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Employment and exchange rates: the role of openness and technology*

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Abstract

Real exchange rate movements are important drivers of the reallocation of resources between sectors of the economy. Economic theory suggests that the impact of exchange rates should vary with the degree of exposure to international competition and with the technology level. This paper contributes by bringing together these two views, both theoretically and empirically. We show that both the degree of openness and the technology level mediate the impact of exchange rate movements on labour market developments. According to our estimations, whereas employment in high-technology sectors seems to be relatively immune to changes in real exchange rates, these appear to have sizable and significant effects on highly open low-technology sectors. The analysis of job flows suggests that the impact of exchange rates on these sectors occurs through employment destruction.

Keywords: exchange rates, international trade, job flows.

JEL-codes: J23, F16, F41

1 Introduction

In recent decades, employment in manufacturing has been declining in developed countries – between 1988 and 2006 it decreased by approximately 40% and 20% in the UK and

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in the USA, respectively. In 2006, manufacturing employment represented approximately 10% of the workforce in those countries.[1] Skill-biased technological change – see, for example, Bound and Johnson (1992) or Machin and Van Reenen (1998) – and globalization – see, for example, Wood (1994, 1998) – have been the leading explanations for the observed decline in manufacturing employment and, in particular, for the decrease in the demand for unskilled relative to skilled workers. Analyses of the effect on manufacturing of the reduction in trade barriers in recent years suggest that competition from emerging countries, namely of China and India, has had a negative impact on manufacturing employment in developed countries – see, for example, Bernard et al. (2006).[2]

Another strand of the literature has been focusing on the impact of movements in real exchange rates on manufacturing labour markets. Economic theory suggests that changes in real exchange rates may have an impact on the reallocation of resources between sectors of the economy as they reflect changes in relative prices of domestic and foreign goods.[3] Branson and Love (1988), using data for the 70s and 80s for the US, were among the first to conclude that real exchange rate movements had a strong impact on manufacturing employment. Namely, they found that the appreciation of the dollar in the first half of the 80s had a strong negative effect on employment. A similar result was found by Revenga (1992), for the period 1977-1987, who concluded that real exchange rate movements had sizable effects on employment and a smaller, but significant, effect on US manufacturing wages. Burgess and Knetter (1998) evaluated the impact of real exchange rate movements on employment at the industry level for the G-7 countries and showed that real appreciations were associated with declines in manufacturing employment in most cases. In particular, these authors conclude that employment growth in the US, UK, Canada and Italy is more sensitive to exchange rates than in Germany, Japan and France. In the same vein, Gourinchas (1999) and Klein et al. (2003a) found that real exchange rates have a significant impact on job reallocation.

These papers, among others, have emphasized the role of openness in the determination of the impact of exchange rates on economic activity. As expected, the conclusion of these studies was that trading sectors and, in particular, sectors more exposed to international competition are more affected by exchange rate movements.

Recent studies in international trade theory, following Melitz (2003), have been focusing on the relation between international trade and productivity. Namely, these authors have concluded that firms' reaction to international competition differs sharply across

[1] Data from the OECD STAN database.

[2] Auer and Fischer (2008), in a related paper, conclude that trade with low-income countries have had a significant impact on U.S. industry productivity and prices.

[3] The effect on firms' competitiveness of an exchange rate movement may be likened to that of a change in tariffs – see Feenstra (1989).

different levels of productivity. A recent study by Berman et al. (2009) looks at the implications of the new literature on trade to the adjustment of export firms to exchange rate movements. They conclude that heterogeneity in productivity across firms implies different responses to exchange rate movements. According to their conclusions high productivity firms use their markups to adjust for exchange rate shocks; on the other hand, low productivity firms adjust to exchange rate movements by changing quantities. Given that high productivity firms (and sectors) are also more exposed to international competition it is not clear which sectors should be expected to be more affected by exchange rate movements.

In this paper we take the model of Berman et al. (2009) one step further and show how openness to trade and productivity interact to determine the impact of exchange rates on labour demand. We test the implications of the model at the expenses of the Portuguese case and we focus our analysis on the effect of real exchange rate movements on 20 manufacturing sectors, in the period 1988-2006. In that period, manufacturing employment decreased by 15% in Portugal, accompanying the international trends described above. In 2006, low and medium-low technology sectors (according to the OECD technology classification) still represented over 80% of manufacturing employment, and accounted for more than 50% of Portuguese exports. The degree of openness has increased for all technology levels in the period, and is higher for higher levels of technology. During the same period, the real effective exchange rate appreciated by more than 20%. The timing of those changes suggests that analysis of the Portuguese experience may improve the understanding of the role of differences in trade openness and technology level across sectors in the effects of exchange rate movements on economic activity.

In our analysis, we focus on the effects on employment growth and job flows. Foreshadowing our conclusions, our estimates suggest that exchange rate movements have a larger impact on very open and low-technology industries. On the other hand, our estimates seem to indicate that open economies specialised in high-technology sectors are more insulated from disturbances in exchange rates. These results suggest that the evaluation of the benefits from joining an economic and monetary union should take into consideration the degree of openness to trade and the technological content of manufacturing sectors.

The remainder of the paper is organized as follows. Section 2 discusses the relation between openness and technology level and its implications for the impact of exchange rate movements on employment. The exchange rate elasticity of labour demand is deduced as a function of productivity. Section 3 describes the data for trade, employment and exchange rates used in the estimation of the empirical models. Section 4 estimates a set of models in first-differences to evaluate the role of openness and technology in the determination of the impact of real exchange rates on employment. Section 5 concludes.

2 Employment and exchange rates

There have been several approaches to modelling the impact of exchange rate movements on firms' decisions concerning quantities and prices. Real exchange rate movements reflect changes in relative prices of domestic and foreign goods. These changes affect firms' international competitiveness and may result in a reallocation of resources, namely, of workers. For example, a real exchange rate appreciation, by decreasing foreign prices denominated in domestic currency, implies a decrease in the competitiveness of domestic firms which may affect profit margins, investment decisions, and hiring and firing decisions – see, for example, Campa and Goldberg (2001). However, these effects are expected to be more acute for exporting and import-competing firms. Sectors more exposed to international competition, that is, sectors with higher trade openness, should be more affected by changes in exchange rates. These channels are emphasized by Klein et al. (2003a), who estimate a model for job flows where the impact of exchange rate movements depends positively on the degree of openness.

Recent advances in international trade theory, namely the work by Melitz (2003), have led Berman et al. (2009) to suggest an alternative mechanism. Berman et al. (2009) highlight the role of productivity, i.e., they show that high and low performance (measured in terms of productivity or value added per worker) firms react very differently to exchange rate depreciations, that is, heterogeneity in productivity across firms results in differentiated responses to exchange rate depreciations. According to their theoretical and empirical results, high performance firms raise their markup instead of exported quantities when there is an exchange rate depreciation, whereas low performance firms follow the opposite strategy.

We follow the modelling approach of Berman et al. (2009), which is a variant of the model proposed by Melitz (2003), to derive the exchange rate elasticity of labour demand as a function of productivity. We show that both productivity and competition affect the reaction of employment to exchange rate movements, which we assume to be exogenous.[4] The representative consumer is assumed to have the usual Dixit-Stiglitz utility function, with elasticity of substitution between two differentiated goods given by σ:

$$U(C_i) = \left[\int_X x(\varphi)^{1-1/\sigma} \, d\varphi \right]^{\frac{1}{1-1/\sigma}} \tag{1}$$

[4]Our model is not a general equilibrium model of the type presented in Corsetti and Dedola (2007) where exchange rates movements result from monetary and productivity shocks.

where $x(\varphi)$ is consumption of variety φ, which also represents productivity in the production function of variety φ, i.e., $1/\varphi$ stands for the units of labour necessary for producing the good. This utility function implies the following demand for good φ in country i:

$$x_i(\varphi) = Y_i P_i^{\sigma-1} [p_i^c(\varphi)]^{-\sigma} \tag{2}$$

where Y_i is the income of country i and P_i is the price index in country i. Berman et al. (2009) main innovation is the introduction of distribution costs. These distribution costs affect the price charged in destination countries, which is assumed to be given by:

$$p_i^c(\varphi) = \frac{p_i(\varphi)}{\varepsilon_i} + \eta_i w_i \tag{3}$$

In the formula above, $p_i^c(\varphi)$ is the consumer price, in foreign currency, of a variety φ exported to country i, $p_i(\varphi)$ is the producer price of the good exported to i expressed in domestic currency, ε_i is the nominal exchange rate between the home country and country i expressed as the price of foreign currency in terms of home's currency, w_i is the wage in country i, and η_i is the distribution cost in units of labour in country i per unit consumed in that country.

