4)) and 4% for high-technology sectors (columns (3) and (5)). This conclusion is reinforced by the comparison of the log-likelihood of the different models.

3.3 Sensitivity analysis

Our empirical approach essentially estimates an approximation to an equation similar to equation (18) derived in the context of our theoretical model, where we assumed that the production function is a linear function of the labour input. The approximation is linear except in the part concerning the exchange rate and the dependence of its coefficient on openness and labour market rigidity. However, being an approximation, the presence or absence of other functions of the variables involved could be envisaged, namely *Open* and EPL, though parcimoniously, to avoid over-fitting.

In what follows we discuss two alternative specifications of equation (23). We extend the estimates presented in columns (4) and (5) of Table 1 by, first, replacing $Open_{jc,t-1}$ and $EPL_{c,t-1}$ by their first-differences counterparts, and, second, eliminating these variables from our specification, while keeping their interactions with the exchange rate. The estimates, and corresponding elasticities, are presented in Tables 3 and 4, respectively.

The new set of estimates indicates that our results are robust. More of our estimates, and corresponding elasticities, are now statistically significant, further strengthening the results discussed in the previous section. By including lagged changes of both *Open* and EPL, instead of their levels, we now observe that for high-technology the exchange rate effects are also mediated by the degree of openness. This result is valid for both specifications, columns (2) and (4), Table 3. As before, exchange rate effects seem not to be determined by labour market rigidities for high-technology industries.

Table 3: Employment regressions

	Low-Tech	High-Tech	Low-Tech	High-Tech
Model	(1)	(2)	(3)	(4)
$\Delta ExRate_{t-1}$	-.0788	-.3653	-.1248	-.2313
	(.1203)	(.4154)	(.1247)	(.3687)
$\Delta ExRate \times Open_{t-1}$	1.2254***	1.6339*	1.3437***	1.4180*
	(.3713)	(.8626)	(.3844)	(.7711)
$\Delta ExRate \times EPL_{t-1}$	-.1068**	-.1365	-.0980**	-.1592
	(.0423)	(.1012)	(.0428)	(.1017)
$\Delta Open_{t-1}$	-.0817	-.0328		
	(.0638)	(.0868)		
ΔEPL_{t-1}	-.0033	-.0043		
	(.0065)	(.0199)		
$\Delta ShareChinaW_{t-1}$	-.0913	.3057	-.0846	.2868
	(.1599)	(.4552)	(.1645)	(.4568)
$\Delta ShareChina_{t-1}$	-.0745*	-.3050	-.0794*	-.2951
	(.0438)	(.2268)	(.0467)	(.2271)
ΔULC_{t-1}	-.1632***	.0802	-.1582***	.1520
	(.0627)	(.1525)	(.0602)	(.1821)
ΔGDP_{t-1}	.8199***	.5022*	.7653***	.3622
	(.0948)	(.2886)	(.0951)	(.2758)
$\Delta IntRate_{t-1}$	-.0013	.00004	-.0013	-.0007
	(.0009)	(.0024)	(.0009)	(.0025)
Countries	23	23	23	23
Observations	3273	2400	3295	2428
Adj. R^2	.1097	.0286	.1038	.0282
LogLikelihood	5417.134	1954.527	5412.136	1957.976

Notes: Significance levels: $*$: 10% $**$: 5% $***$: 1%. Robust standard errors in parentheses. All regressions are estimated by fixed-effects at the sector/country level, and include time dummies. The dependent variable is Δy_{jct} (change in log employment).

In Table 4, the regressions used in the estimation of elasticities under (1) use $\Delta Open$ and ΔEPL as explanatory variables — corresponding to columns (1) and (2) in Table 3 —, while the regressions used in the estimation of elasticities under (2) do not use $Open$ and EPL on their own as explanatory variables — corresponding to columns (3) and (4) in Table 3. For very open low-technology industries with rigid labour markets the employment exchange rate elasticity has virtually the same value as in Table 2, i.e., 0.43. Comparing the top-left half of Table 4 with column (2) in Table 2, we see that the elasticities increase with the exclusion of the testing variables, $Open$ and EPL. Moving to the top-right half of Table 4, concerning very open high-technology industries, we now observe a clearer effect of labour market rigidities on the employment exchange rate elasticities. Once we have at least a median level of flexibility, exchange rate movements