The production cost of good φ is assumed to be:

$$c_i(\varphi) = \frac{w x_i(\varphi)}{\varphi} + F_i(\varphi) \tag{4}$$

where w is the wage in the home country and $F_i(\varphi)$ is the fixed cost of exporting to country i, assumed to depend also on productivity.

Applying Shephard's lemma, the demand for labour is:

$$L_i(\varphi) = \frac{\partial c_i(\varphi)}{\partial w} = \frac{x_i(\varphi)}{\varphi} \tag{5}$$

From this we can deduce the elasticity of labour demand with respect to the exchange rate:

$$\zeta = \frac{\partial L_i(\varphi)}{\partial q_i} \frac{q_i}{L_i(\varphi)} = \sigma \frac{1}{1 + \eta_i q_i \varphi} \tag{6}$$

where the real exchange rate is $q_i = \varepsilon_i w_i / w$. Similarly to what Berman et al. (2009) conclude in the case of output, a higher productivity decreases the sensitivity of labour demand to the exchange rate. However, equation (6) also shows that the exchange rate elasticity of labour demand is an increasing function of elasticity of substitution, σ. As a higher degree of openness means that consumers may substitute more easily goods produced elsewhere, it may be argued that the elasticity of substitution, σ, is an increasing function of openness, as in Klein et al. (2003a).[5]

The expression for the elasticity derived above suggests that the effect of exchange rate movements on labour demand should vary across different combinations of degrees of trade openness and levels of productivity. We synthetize the information conveyed by the expression for the exchange rate elasticity of labour demand in the following table:

		φ	
	ζ	*Low Productivity*	*High Productivity*
σ	*Open+*	$++$	$+-$
	Open−	$-+$	$--$

The table illustrates that for a given degree of openness, σ, a higher productivity level, φ, decreases the sensitivity of labour demand to exchange rate movements. On the other hand, for a given level of productivity, φ, a higher σ increases the sensitivity of labour to exchange rates. Therefore, the model indicates that very open low-technology sectors should be the most affected by exchange rate movements, whereas less open and high-technology sectors should be the least affected by changes in exchange rates.[6]

The alternative views discussed above suggest that we estimate a model in which both the degree of openness and the technology level mediate the impact of exchange rate movements on labour markets developments. In this paper we do this using data for the Portuguese economy, in the period 1988-2006. The (sectoral) data is presented in the next section. These data show that high-technology sectors are also the most open and productive, two characteristics that, according to the models discussed above, push the impact of exchange rate movements in different directions. Our contribution is to bring together the two views concerning the impact of exchange rates on employment, and to explore their interactions. In our analysis we use the OECD technology classification to distinguish between high- and low-productivity sectors.

[5] The result that the elasticity of labour demand depends on productivity hinges on the inclusion of distribution costs. In the absence of these costs, the elasticity of labour demand with respect to the exchange rate would be σ. In fact, this is the result Klein et al. (2003a), who do not model distribution costs, reach.

[6] Since high-technology sectors are more productive than low-technology sectors, we expect high-technology sectors to be less sensitive to exchange rate movements. The next section shows evidence supportive of that relation between productivity and the OECD industry classification by technology level. See next section and OECD (2005) for further details on the technology classification.

3 Employment, trade, technology and exchange rates: the Portuguese experience

In the last two decades, Portuguese international trade patterns changed significantly, both in terms of export destinations and of import origins. The behaviour of aggregate and sector specific exchange rate indexes in the period will be described in section 3.1. The behaviour of the exchange rate will be contrasted with that of manufacturing employment. In section 3.2, we will describe briefly the main trends in Portuguese international trade, between 1988 and 2006. In both sections, the discussion will highlight the evolution of the technology level of exports and imports.

Data on Portuguese international trade comes from OECD STAN bilateral trade database.[7] We focus on 20 manufacturing sectors, as they are more exposed to foreign trade – see the list of sectors in Table 7. The sectors were selected to match the International Standard Industrial Classification of all economic activities, Revision 3 (ISIC Rev. 3) – for the list of sectors see, for example, Table 10 in the Appendix. Data on employment comes from the "Quadros de Pessoal" dataset provided by the Portuguese Ministry of Labour and Social Solidarity (Portugal, MSSE, 1988-2006). This dataset is based on a compulsory survey that matches all firms and establishments with at least one employee with their workers. In 1988, it included 122,774 firms and 1,996,933 workers, covering 44.6% of total employment. In 2006, it included 344,024 firms and 3,099,513 workers, covering 60.5% of total employment.

3.1 Employment and exchange rates

The Portuguese manufacturing labour force followed the declining trend described in the introduction for industrialized countries: using the STAN database, we found that in 2006 manufacturing sectors accounted for 18.1% of total employment, down from 24.4% in 1988. Over this period, total employment in these sectors declined 15%, representing a loss of almost 160 000 jobs.[8] This reduction of manufacturing sectors' share in the labour force partly reflects the deindustrialization trend, mentioned above, that has affected advanced countries since the 1980s. However, it is also important to analyse sectoral trends. Table 10 in the Appendix shows the evolution of employment in the 20 manufacturing sectors and by OECD level of technology, using "Quadros de Pessoal". The main facts in Table 10 are captured by Figure 1 that shows the evolution of employment shares by OECD level of technology. There are clear decreasing trends in low and medium-low

[7] The STAN bilateral trade database is available at www.oecd.org/sti/stan/.

[8] However, the decrease manufacturing employment was accompanied by a 15% increase in the labour force.

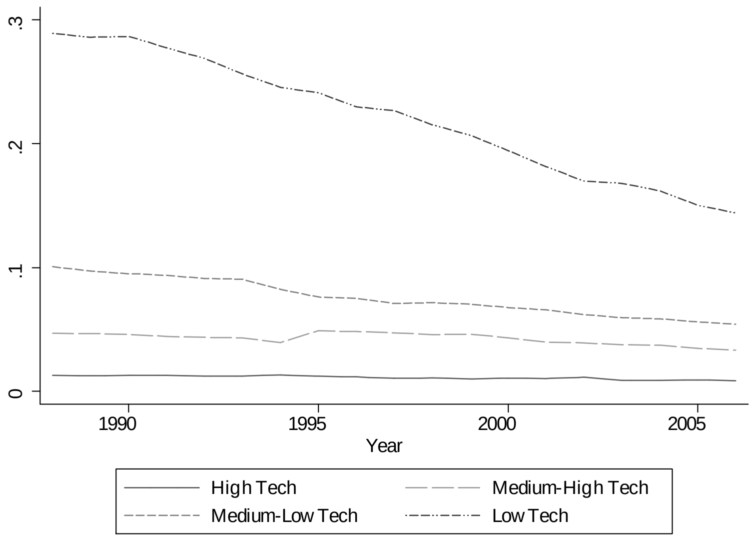

Figure 1: Share of employment by technology level

technology sectors. Low and medium-low technology sectors accounted for over 80% of total manufacturing employment: 86.6% in 1988 and 82.4% in 2006. In this period, these sectors lost over 150 000 jobs, i.e., these sectors accounted for all the manufacturing jobs lost in this period. In particular, more than 80% of these lost jobs were in Textiles, textile products, leather and footwear. Nevertheless, this sector stands throughout the period as the largest employer among the 20 sectors. Medium-high and high technology sectors increased the number of jobs slightly over the same period. Within these sectors, Motor vehicles, trailers and semi-trailers and Machinery and equipment nec were the largest employers and increased significantly in relative terms between 1988 and 2006 (Table 10 in the Appendix presents the sectors' rank in terms of employment).

One explanation in the literature for the trends described above is movements in exchange rates – see, for example, Campa and Goldberg (2001) and Gourinchas (1999). In section 4 we investigate whether this hypothesis holds for the Portuguese economy. In fact, the period under study (1988-2006) was characterized by an appreciation of the real effective exchange rate over 20% – see Figure 2.

The bulk of this appreciation took place between 1988 and 1992. This period was followed by marginal variations in the real exchange rate until the Portuguese escudo joined the euro. The period since then has again been characterized by an appreciation of approximately 7%. The real aggregate exchange rate presented in Figure 2 was computed using as bilateral weights an average of exports and imports' shares of 29 OECD trade partners plus 24 non-OECD trade partners of Portuguese manufacturing industries. Alexandre, Bação, Cerejeira and Portela (2009) provide a detailed description of

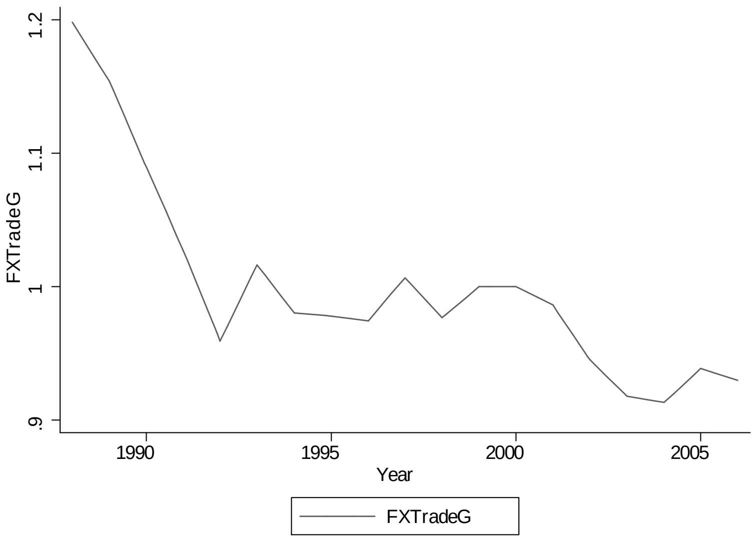

Figure 2: Real effective exchange rate

the computations for a set of alternative effective exchange rates indexes for the Portuguese economy in the period 1988-2006. The results in that paper suggest that the choice of bilateral weights does not make much difference. The set of countries included in exchange rate indexes originates more variation but produces similar trends. A more important issue is whether to use aggregate or sector-specific exchange rates.

When the importance of trading partners varies across sectors, sector-specific exchange rates may be more informative than aggregate exchange rate indexes as indicators of industries' competitiveness – see, for example, Goldberg (2004). In fact, several authors have shown that sector-specific exchange rates are better explanatory variables of labour markets dynamics - see, for example, see, for example, Campa and Goldberg (2001) for the US and Gourinchas (1999) for France. Alexandre et al. (2009) have reached the same conclusion for the Portuguese economy, although the sector-specific and the aggregate exchange rate indexes display very similar patterns - cf. Figure 3, where sector-specific exchange rates for the six most important exporting sectors are presented. Section 4 explores this matter further, taking the different behaviour of high- and low-technology sectors into account. Before that, the next section provides additional information on the characteristics of high- and low-technology sectors in Portugal, especially concerning participation in international trade.

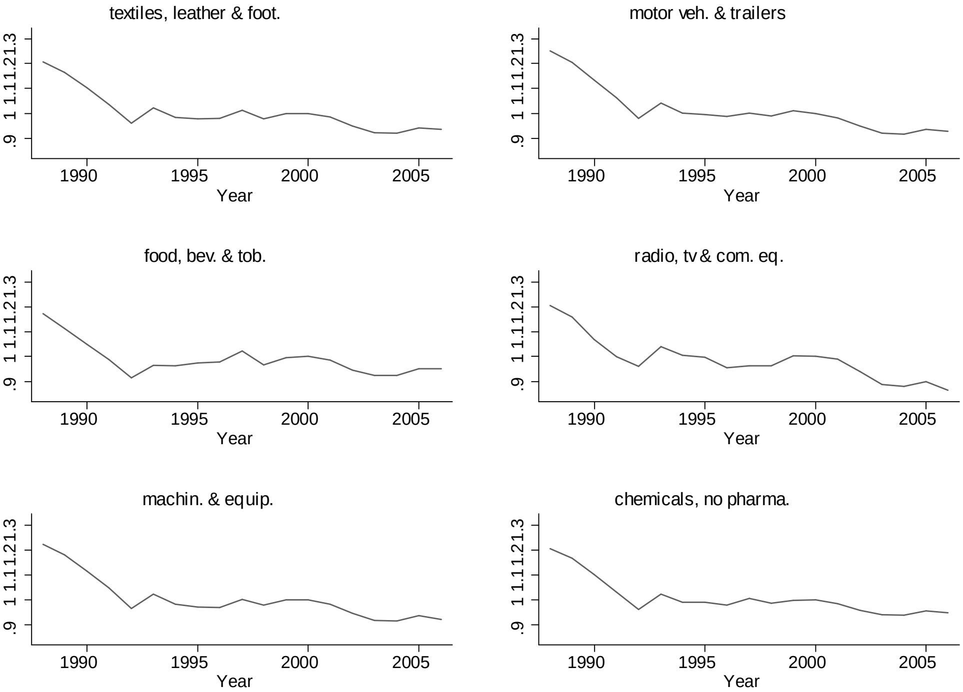

Figure 3: Sector-specific exchange rates

3.2 Trade patterns and technology level

The most noteworthy trend in Portugal's trade patterns in recent decades is the change in trade shares according to sectors' technology level. In Table 1 we present the evolution of the shares in total exports and in total imports according to the OECD classification system which divides sectors into four classes of technology: low, medium-low, medium-high and high. The OECD technology classification ranks industries according to indicators of technology intensity based on R&D expenditures (OECD, 2005). From the analysis of the data it stands out the steady decrease in the share of low-technology sectors' exports, from 62% in 1988 to 33% in 2006. Despite this, in 2006, low-technology sectors still constituted the main exporting sector. Among low-technology sectors, the OECD class Textiles, textile products, leather and footwear registered the largest decrease, from 38.5% in 1988 to 15.6% in 2006. However, throughout the 1988-2006 period this sector remained the leading export sector.

In contrast, in the same period, medium-low, medium-high and high technology sectors have increased their shares in exports from 11.5%, 18.2% and 5.7% to 20.9%, 29% and 11%, respectively (see Table 1). The higher share of medium-high technology sectors in exports reflects the increase in the OECD class Motor vehicles, trailers and semi-trailers from 7% to 13% (see Table 9 in the Appendix). The share of high technology sectors in exports remained low by world standards, but similar to Greece and Spain (Amador et al. 2007: Table 3, pp. 16).

The results presented in Table 1 show that the degree of openness increases with the level of technology.[9] Our openness measure is: $(X + M)/(GO + X + M)$, where X stands for exports, M stands for imports and GO stands for gross output. This may be decomposed as the sum of export share ($X/(GO + X + M)$) and import penetration rate ($M/(GO + X + M)$). From that decomposition we conclude that, in Portugal, imports dominate the openness measure for higher technology sectors. However, the import penetration ratio has been diminishing in these higher technology sectors and increasing in lower technology sectors. Concerning the export share it should be noticed the decrease in low technology sectors and the increase in all other sectors.

The picture that these numbers provide is that of a country that has been losing low-qualification jobs and trying to upgrade its manufacturing sector. The next section attempts to assess the role of the exchange rate in this evolution, making use of the framework presented in section 2.

Table 1: Trade shares, openness and penetration rates for the Portuguese economy

	1988	2006	$\Delta p.p.$
Share in total exports (%)			
High-technologies manufactures	5,7	11,03	5,33
Medium-high technology manufactures	18,23	28,97	10,74
Medium-low technology manufactures	11,49	20,88	9,39
Low technology manufactures	62,01	32,78	-29,23
Share in total imports			
High-technologies manufactures	10,85	14,40	3,55
Medium-high technology manufactures	40,24	28,39	-11,85
Medium-low technology manufactures	12,92	16,05	3,13
Low technology manufactures	20,44	20,68	0,24
Openess $= (X + M) / (GO + X + M)$			
High-technologies manufactures	69,2	74,4	5,2
Medium-high technology manufactures	62,5	68,3	5,8

Continued on next page...