Table 4: Employment exchange rate elasticities

		Low-Tech		High-Tech	
		(1)	(2)	(1)	(2)
Open(+)	EPL(+)	0.4273** (0.0404)	0.4970** (0.0220)	0.3304 (0.3888)	0.2299 (0.5175)
		0.5747*** (0.0024)	0.6323*** (0.0013)	0.5188** (0.0795)	0.4496* (0.0939)
	EPL(-)	0.7211*** (0.0001)	0.7666*** (0.0001)	0.7057*** (0.0065)	0.6676*** (0.0054)
Open(-)	EPL(+)	-0.1765* (0.0759)	-0.1650* (0.0972)	-0.4746 (0.1167)	-0.4688 (0.1237)
		-0.0291 (0.6022)	-0.0297 (0.5905)	-0.2863 (0.1921)	-0.2491 (0.2373)
	EPL(-)	0.1173** (0.0385)	0.1046* (0.0657)	-0.0993 (0.6358)	-0.0310 (0.8697)

Notes: p-values in parentheses. Significance levels: $*$: 10% $**$: 5% $***$: 1%. The regressions used in the estimation of elasticities under (1) use $\Delta Open$ and ΔEPL as explanatory variables — see columns (1) and (2) in Table 3. The regressions used in the estimation of elasticities under (2) do not use $\Delta Open$ and ΔEPL as explanatory variables — see columns (3) and (4) in Table 3.

do impact on employment changes, even for high-productivity industries. However, it should be noted that again we obtain the result that the magnitude of such effect is higher for low-technology sectors. For example, excluding $Open$ and EPL variables (last column of Table 4), we conclude that a 1% depreciation leads to an increase of 0.67% in employment in high-technology sectors, while it leads to an increase of 0.77% in low-technology sectors (column (2) of Table 4).

There is one result that deserves an additional comment. As we can see in Table 4, columns (1) and (2) under low-technology, the employment exchange rate elasticity is negative for low-technology closed sectors in face of a rigid labour market. A possible explanation might be related with input costs — see, for example, (Ekholm, Moxnes, and Ulltveit-Moe 2008). However, we cannot test such explanation as we lack appropriate data.

From our sensitivity analysis we confirm the previous conclusion that exchange rate impacts on the labour market depends on the degree of labour market rigidity and the industry's openness and productivity.

4 Conclusion

This paper studies the role of labour adjustment costs in the determination of the impact of exchange rates on employment. We presented an international trade model with labour market rigidities in the form of labour adjustment costs. The introduction of this feature produces a dynamic and nonlinear model, which we log-linearize in order to obtain an analytical expression for the employment exchange rate elasticity. Previous work in this area had emphasized the dependence of this elasticity on openness and productivity. Our model of exporting firm behaviour suggests that higher labour adjustment costs reduce the influence of exchange rate movements on employment and, therefore, should also be taken into account in empirical studies. In fact, our econometric analysis, based on a sample of 23 OECD countries, shows that employment is more sensitive to exchange rate movements in the context of low-technology sectors, high degree of openness to international trade and flexible labour markets.

This paper provides additional evidence on the importance of institutions for explaining economic adjustment following shocks. In particular, we show that labour market institutions may help understand the impact of exchange rate shocks on employment. However, the fact that higher labour adjustment costs appear to reduce the elasticity of employment with respect to the exchange rate may have contradictory macroeconomic implications. On the one hand, it may smooth unemployment variations and, consequently, prevent some social costs associated with sharp increases in unemployment, and even social unrest. On the other hand, it may also hinder efficient reallocation of resources.

References

Addison, J. and P. Teixeira (2003). The economics of employment protection. *Journal of Labour Research 24*(1), 85–129.

Alexandre, F., P. Bação, J. Cerejeira, and M. Portela (2009a). Aggregate and sector-specific exchange rates for the Portuguese economy. *Notas Económicas 30*, 6–28.

Alexandre, F., P. Bação, J. Cerejeira, and M. Portela (2009b). Employment and exchange rates: The role of openness and technology. IZA Discussion Paper No. 4191, Bonn.

Berman, N., P. Martin, and T. Mayer (2009). How do different exporters react to exchange rate changes? Theory and empirics. CEPR Discussion Paper Series No. 7493.

Bertola, G. (1990). Job security, employment and wages. *European Economic Review 34*, 851–886.

Bertola, G. (1992). Labor turnover costs and average labor demand. *Journal of Labor Economics 10*(4), 389–411.