[9] Using data from the STAN bilateral trade database we found that this result also holds for other industrialised countries such as France, Germany, Italy, Spain, the UK and the USA.

... table 1 continued

	1988	2006	$\Delta p.p.$
Medium-low technology manufactures	33,5	46,6	13,1
Low technology manufactures	37,1	44,4	7,3
Export share			
High-technologies manufactures	16,9	23,4	6,5
Medium-high technology manufactures	13,6	27,0	13,4
Medium-low technology manufactures	11,9	21,2	9,3
Low technology manufactures	24,2	22,4	-1,8
Import penetration rate			
High-technologies manufactures	52,3	51,0	-1,3
Medium-high technology manufactures	48,9	41,3	-7,6
Medium-low technology manufactures	21,7	25,4	3,7
Low technology manufactures	12,9	22,0	9,1
Productivity: annual sales per worker (10^3 euros)			$\Delta\%$
High-technologies manufactures	41,2	70,8	71,8
Medium-high technology manufactures	59,2	76,8	29,7
Medium-low technology manufactures	37,2	51,4	38,2
Low technology manufactures	40,5	49,6	22,5

Notes: Authors' computations based on STAN, OECD Bilateral Trade database. $\Delta p.p.$ stands for percentage points change between 1988 and 2006.

4 Estimation and results

In order to disentangle the relevance of trade openness and productivity to the effects of exchange rate movements on employment, implied by equation (6), we implement a three-step strategy. First, we estimate benchmark regressions, like those estimated in Campa and Goldberg (2001) and Klein et al. (2003a), among others, where we include only the exchange rate and its interaction with openness. In a second step we allow the technology level to influence the impact on employment of both the exchange rate and trade openness. Finally, we introduce additional flexibility by estimating the model separately for each technology level. Throughout the analysis we divide our sample in high technology sectors (high and medium-high technology level, according to the

OECD classification) and low technology sectors (low and medium-low technology level, according to the OECD classification).

The baseline specification for the econometric analysis is as follows:

$$\begin{aligned}\Delta y_{jt} = {} & \beta_0 + \beta_1 \Delta ExRate_{j,t-1} + \beta_2 \Delta ExRate_{j,t-1} \times Open_{j,t-1} \\ & + \beta_{1L} \Delta ExRate_{j,t-1} \times Low_j + \beta_{2L} \Delta ExRate_{j,t-1} \times Open_{j,t-1} \times Low_j \\ & + \beta_3 \Delta ShareImp_{j,t-1} + \beta_4 Open_{j,t-1} + \lambda_t + \theta_j + \varepsilon_{jt}, \end{aligned} \quad (7)$$

where Δ denotes first-difference, j refers to sectors and t indexes years. The dependent variables y_{jt} may be either employment (measured as total workers or total hours), job creation, job destruction or gross reallocation (these three variables are defined at the sector level – see section 4.2). $ExRate_{j,t-1}$ is the lagged real effective exchange rate for sector j, where the bilateral weights are given by total trade (exports plus imports) shares.[10] The exchange rate index is defined such that an increase of the index is a depreciation of the currency. This exchange rate is smoothed by the Hodrick-Prescott filter, which filters out the transitory component of the exchange rate.[11] This is the usual procedure in the literature – see, for example, Campa and Goldberg (2001) – as firms, in the presence of hiring and firing costs, are expected to react only to permanent exchange rate variations.

As discussed above, the effects of exchange rates on employment should differ according to the degree of trade openness. Therefore, we include in equation (7) an interaction term for the exchange rate and trade openness, $Open_{j,t-1}$. Similarly, following the discussion of equation (6), we include the interaction of the exchange rate with a dummy variable indicating low technology sectors, Low_j. For additional flexibility of the model's functional form, we also extend this interaction to the sectors' trade openness.

Recent studies have concluded that competition from emerging countries has had a significant impact on manufacturing sectors in industrialized countries – see, for example, Auer and Fischer (2008). The competition from emerging countries may affect Portuguese firms either directly, through their penetration in the domestic market, or indirectly, by reducing exporting firms' external demand. Therefore, to account for competitors from emerging countries,[12] we include in our regressions the variable $ShareImp_{j,t-1}$, which is

[10] Data for exchange rates were computed in Alexandre et al. (2009) and are available at http://www3.eeg.uminho.pt/economia/nipe/docs/2009/DATA_NIPE_WP_13_2009.xls.

[11] Following Ravn and Uhlig (2002), the smoothing parameter was set equal to 6.25.

[12] The set of emerging countries includes Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Litunia, Poland, Romania, Slovak Republic, Slovenia, China, Chinese Taipei, Kong Kong, India, Indonesia, Malasya, Philippines, Singapore, Thailand.

the share of these countries in sector j OECD countries' imports.[13]

The model also includes a set of time dummies, λ_t, in order to control for any common aggregate time varying shocks that are potentially correlated with exchange rates, and a set of sectoral dummies θ_j. Since we specify a model in first-differences, these dummies account for sector-specific trends. Finally, ε_{jt} is a white noise error term. All variables are in real terms. The model is estimated by OLS, with robust standard errors allowing for within-sector correlation.[14]

4.1 Results: exchange rates and employment

Tables 2 and 3 summarize the results for the model specified in equation (7), using employment and hours as dependent variables. The first two columns of Table 2 show the results for the effect of real exchange rates using the benchmark regression, ALL. Columns (3) and (4), under FULL, extend this specification by including the level of technology. The next two sets of regressions, columns (5) and (6), and columns (7) and (8), respectively, implement the estimation of the model for the high-technology sectors, HighTech, and low-technology sectors, LowTech. Even-numbered columns include sectoral dummies.[15]

In the top panel of Table 2 we show the estimated coefficients and their standard errors. In order to assess the roles of openness and technology in the sensitivity of employment to exchange rate movements we compute exchange rate elasticities of employment for different degrees of trade openness, which are shown in the second part of the table. In our analysis we consider a low, a median and a high degree of openness. We measure these as three percentiles of the degree of openness: 10, 50 and 90.

Looking at the benchmark regressions (ALL), which do not control for the technology level, we observe that the interaction term between the exchange and openness is statistically significant and positive. This result seems to corroborate the results of Klein et al. (2003a), that is, the effect of the exchange rate on employment is magnified by trade openness.[16]

Computing the exchange rate elasticity of employment at different openness percentiles, its magnitude does increase, going from 0.4 to 2.1 (column 2). However, these

[13] Alternatively, we have included the share of non-OECD imports in Portuguese manufacturing sectors. However, this was not statistically significant in explaining employment variations. Results are available form the authors upon request.

[14] Since we use time dummies to account for aggregate shocks, our identification strategy relies mainly on the inclusion of the sectoral exchange rates. Other sources of heterogeneity are variations in overall level of trade exposure $Open_{j,t-1}$.

[15] Table 14 in the Appendix provides descriptive statistics per sector for the main variables used in our analysis.

[16] Klein et al. (2003a) measure industry openness using a five-year moving average of the ratio of total trade to total market sales.

estimated elasticities are not statistically different from zero.

Nevertheless, the benchmark model ignores Berman et al. (2009) view that productivity influences the exchange rate elasticity of employment. It is to this alternative that we now turn. Specification FULL (columns 3 and 4 in Table 2) introduces the dummy variable Low in the model via additional interactions: (i) $\beta_{1L}\Delta ExRate_{j,t-1} \times Low_j \beta_{2L}$; (ii) $\Delta ExRate_{j,t-1} \times Open_{j,t-1} \times Low_j$. These interactions aim at evaluating the importance of trade openness and technology level for the impact of exchange rate movements on employment. Our results, shown in columns (3) and (4), FULL, indicate that for a high degree of openness, percentile 90, employment in high-technology sectors does not seem to be sensitive to exchange rate movements (the estimated elasticity is 1.5, but not statistically different from zero). However, for low-technology sectors a 1% depreciation of the exchange rate is associated with a 4.8% increase in employment. Moreover, the F-statistic of 5.4 indicates that exchange rate elasticity is different for low- and high-technology sectors. Even though the sign and the magnitude of the elasticities are as expected when the specification includes sectoral dummies – column (4) –, its statistical significance does not hold.