Blanchard, O. J. (1999). European unemployment: The role of shocks and institutions. Baffi Lecture, Rome.

Blanchard, O. J. and P. Portugal (2001). What hides behind an unemployment rate: Comparing Portuguese and U.S. labor markets. *American Economic Review 91*(1), 187–207.

Blanchard, O. J. and J. Wolfers (2000). The role of shocks and institutions in the rise of European unemployment: The aggregate evidence. *Economic Journal 110*, C1–C33.

Branson, W. H. and J. P. Love (1988). United States manufacturing and the real exchange rate. In R. C. Marston (Ed.), *Misalignment of Exchange Rates: Effects on Trade and Industry*, pp. 241–275. Chicago, MA: University of Chicago Press.

Burstein, A. T., J. C. Neves, and S. Rebelo (2003). Distribution costs and real exchange rate dynamics during exchange-rate-based stabilizations. *Journal of Monetary Economics 50*(6), 1189–1214.

Calmfors, L. and J. Driffill (1988). Bargaining structure, corporatism, and macroeconomic performance. *Economic Policy 6*, 14–61.

Campa, J. M. and L. S. Goldberg (2001). Employment versus wage adjustment and the U.S. dollar. *Review of Economics and Statistics 83*(3), 477–489.

Campa, J. M. and L. S. Goldberg (2008). The insensitivity of the CPI to exchange rates: Distribution margins, imported inputs, and trade exposure. *Review of Economics and Statistics*, forthcoming.

Cingano, F., M. Leonardi, J. Messina, and G. Pica (2009). The effect of employment protection legislation and financial market imperfections on investment: Evidence from a firm-level panel of EU countries. *Economic Policy 61*, 117–163.

Driffill, J. (2006). The centralization of wage bargaining revisited: What have we learned? *Journal of Common Market Studies 44*(4), 731–756.

Ekholm, K., A. Moxnes, and K.-H. Ulltveit-Moe (2008). Manufacturing restructuring and the role of real exchange rate shocks: A firm level analysis. CEPR Discussion Paper Series No. 6904.

European Commission (2003). 2003 Adopted employment guidelines. Available at http://europa.eu.int/eur-lex/pri/en/oj/dat/2003/l_197/l_19720030805en00130021.pdf.

Felbermayr, G., J. Prat, and H. Schmerer (2008). Globalization and labor market outcomes: Wage bargaining, search frictions, and firm heterogeneity. IZA Discussion Papers No. 3363, Bonn.

Gómez-Salvador, R., J. Messina, and G. Vallanti (2004). Gross job flows and institutions in Europe. *Labour Economics 11*, 469–485.

Gourinchas, P.-O. (1999). Exchange rates do matter: French job reallocation and exchange rate turbulence, 1984-1992. *European Economic Review 43*(7), 1279–1316.

Haltiwanger, J., S. Scarpeta, and H. Schweiger (2006). Assessing job flows across countries: The role of industry, firm size and regulations. IZA Discussion Paper No. 2450, Bonn.

Helpman, E. and O. Itskhoki (2010). Labour market rigidities, trade and unemployment. *Review of Economic Studies*, forthcoming.

Hopenhayn, H. and R. Rogerson (1993). Job turnover and policy evaluation: A general equilibrium analysis. *Journal of Political Economy 101*(5), 915–938.

International Monetary Fund (2008). International Financial Statistics. Statistical Department, Online data, July.

Klein, M. W., S. Schuh, and R. K. Triest (2003). Job creation, job destruction, and the real exchange rate. *Journal of International Economics 59*(2), 239–265.

Melitz, M. J. (2003). The impact of trade on intra-industry reallocations and aggregate industry productivity. *Econometrica 71*(6), 1695–1725.

Nickell, S. (1997). Unemployment and labour market rigidities: Europe versus North-America. *Journal of Economic Perspectives 11*, 55–74.

Nickell, S., L. Nunziata, W. Ochel, and G. Quintini (2002). The Beveridge curve, unemployment and wages in the OECD from the 1960s to the 1990s. Centre for Economic Performance, London School of Economics.

OECD (1999). Employment Outlook. Online at http://www.oecd.org.

OECD (2004). Employment Outlook. Online at http://www.oecd.org.

OECD (2005). OECD science, technology and industry scoreboard, Annex 1. OECD.

OECD (2008). Employment Outlook. Online at http://www.oecd.org.

OECD (2008). STAN Structural Analysis Database. Online at http://www.oecd.org.

Pfann, G. A. and B. Verspagen (1989). The structure of adjustment costs for labour in the Dutch manufacturing sector. *Economics Letters 29*(4), 365–371.

Ravn, M. O. and H. Uhlig (2002). On adjusting the Hodrick-Prescott filter for the frequency of observations. *Review of Economics and Statistics 84*(2), 371–376.

Revenga, A. L. (1992). Exporting jobs? The impact of import competition on employment and wages in U.S. manufacturing. *The Quarterly Journal of Economics 107*(1), 255–84.

Turner, P. and J. Van't dack (1993). Measuring international price and cost competitiveness. BIS Economic Papers, 39.

Appendix

Descriptive Statistics

Table 5: Descriptive statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
y	5723	10.8519	1.6975	4.0604	14.7722
$ExRate$	5723	-0.0336	0.0989	-0.4142	0.4043
$Open$	5723	0.4553	0.1898	0.0350	1.0000
EPL	5723	2.2065	0.9638	0.2100	4.1000
$ShareChinaW$	5723	0.0362	0.0447	0.0000	0.4146
$ShareChina$	5723	0.0427	0.0714	0.0000	0.7251
ULC	5723	1.0308	0.0625	0.8835	1.2300
GDP	5723	14.0023	2.1339	10.3809	20.5785
$IntRate$	5723	3.7687	1.9641	-3.5641	10.0059
Δy	5723	-0.0120	0.0857	-1.4663	1.2054
$\Delta ExRate$	5723	0.0007	0.0244	-0.0913	0.0947
$\Delta Open$	5673	0.0053	0.0272	-0.4091	0.3613
ΔEPL	5723	-0.0345	0.1535	-1.0200	0.5000
$\Delta ShareChinaW$	5723	0.0039	0.0083	-0.1347	0.1147
$\Delta ShareChina$	5723	0.0046	0.0193	-0.4770	0.4722
ΔULC	5723	-0.0054	0.0194	-0.0810	0.0586
ΔGDP	5723	0.0242	0.0177	-0.0645	0.0691
$\Delta IntRate$	5723	-0.2238	1.2419	-7.3470	6.3962

Over the 19 years under analysis, 1988-2006, within manufacturing sectors employment has decreased on average 1.2% per year, with a median yearly decrease of 0.9%. The percentiles 25 and 75 of annual sectoral employment change are -3.9% and 2.0%. The dispersion across sectors/countries is considerable, as the standard deviation is about 0.0857. These simple descriptive statistics indicate that there have been structural employment shifts. In half of the sectors/years observations across countries we see a depreciation of the real exchange rate, with the mean change being 0.0007, although with considerable variation: $\Delta ExRate$ fluctuates between -0.0913 and 0.0947, with a standard deviation of 0.0244. The data also shows that industries became more open and that labour markets became more flexible. In addition, we observe that China increased its export share in the countries included in our sample. As for the macroeconomic variables, on average, unit labour costs have decreased over time, the same being true for the interest rate, whereas GDP has increased at an average rate of 2.4%.

Countries and Sectors

Table 6: Observations per country and technology level

Country	Low-Tech	High-Tech	Country	Low-Tech	High-Tech
Austria*	118	100	Hungary	48	6
Belgium*	198	106	Italy*	202	170
Canada*	195	153	Japan*	192	159
Switzerland	81	54	South Korea*	48	40
Czech Republic	40	39	Netherlands*	153	112
Germany	176	142	Norway*	185	147
Denmark*	193	137	Poland	40	5
Spain*	197	158	Portugal*	151	110
Finland*	202	159	Slovakia	44	40
France*	202	170	Sweden*	202	168
United Kingdom*	136	17	United States*	180	150
Greece*	112	86			
	Low-Tech			High-Tech	
Total observations	3295			2428	

Note: OECD17 refers to countries marked with *.