This result appears to support the implications of equation (6), that is, that the level of technology plays a role in the transmission of exchange rate movements to labour markets, and motivates further estimations. Namely, we separate the sample between low- and high-technology sectors for the estimation of equation (7). What stands out in columns (5) and (6), HighTech – high-technology sectors –, is the negative exchange rate elasticity of employment for the less open sectors (percentile 10). For higher degrees of openness the absolute magnitude of the elasticity decreases and becomes statistically insignificant. From a theoretical perspective this result may be explained by the effect of the exchange rate variation on the price of imported inputs, that is, firms that rely heavily on imported inputs may have their competitiveness negatively affected by a depreciation of the exchange rate. Empirically we cannot test this hypothesis as we do not have data on firms' foreign trade.[17]

Proceeding to columns (7) and (8), LowTech – low-technology industries –, we find that a depreciation increases employment growth, and that this effect is larger when the degree of openness is higher. As we shift our attention to low-technology sectors with a higher degree of exposure to external innovations, the impact of exchange rate movements on employment growth becomes clear-cut in terms of economic and statistical significance. Sectors with a high openness degree, that is, in percentile 90, present an exchange rate elasticity of employment of 4.9: a 1% depreciation induces a 4.9% in-

[17] For an empirical analysis of the effect of exchange rate movements on employment, through its effect on the cost of imported inputs, see, for example, Ekholm, Moxnes and Ulltveit-Moe (2008).

crease in low-technology sectors' employment. This estimated elasticity is larger than those reported in the literature for other countries, namely for the US (Revenga, 1992, Campa and Goldberg, 2001) and France (Gourinchas, 1998). The fact that Portugal is a smaller and more open economy may help explain the larger impact of exchange rates on employment in Portugal.

The specification of our regressions controls for the impact of emerging countries competition on domestic employment. The coefficients estimated for the share of emerging countries in sector j OECD countries' imports show that this competition has had a negative and statistically significant impact on employment growth. The statistical significance of this effect is independent of the technology level. However, the impact of the competition of emerging countries' imports seems to be larger for high-technology sectors (HighTech regressions in Table 2). For example, from the analysis of column (8) we conclude that for low-technology sectors a 1 percentage point increase in the share of emerging countries decreases employment by 1.4%.

As a further test, we estimated equation (7) using hours[18] as the dependent variable instead of employment. Table 3 shows the results and follows the layout of Table 2. The figures presented in Table 3 reinforce the results found in the estimates for employment growth (Table 2). The estimates for the FULL specification (which uses the dummy variable *Low* to distinguish high- and low-technology sectors) continue to point to a different impact of exchange rate movements on hours worked according to technology level. For high-technology sectors (see HighTech columns) the exchange rate elasticity of hours is not statistically significant. On the contrary, and most noticeable, hours worked in low-technology sectors are sensitive to exchange rate movements and this sensitivity increases with the degree of openness. In particular, a 1% exchange rate depreciation is associated with a 6.2% increase in the number of hours worked.

Again, the empirical results suggest that both the degree of openness and the technology level mediate the impact of exchange rate movements on employment growth. In particular, we find robust evidence that exchange rate movements affect employment growth in low-technology sectors more than in high-technology sectors and that this effect increases with the degree of openness.

[18] Data for hours is not available for 1990 and 2001.

Table 2: Employment: OLS regressions in first-differences

Model	ALL		FULL		HighTech		LowTech	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\Delta LogExRate_{t-1}$	-.655	-.486	.010	-3.135	-8.310***	-7.632**	-.217	-.045
	(1.376)	(1.505)	(1.910)	(2.605)	(2.903)	(3.127)	(.916)	(.997)
$\Delta LogExRate_{t-1} * Low$			-2.202	1.652				
			(1.544)	(2.117)				
$\Delta LogExRate_{t-1} * Open$	2.666**	3.665**	2.089	6.929**	8.519***	8.380***	8.210***	7.066**
	(1.195)	(1.545)	(2.290)	(2.789)	(2.789)	(2.935)	(2.508)	(2.899)
$\Delta LogExRate_{t-1} * Open * Low$			7.827**	.454				
			(3.580)	(4.351)				
$\Delta ShareImp_{t-1}$	-1.398***	-1.811***	-1.527***	-1.843***	-2.445**	-2.701*	-1.157**	-1.425***
	(.403)	(.567)	(.455)	(.594)	(1.036)	(1.552)	(.485)	(.525)
$Open_{t-1}$	.101***	.211	.104***	.269*	.336***	.309*	.046*	.162
	(.037)	(.149)	(.036)	(.140)	(.065)	(.169)	(.025)	(.209)
Sectoral dummies	no	yes	no	yes	no	yes	no	yes
	Exchange Rate Employment Elasticities							
	Percentile 10							
ExRate Elasticity	.004	.419						
HighTech Elasticity			.526	-1.423	-6.205**	-5.562*		
LowTech Elasticity			.258	.341			1.812	1.700
F-test: equal elasticities			.089	1.850				
	Percentile 50							
ExRate Elasticity	.622	1.268						

Continued on next page...

... table 2 continued

Model	ALL		FULL		HighTech		LowTech	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
HighTech Elasticity			1.010	.183	-4.231*	-3.620		
LowTech Elasticity			2.555	2.052			3.714*	3.338
F-test: equal elasticities			3.145*	3.017*				
				Percentile 90				
ExRate Elasticity	1.215	2.084						
HighTech Elasticity			1.475	1.725	-2.334	-1.754		
LowTech Elasticity			4.763**	3.695			5.542**	4.911*
F-test: equal elasticities			5.388**	1.511				
Observations	360	360	360	360	162	162	198	198
R^2	.124	.177	.14	.186	.22	.23	.252	.32
RMSE	.103	.103	.103	.103	.125	.128	.074	.073

Notes: Significance levels: $*$: 10% $**$: 5% $***$: 1%. The dependent variable in each model is the difference in the log of the variable identified in each section of the Table. All regressions are estimated by OLS, and include time dummies. RMSE is root mean squared error. The exchange rate is the average import/export exchange rate.

Table 3: Hours: OLS regressions in first-differences

Model	ALL		FULL		HighTech		LowTech	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\Delta LogExRate_{t-1}$	1.589	1.816	3.531	.038	-1.748	-.267	1.156	1.487*
	(.975)	(1.115)	(2.375)	(3.000)	(3.076)	(3.135)	(.995)	(.890)
$\Delta LogExRate_{t-1} * Low$			-4.823*	-.030				
			(2.730)	(3.317)				
$\Delta LogExRate_{t-1} * Open$	-.297	-.132	-2.999	1.700	4.532	.377	6.855*	6.735*
	(1.563)	(1.916)	(3.791)	(4.062)	(4.437)	(4.843)	(3.797)	(3.531)
$\Delta LogExRate_{t-1} * Open * Low$			14.669**	4.735				
			(5.963)	(7.241)				
$\Delta ShareImp_{t-1}$	-.237	-.852***	-.401	-.879**	-.591	-1.505**	-.888***	-.846**
	(.489)	(.319)	(.426)	(.392)	(.823)	(.692)	(.263)	(.353)
$Open_{t-1}$	.043	-.132	.045	-.128	.240***	-.206	-.076**	.162
	(.043)	(.128)	(.041)	(.167)	(.082)	(.200)	(.037)	(.235)
Sectoral dummies	no	yes	no	yes	no	yes	no	yes
	Exchange Rate Hours Elasticities							
	Percentile 10							
ExRate Elasticity	1.516	1.783						
HighTech Elasticity			2.790*	.458	-.628	-.174		
LowTech Elasticity			1.592**	1.598			2.850*	3.151*
F-test: equal elasticities			.732	.499				
	Percentile 50							
ExRate Elasticity	1.447	1.753						

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... table 3 continued

Model	ALL		FULL		HighTech		LowTech	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
HighTech Elasticity			2.095**	.852	.422	-.087		
LowTech Elasticity			4.296***	3.089			4.439*	4.712*
F-test: equal elasticities			6.372**	9.189***				
	Percentile 90							
ExRate Elasticity	1.381	1.723						
HighTech Elasticity			1.427*	1.231	1.431	-.003		
LowTech Elasticity			6.894***	4.522			5.965*	6.212*
F-test: equal elasticities			9.331***	2.798				
Observations	280	280	280	280	126	126	154	154
R^2	.117	.205	.15	.214	.222	.274	.335	.377
RMSE	.101	.099	.099	.099	.117	.118	.072	.073

Notes: Significance levels: $*$: 10% $**$: 5% $***$: 1%. The dependent variable in each model is the difference in the log of the variable identified in each section of the Table. All regressions are estimated by OLS, and include time dummies. RMSE is root mean squared error. The exchange rate is the average import/export exchange rate.