Table 7: List of sectors used in the analysis

ISIC Rev. 3	Descritpion	Technology Classification
15-16	Food products, beverages and tobacco	Low and Medium Low Technology
17-19	Textiles, textile products, leather and footwear	Low and Medium Low Technology
20	Wood and products of wood and cork	Low and Medium Low Technology
21-22	Pulp, paper, paper products, printing and publishing	Low and Medium Low Technology
23	Coke, refined petroleum products and nuclear fuel	Low and Medium Low Technology
24 less 2423	Chemicals excluding phamaceuticals	High and Medium High Technology
2423	Pharmaceuticals	High and Medium High Technology
25	Rubber and plastics products	Low and Medium Low Technology
26	Other non-metallic mineral products	Low and Medium Low Technology
271+2731	Iron and steel	Low and Medium Low Technology
272+2732	Non-ferrous metals	Low and Medium Low Technology
28	Fabricated metal products, except machinery and equipment	Low and Medium Low Technology
29	Machinery and equipment, n.e.c.	High and Medium High Technology
30	Office, accounting and computing machinery	High and Medium High Technology
31	Electrical machinery and apparatus, n.e.c.	High and Medium High Technology
32	Radio, television and communication equipment	High and Medium High Technology
33	Medical, precision and optical instruments	High and Medium High Technology
34	Motor vehicles, trailers and semi-trailers	High and Medium High Technology
351	Building and repairing of ships and boats	Low and Medium Low Technology
352+359	Railroad equipment and transport equipment n.e.c.	High and Medium High Technology
353	Aircraft and spacecraft	High and Medium High Technology
36-37	Manufacturing n.e.c. and recycling	Low and Medium Low Technology

Variables

Table 8: Description of the variables

Variable	Description	Source
y	Number of employees (full and part-time) in logs.	OECD STAN: EMPN.
$ExRate$	See the next subsection in this Appendix.	
$Open$	Exports plus imports over gross output plus exports and imports; all variables measured in national currency, current prices.	OECD STAN: EXPO, IMPO and PROD.
EPL	OECD's employment protection legislation index.	OECD Indicators on Employment Protection — annual time series data 1985-2008: unweighted average of version 1 sub-indicators for regular contracts (EPR_{v1}) and temporary contracts (EPT_{v1}).
$ShareChina_j$	Share of imports from China in sector j's own country imports.	OECD STAN Structural Analysis Database.
$ShareChinaW_{j,c,t}$	Weighted average of the share of Chinese imports in OECD countries, where the weights are defined as the share of each country i in country c exports ($X_{c,t}^{i,j}$ ($M_{c,t}^{i,j}$) stands for exports (imports) from country c to country i, in sector j, in year t): $ShareChinaW_{jc,t} = \left(\frac{X_{c,t}^{i,j}}{\sum_{i=1}^{N(t)} X_{c,t}^{i,j}}\right)\left(\frac{M_{i,t}^{China,j}}{\sum_{k=1}^{N(t)} M_{i,t}^{k,j}}\right)$, where $X_{c,t}^{i,j}$ ($M_{c,t}^{i,j}$) stands for exports (imports) from country c to country i, in sector j.	OECD STAN Structural Analysis Database.
ULC	Real unit labour costs measure the average cost of labour per unit of output and are calculated as the ratio of total labour costs to real output.	OECD STAN Database, variable: "ULC — total economy, annual". ULC was deflated using OECD's consumer price indexes (2005=100).
GDP	Gross Domestic Product (in logs), constant prices.	OECD STAN Database.
$IntRate$	Long-term real interest rates, per cent per annum.	OECD STAN Database, variable: "Interest Rates, Long-term government bond yields".

Exchange rate computation

$ExRate_{jc,t-1}$ is the lagged real sectoral effective exchange rate (in logs) computed using trade-weights:

$$ExRate_{jc,t} = \log \left[\prod_{c=1}^{N(t)} \left(rer_{c,t}^{i} \right)^{w_{c,t}^{i,j}} \right] \tag{25}$$

where

$$rer_{c,t}^{i} = \frac{e_{i,t} \cdot p_{i,t}}{p_{c,t}} \tag{26}$$

is the bilateral real exchange rate between country c and country i, $e_{i,t}$ is the price of foreign currency i in terms of country c currency at time t, $p_{c,t}$ and $p_{i,t}$ are consumer price indexes for the country c economy and for economy i, $N(t)$ is the number of foreign currencies in the index at time t and $w_{c,t}^{i,j}$ is the weight of currency i in the index of country c at time t, with $\sum_i w_{c,t}^{i,j} = 1$. An increase in the value of this index corresponds to a real depreciation of the country c currency. The base of the index is the year 2000. The nominal exchange rates (national currency per US dollar at the end of the period) and consumer price indexes were collected from IMF International Financial Statistics database.

We computed exchange rate weights in order to include information that would allow us to take into account for sectoral third-party competition. We followed Turner and Van't dack (1993) and defined the weight $w_{c,t}^{j,i}$ given to country i's currency in the double-weighted effective index as

$$w_{c,t}^{j,i} = \left(\frac{M_{c,t}^{i,j}}{X_{c,t}^{i,j} +_j M_{c,t}^{i,j}} \right) w_{M,c,t}^{i,j} + \left(\frac{X_{c,t}^{i,j}}{X_{c,t}^{i,j} + M_{c,t}^{i,j}} \right) w_{X,c,t}^{i,j} \tag{27}$$

where $w_{X,c,t}^{i,j}$ is defined as

$$w_{X,c,t}^{i,j} = \left(\frac{X_{c,t}^{i,j}}{\sum_{i=1}^{N(t)} X_{c,t}^{i,j}} \right) \left(\frac{\gamma_{i,t}^{j}}{\gamma_{i,t}^{j} + \sum\limits_{h \neq i,c} X_{i,t}^{h,j}} \right) + \sum_{k \neq i} \left(\frac{X_{c,t}^{k,j}}{\sum_{k=1}^{N(t)} X_{c,t}^{k,j}} \right) \left(\frac{X_{i,t}^{k,j}}{\gamma_{k,t}^{j} + \sum\limits_{h \neq k,c} X_{h,t}^{k,j}} \right) \tag{28}$$

In the formulas, $X_{c,t}^{i,j}$ ($M_{c,t}^{i,j}$) stands for exports (imports) from country c to country i, in sector j (in year t).

Data on trade comes from OECD STAN Bilateral Trade Database (OECD, 2008).