4.2 Results: exchange rates and job flows

In this section, we evaluate the impact of exchange rate movements on job creation, job destruction and job reallocation. The analysis of job flows may contribute to a better understanding of the role of openness and technology level on the effect of exchange rate movements on employment growth. Indeed, gross creation and destruction flows are usually one order of magnitude higher that net ones: the same net variation in jobs might be in principle generated by different combination of creation and destruction with diverse welfare implications. As summarized by Klein, Schuh and Triest (2003b), labour adjustment costs arise with hiring and firing costs, particularly training, in case of job creation, and loss of firm-specific human capital, in case of job destruction. Therefore, measures of job creation and destruction provide additional information on the dynamics of labour markets. (Davis, Haltiwanger and Schuh, 1996).

The rate of job creation in sector j, in year t, C_{jt}, and the rate of job destruction, D_{jt}, are defined as

$$C_{jt} = \frac{\sum\limits_{i \in j^+} \Delta E_{it}}{\frac{1}{2}\left(E_{j,t-1} + E_{j,t}\right)} \tag{8}$$

and

$$D_{jt} = \frac{\sum\limits_{i \in j^-} \mid \Delta E_{it} \mid}{\frac{1}{2}\left(E_{j,t-1} + E_{j,t}\right)} \tag{9}$$

where j^+ is the set of firms of sector j for which $\Delta E_{it} > 0$, j^- is the set of firms of sector j for which $\Delta E_{it} < 0$ and $E_{j,t}$ is sector j employment level at year t. Job reallocation is given by the sum of job creation and job destruction rates: $R_{jt} = C_{jt} + D_{jt}$.

Table 11 in the Appendix presents annual average rates of job creation, destruction and reallocation for 20 manufacturing sectors, for OECD technology level sectors and for total sectors in "Quadros de Pessoal". The numbers in Table 11 in the Appendix show that annual job reallocation for the period 1988-2006 was around 21% for manufacturing sectors and 31% for the whole economy. These flows are very large but nevertheless comparable to international evidence on labour market dynamics – see, for example, Haltiwanger, Scarpeta and Schweiger (2006). Job flows in high and medium-high technological level sectors are slightly higher than in low and medium-low technology level sectors. Annual average job reallocation rates in high and medium-high technology level sectors were 25.7% and 23.1%, respectively, against 20.4% and 20.2% in low and medium-low technology level sectors. These differences result from both higher job creation and higher job destruction rates.[19]

In this section we estimate equation (7) using as dependent variables C_{jt}, D_{jt}, and R_{jt} as defined above. Tables 4, 5 and 6 present the results for the creation rate, the destruction rate and the reallocation rate, respectively. As for the creation rate, it should be noticed the negative exchange rate elasticity of job creation for high technology sectors. This result may be related to the negative elasticity of employment found in the previous set of regressions (see HighTech columns in Table 2), which may be related to the impact of exchange rate movements on the price of imported inputs.

As for the destruction rate (Table 5), the noticeable result is the negative effect that a depreciation has on employment destruction for very open (percentile 90) low-technology sectors: a 1% depreciation decreases employment destruction by 3.8%. This result reinforces the findings in previous estimates: exchange rate movements appear to have a larger impact on highly open low-technology sectors and this effect seems to occur through employment destruction. Job destruction in high-technology sectors seems to be immune to exchange rate movements. The inclusion of sectoral dummies makes the exchange rate elasticity for job destruction statistically insignificant, but does not change the sign, nor the economic significance, of the estimated elasticities.

The asymmetry of the response of job creation and job destruction to exchange rate variations is consistent with the idea that costs associated with firm size reductions might be smaller than the ones related with firm growth. This asymmetry may have welfare implications as decreases in job creation and increases in job destruction may carry very different costs for firms and workers. For example, in low-technology sectors, older and less skilled workers are more likely to be dismissed in the process of job destruction. This is an issue that deserves further research.

Finally, Table 6 shows the results for the reallocation rate. The main result is the possibility that a depreciation may produce a 'chill' effect in the labour market, i.e., a reduction in job creation and destruction, and thus in job reallocation (see, e.g., Gourinchas, 1999). Namely, this may occur in the case of high-technology sectors with lower degrees of openness.

[19] Centeno, Machado and Novo (2007) present a description of job creation and destruction in Portugal.

Table 4: Job Creation: OLS regressions in first-differences

Model	ALL		FULL		HighTech		LowTech	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\Delta LogExRate_{t-1}$	-1.300	-1.204	-.188	-3.677	-9.778***	-8.703**	.384	.598
	(1.383)	(1.591)	(2.121)	(2.729)	(3.031)	(3.435)	(.625)	(.555)
$\Delta LogExRate_{t-1} * Low$			-1.640	2.653				
			(1.386)	(1.824)				
$\Delta LogExRate_{t-1} * Open$	1.435	2.122	.008	5.378*	9.364***	8.470***	.540	.534
	(2.046)	(1.699)	(3.182)	(3.135)	(2.944)	(2.558)	(1.802)	(1.673)
$\Delta LogExRate_{t-1} * Open * Low$			3.569	-4.220				
			(2.803)	(3.731)				
$\Delta ShareImp_{t-1}$	.015	-.540*	-.041	-.512	-.672	-1.713***	.089	-.091
	(.334)	(.328)	(.330)	(.338)	(.718)	(.446)	(.212)	(.238)
$Open_{t-1}$	.052	.134	.053	.194**	.373***	.335***	-.048*	-.004
	(.059)	(.098)	(.059)	(.099)	(.074)	(.083)	(.026)	(.054)
Sectoral dummies	no	yes	no	yes	no	yes	no	yes
	Exchange Rate Job Creation Elasticities							
	Percentile 10							
ExRate Elasticity	-.946	-.680						
HighTech Elasticity			-.186	-2.348	-7.464**	-6.610*		
LowTech Elasticity			-.944	-.737			.517	.729
F-test: equal elasticities			.951	2.736				
	Percentile 50							
ExRate Elasticity	-.613	-.189						

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... table 4 continued

Model	ALL		FULL		HighTech		LowTech	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
HighTech Elasticity			-.184	-1.101	-5.295**	-4.647		
LowTech Elasticity			-.115	-.469			.642	.853
F-test: equal elasticities			.020	1.540				
	Percentile 90							
ExRate Elasticity	-.293	.284						
HighTech Elasticity			-.183	.096	-3.210**	-2.762		
LowTech Elasticity			.681	-.211			.763	.972
F-test: equal elasticities			1.085	.094				
Observations	360	360	360	360	162	162	198	198
R^2	.114	.291	.123	.307	.357	.436	.307	.4
RMSE	.05	.046	.049	.045	.058	.056	.029	.027

Notes: Significance levels: $*$: 10% $**$: 5% $***$: 1%. The dependent variable in each model is the difference in the log of the variable identified in each section of the Table. All regressions are estimated by OLS, and include time dummies. RMSE is root mean squared error. The exchange rate is the average import/export exchange rate.

Table 5: Job destruction: OLS regressions in first-differences

Model	ALL		FULL		HighTech		LowTech	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\Delta LogExRate_{t-1}$	-.302	-.317	1.288	1.572	1.907	2.676	-1.486	-1.687
	(1.374)	(1.279)	(1.944)	(1.859)	(2.801)	(2.783)	(2.179)	(1.764)
$\Delta LogExRate_{t-1} * Low$			-1.499	-2.164*				
			(1.613)	(1.234)				
$\Delta LogExRate_{t-1} * Open$	-1.431	-1.923**	-3.662*	-4.437***	-2.140	-3.635	-3.270***	-1.395
	(.876)	(.911)	(1.986)	(1.627)	(2.647)	(2.289)	(1.261)	(.967)
$\Delta LogExRate_{t-1} * Open * Low$			1.168	3.798*				
			(3.211)	(2.170)				
$\Delta ShareImp_{t-1}$	.696**	.404	.681***	.375	1.018	-.082	.198	.531*
	(.281)	(.323)	(.230)	(.305)	(.669)	(.487)	(.144)	(.311)
$Open_{t-1}$	-.026	-.135	-.026	-.181**	.036	-.065	-.046	-.345***
	(.032)	(.083)	(.033)	(.078)	(.045)	(.095)	(.050)	(.063)
Sectoral dummies	no	yes	no	yes	no	yes	no	yes
	Exchange Rate Job Destruction Employment Elasticities							
	Percentile 10							
ExRate Elasticity	-.655	-.792						
HighTech Elasticity			.383	.475	1.378	1.778		
LowTech Elasticity			-.827	-.750			-2.294	-2.031
F-test: equal elasticities			1.924	2.435				
	Percentile 50							
ExRate Elasticity	-.987	-1.238						

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... table 5 continued

Model	ALL		FULL		HighTech		LowTech	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
HighTech Elasticity			-.466	-.553	.882	.936		
LowTech Elasticity			-1.405	-.899			-3.052	-2.355
F-test: equal elasticities			4.980**	.411				
				Percentile 90				
ExRate Elasticity	-1.305	-1.666						
HighTech Elasticity			-1.281	-1.541	.406	.126		
LowTech Elasticity			-1.960	-1.041			-3.780*	-2.665
F-test: equal elasticities			.700	.550				
Observations	360	360	360	360	162	162	198	198
R^2	.172	.308	.186	.314	.236	.349	.248	.372
RMSE	.061	.058	.061	.057	.055	.052	.064	.06

Notes: Significance levels: $*$: 10% $**$: 5% $***$: 1%. The dependent variable in each model is the difference in the log of the variable identified in each section of the Table. All regressions are estimated by OLS, and include time dummies. RMSE is root mean squared error. The exchange rate is the average import/export exchange rate.

Table 6: Job Reallocation: OLS regressions in first-differences

Model	ALL		FULL		HighTech		LowTech	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\Delta LogExRate_{t-1}$	-1.602	-1.521	1.100	-2.105	-7.871***	-6.026**	-1.103	-1.089
	(1.304)	(1.325)	(2.046)	(2.109)	(2.329)	(2.514)	(1.870)	(1.617)
$\Delta LogExRate_{t-1} * Low$			-3.138	.489				
			(1.992)	(1.679)				
$\Delta LogExRate_{t-1} * Open$	.005	.198	-3.654	.941	7.224***	4.834**	-2.730	-.862
	(1.640)	(1.269)	(2.763)	(2.593)	(2.332)	(2.051)	(2.369)	(2.090)
$\Delta LogExRate_{t-1} * Open * Low$			4.737	-.422				
			(3.784)	(3.897)				
$\Delta ShareImp_{t-1}$	.712	-.137	.640	-.137	.346	-1.795***	.286*	.440***
	(.520)	(.547)	(.484)	(.546)	(1.298)	(.690)	(.169)	(.144)
$Open_{t-1}$	.026	-.00006	.027	.013	.410***	.270*	-.094	-.349***
	(.084)	(.166)	(.084)	(.163)	(.093)	(.138)	(.063)	(.063)
Sectoral dummies	no	yes	no	yes	no	yes	no	yes
	Exchange Rate Job Reallocation Elasticities							
	Percentile 10							
ExRate Elasticity	-1.601	-1.472						
HighTech Elasticity			.197	-1.872	-6.086**	-4.832*		
LowTech Elasticity			-1.771	-1.488			-1.777	-1.302
F-test: equal elasticities			3.066*	.189				
	Percentile 50							
ExRate Elasticity	-1.600	-1.426						

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... table 6 continued

Model	ALL		FULL		HighTech		LowTech	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
HighTech Elasticity			-.650	-1.654	-4.412**	-3.712		
LowTech Elasticity			-1.520	-1.367			-2.410	-1.502
F-test: equal elasticities			2.403	.147				
				Percentile 90				
ExRate Elasticity	-1.599	-1.382						
HighTech Elasticity			-1.463	-1.445	-2.804*	-2.635		
LowTech Elasticity			-1.279	-1.252			-3.018	-1.693
F-test: equal elasticities			.040	.020				
Observations	360	360	360	360	162	162	198	198
R^2	.151	.34	.166	.34	.318	.47	.266	.379
RMSE	.083	.076	.083	.076	.086	.078	.072	.068

Notes: Significance levels: $*$: 10% $**$: 5% $***$: 1%. The dependent variable in each model is the difference in the log of the variable identified in each section of the Table. All regressions are estimated by OLS, and include time dummies. RMSE is root mean squared error. The exchange rate is the average import/export exchange rate.

5 Conclusion

Several studies have shown that the degree of openness is an important determinant of the impact of exchange rate movements on labour markets. More recent theoretical and empirical work has highlighted instead the role of productivity. The contribution of this paper is to show that both these variables matter in the determination of the exchange rate elasticity of labour demand. Therefore, in order to capture the effect of exchange rate changes in employment, hours and job flows, we estimated a model (using Portuguese data) that includes both a measure of openness and a measure of productivity, interacted with the exchange rate. Our estimates suggest that low-technology sectors very exposed to international competition suffer the most from exchange rate changes. Estimations using job flows suggest that the impact of exchange rates on these sectors occurs through employment destruction. On the contrary, high-technology sectors seem to be insensitive to exchange rate shocks.

Additionally, the estimated elasticities are larger than those estimated for more advanced economies. The fact that Portugal is a very open economy and specialized in low-technology products may explain these results.

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6 Appendix

Table 7: List of Sectors

Sector	ISIC Rev. 3
food products, beverages and tobacco	15 - 16
textiles, textile products, leather and footwear	17 - 19
wood and products of wood and cork	20
pulp, paper, paper products, printing and publishing	21 - 22
chemicals excluding pharmaceuticals	24, excl. 2423
pharmaceuticals	2423
rubber and plastics products	25
other non-metallic mineral products	26
iron and steel	271 + 2731
non-ferrous metals	272 + 2732

Continued on next page...

... table 7 continued

Sector	ISIC Rev. 3
fabricated metal products, except machinery and equipment	28
machinery and equipment, nec	29
office, accounting and computing machinery	30
electrical machinery and apparatus, nec	31
radio, television and communication equipment	32
medical, precision and optical instruments, watches and clocks	33
motor vehicles, trailers and semi-trailers	34
building and repairing of ships and boats	351
railroad equipment and transport equipment nec	352 + 359
manufacturing nec	36 - 37

Table 8: Exports by Sector and Technology Level: Total exports (US 10^3 dollars), sector share and rank

	1988			2006		
Sector	*Ex*	*S*	*R*	*Ex*	*S*	*R*
pharmaceuticals	88133	0.008	14	453816	0.012	17
office, accounting and computing machinery	66290	0.006	16	748174	0.020	15
radio, television and communication equipment	371430	0.035	8	3039757	0.080	4
medical, precision and opt. inst., watches, clocks	64578	0.006	18	374783	0.010	18
aircraft and spacecraft	38257	0.004	20	99656	0.003	20
high-technology manufactures	628689	0.060	4	4716186	0.124	4
chemicals excluding pharmaceuticals	617246	0.059	6	2462823	0.065	6
machinery and equipment, nec	361495	0.035	9	2572785	0.068	5
electrical machinery and apparatus, nec	297018	0.028	10	1678416	0.044	9
motor vehicles, trailers and semi-trailers	721393	0.069	5	5482275	0.144	2
railroad equipment and transport equipment nec	12225	0.001	21	188601	0.005	19
medium-high technology manufactures	2009377	0.192	2	12384899	0.326	2
rubber and plastics products	134250	0.013	13	1689521	0.045	8
other non-metallic mineral products	431736	0.041	7	1711633	0.045	7
iron and steel	66259	0.006	17	1084494	0.029	14
non-ferrous metals	75396	0.007	15	633388	0.017	16
fabricated metal products, except mach and equip	239127	0.023	11	1615982	0.043	10
building and repairing of ships and boats	44271	0.004	19	87711	0.002	21
medium-low technology manufactures	991038	0.095	3	6822730	0.180	3

Continued on next page...