Figures

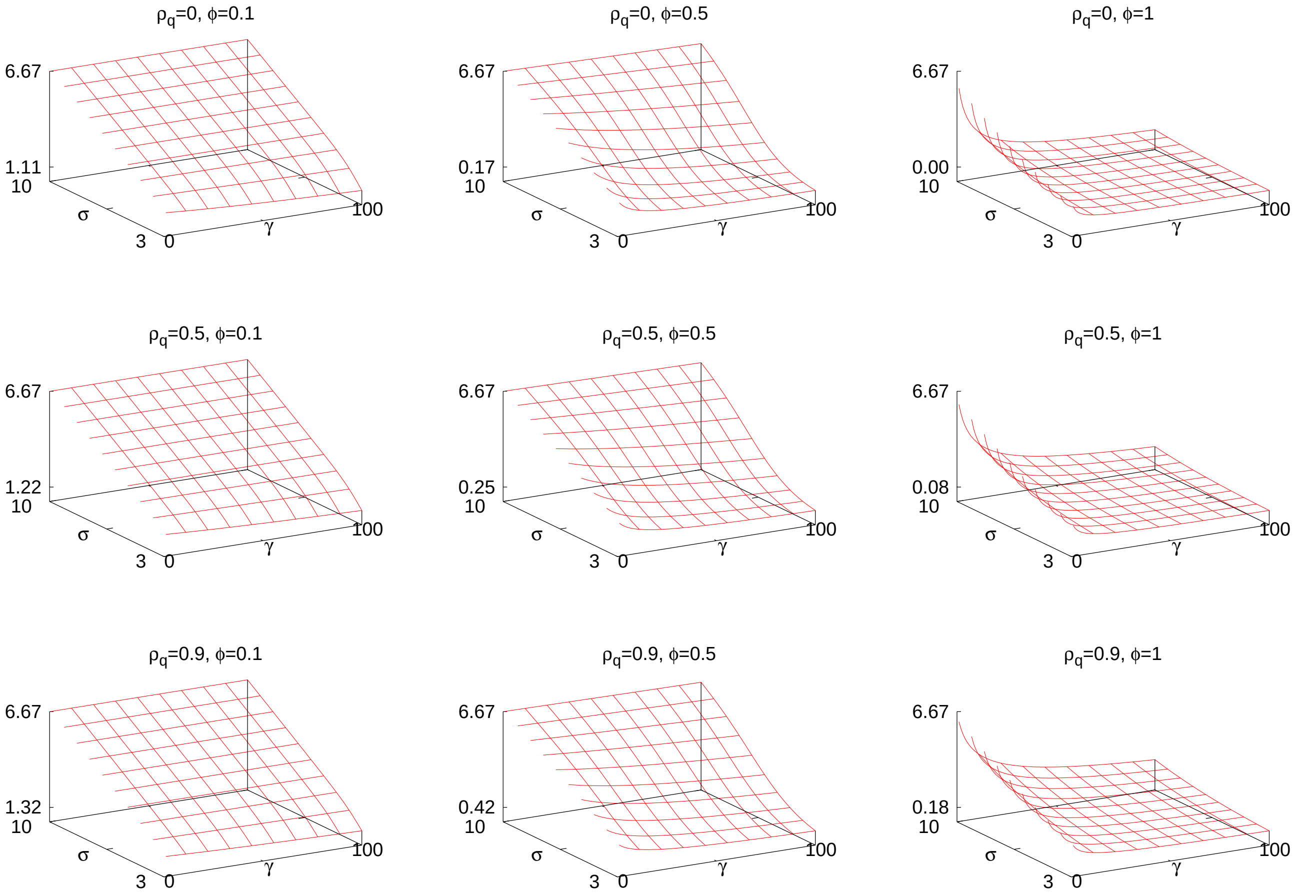

Figure 4: Employment exchange rate elasticity: labour adjustment costs and openness

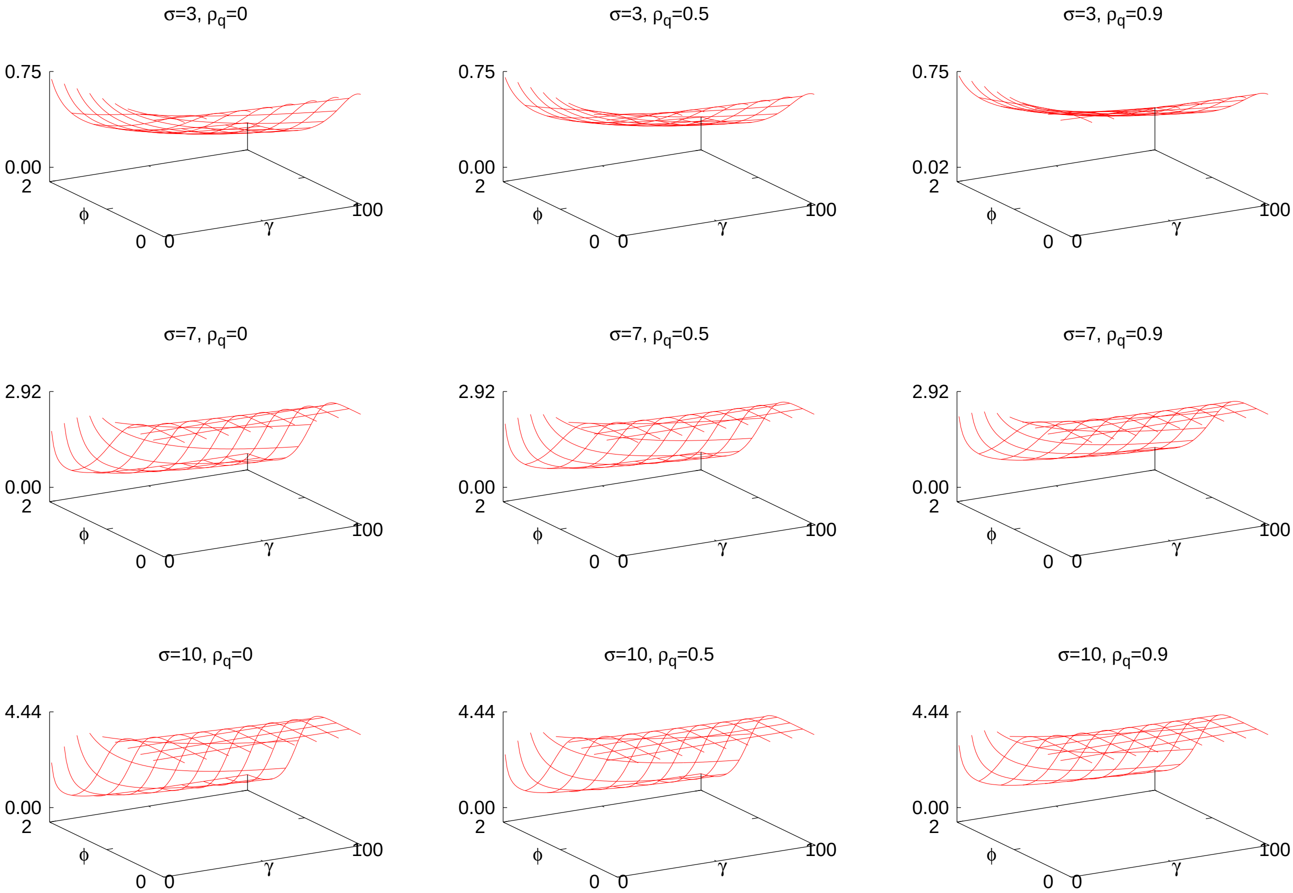

Figure 5: Employment exchange rate elasticity: labour adjustments costs and productivity

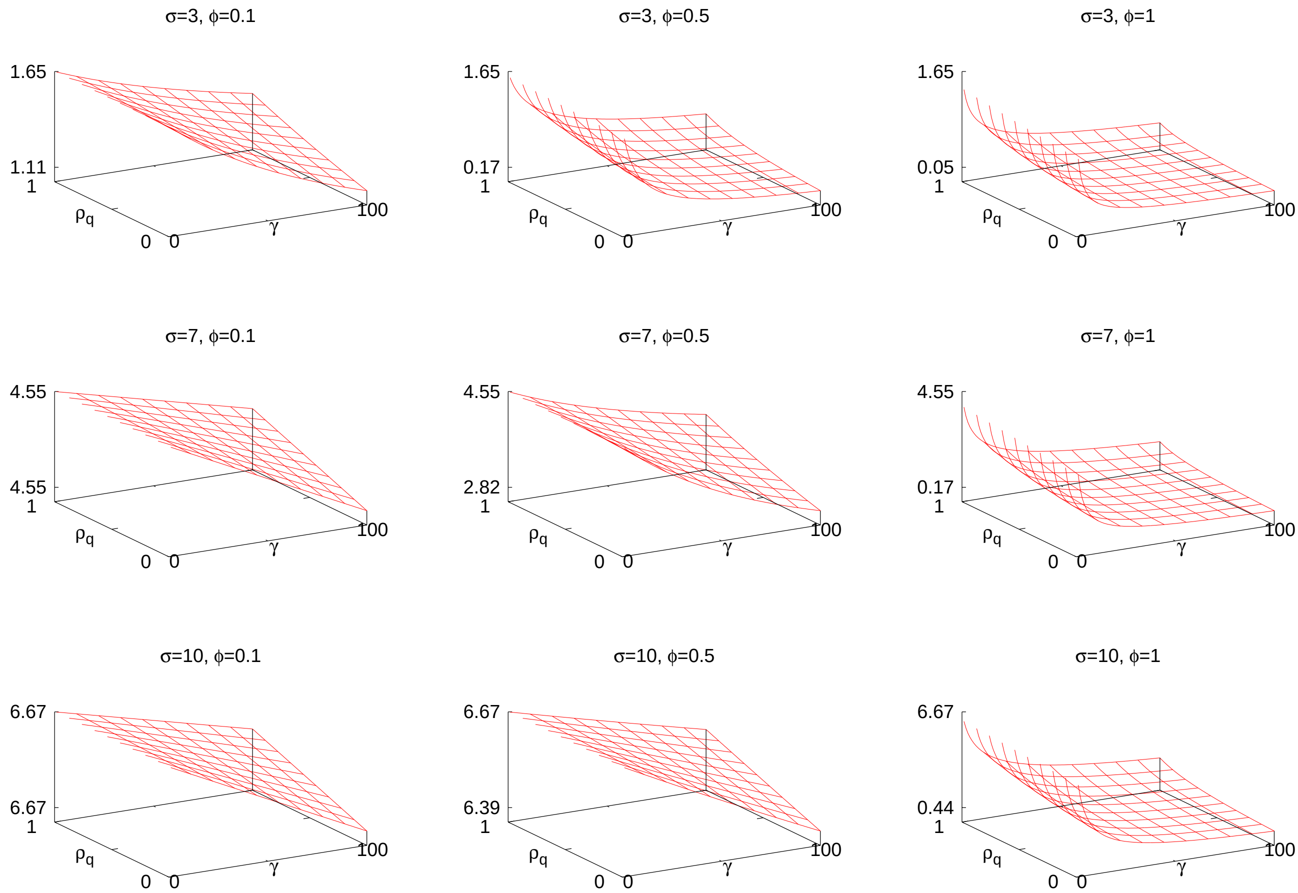

Figure 6: Employment exchange rate elasticity: labour adjustment costs and exchange rate persistence