... table 8 continued

	1988			2006		
Sector	*Ex*	*S*	*R*	*Ex*	*S*	*R*
food products, beverages and tobacco	812261	0.078	3	3076193	0.081	3
textiles, textile products, leather and footwear	4245899	0.406	1	6657559	0.175	1
wood and products of wood and cork	731368	0.070	4	1582630	0.042	11
pulp, paper, paper products, printing and pub	853416	0.082	2	1565557	0.041	12
manufacturing nec	194072	0.019	12	1135634	0.030	13
low technology manufactures	6837016	0.653	1	14017573	0.369	1
Total exports	10466119			37941388		

Note: in the column title 'Ex' stands for exports, 'S' for share and 'R' for rank; numbers stand for years. Export values are in current values.

Table 9: Imports by Sector and Technology Level: Total imports (US 10^3 dollars), sector share and rank

	1988			2006		
Sector	*Im*	*S*	*R*	*Im*	*S*	*R*
pharmaceuticals	288493	0.020	15	2396052	0.046	8
office, accounting and computing machinery	488890	0.033	8	1533581	0.030	13
radio, television and communication equipment	758549	0.051	6	4262404	0.082	6
medical, precision and opt. inst., watches, clocks	352934	0.024	13	1375875	0.027	15
aircraft and spacecraft	55028	0.004	19	703127	0.014	18
high-technology manufactures	1943895	0.132	3	10271038	0.198	3
chemicals excluding pharmaceuticals	1671470	0.113	3	5196197	0.100	3
machinery and equipment, nec	2312008	0.157	2	4469612	0.086	5
electrical machinery and apparatus, nec	463250	0.031	9	1865671	0.036	10
motor vehicles, trailers and semi-trailers	2706021	0.184	1	7176663	0.139	1
railroad equipment and transport equipment nec	53892	0.004	20	224804	0.004	20
medium-high technology manufactures	7206641	0.489	1	18932946	0.366	1
rubber and plastics products	378555	0.026	12	1653024	0.032	12
other non-metallic mineral products	243315	995673	0.019	17		
iron and steel	587824	0.040	7	2685929	0.052	7
non-ferrous metals	388547	0.026	10	1895516	0.037	9
fabricated metal products, except mach and equip	298798	0.020	14	1495433	0.029	14
building and repairing of ships and boats	35974	0.002	21	52798	0.001	21
medium-low technology manufactures	1933012	0.131	4	8778372	0.170	4

Continued on next page...

... table 9 continued

	1988			2006		
Sector	*Im*	*S*	*R*	*Im*	*S*	*R*
food products, beverages and tobacco	1415829	0.096	5	5478461	0.106	2
textiles, textile products, leather and footwear	1546021	4588713	0.089	4		
wood and products of wood and cork	62355	0.004	18	92207	0.011	19
pulp, paper, paper products, printing and pub	385853	0.026	11	1775249	0.034	11
manufacturing nec	251414	0.017	16	1355517	0.026	16
low technology manufactures	3661473	0.248	2	13790147	0.266	2
Total imports	14745021			51772504		

Note: in the column title 'Im' stands for imports, 'S' for share and 'R' for rank; numbers stand for years. Import values are in current values.

Table 10: Employment by Sector: number of workers, sector share and rank

	1988			2006		
Sector	*W*	*S*	*R*	*W*	*S*	*R*
pharmaceuticals	7172	0.008	16	5904	0.008	16
office, accounting and computing machinery	1243	0.001	20	1198	0.002	21
radio, television and communication equipment	13305	0.015	15	12373	0.017	13
medical, precision and opt. inst., watches, clocks	4336	0.005	19	6136	0.008	14
aircraft and spacecraft	89	0.000	21	1938	0.003	20
high-technology manufactures	26145	0.029	4	27549	0.037	4
chemicals excluding pharmaceuticals	29879	0.033	8	15664	0.021	12
machinery and equipment, nec	24573	0.028	9	38849	0.052	8
electrical machinery and apparatus, nec	16130	0.018	12	16529	0.022	11
motor vehicles, trailers and semi-trailers	18063	0.020	11	29481	0.040	9
railroad equipment and transport equipment nec	5091	0.006	18	2962	0.004	19
medium-high technology manufactures	93736	0.105	3	103485	0.139	3
rubber and plastics products	22185	0.025	10	24378	0.033	10
other non-metallic mineral products	64109	0.072	4	54450	0.073	4
iron and steel	15821	0.018	13	6027	0.008	15
non-ferrous metals	5466	0.006	17	5287	0.007	17
fabricated metal products, except mach and equip	72717	0.082	3	73767	0.099	3
building and repairing of ships and boats	14753	0.017	14	4203	0.006	18
medium-low technology manufactures	195051	0.219	2	168112	0.225	2

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... table 10 continued

	1988			2006		
Sector	*W*	*S*	*R*	*W*	*S*	*R*
food products, beverages and tobacco	103711	0.116	2	102122	0.137	2
textiles, textile products, leather and footwear	332766	0.373	1	212525	0.285	1
wood and products of wood and cork	49305	0.055	5	39679	0.053	7
pulp, paper, paper products, printing and pub	45127	0.051	7	42297	0.057	6
manufacturing nec	46261	0.052	6	49783	0.067	5
low technology manufactures	577170	0.647	1	446406	0.599	1
Total employment in manufacturing sectors	892102			745552		
Employment	4469233			5126086		
Share of manufacturing sectors in labour force		0.244			0.181	

Note: in the column title 'W' stands for workers, 'S' for share and 'R' for rank. Employment data is retrieved from STAN, while the remaining data is from 'Quadros de Pessoal' dataset.

Table 11: Job Creaction and Job Destruction by Sector (annual average, 1988-2006)

Sector	C	sdC	D	sdD	R	sdR
pharmaceuticals	0.076	0.062	0.093	0.042	0.169	0.075
office, accounting and computing machinery	0.145	0.076	0.135	0.067	0.280	0.117
radio, television and communication equipment	0.154	0.082	0.146	0.075	0.300	0.138
medical, precision and opt. inst., watches, clocks	0.107	0.052	0.108	0.050	0.215	0.096
aircraft and spacecraft	1.977	4.363	0.821	1.691	2.798	4.419
high-technology manufactures	0.131	0.033	0.127	0.031	0.257	0.060
chemicals excluding pharmaceuticals	0.058	0.031	0.077	0.047	0.135	0.075
machinery and equipment, nec	0.135	0.031	0.139	0.040	0.275	0.059
electrical machinery and apparatus, nec	0.173	0.096	0.176	0.101	0.349	0.120
motor vehicles, trailers and semi-trailers	0.140	0.115	0.116	0.058	0.256	0.142
railroad equipment and transport equipment nec	0.051	0.092	0.073	0.043	0.124	0.125
medium-high technology manufactures	0.114	0.015	0.118	0.015	0.231	0.025
rubber and plastics products	0.094	0.034	0.090	0.036	0.185	0.058
other non-metallic mineral products	0.096	0.035	0.104	0.031	0.200	0.054
iron and steel	0.036	0.029	0.066	0.073	0.102	0.096
non-ferrous metals	0.093	0.051	0.089	0.045	0.182	0.076
fabricated metal products, except mach and equip	0.130	0.036	0.117	0.035	0.247	0.061
building and repairing of ships and boats	0.045	0.038	0.082	0.068	0.127	0.074
medium-low technology manufactures	0.100	0.018	0.102	0.016	0.202	0.032
food products, beverages and tobacco	0.102	0.025	0.104	0.028	0.206	0.050
textiles, textile products, leather and footwear	0.089	0.039	0.108	0.032	0.197	0.058
wood and products of wood and cork	0.102	0.038	0.111	0.029	0.213	0.061

Continued on next page...

... table 11 continued

Sector	C	sdC	D	sdD	R	sdR
pulp, paper, paper products, printing and pub	0.098	0.035	0.101	0.037	0.199	0.061
manufacturing nec	0.123	0.038	0.122	0.037	0.246	0.062
low technology manufactures	0.096	0.024	0.108	0.028	0.204	0.049
Total in the 21 sectors	0.100	0.014	0.108	0.016	0.208	0.029
QP: Total Sectors	0.169	0.069	0.140	0.053	0.309	0.121

Note: Authors' computations based on Portugal (1988-2006). C, D and R are rates of job creation, destruction, and reallocation, respectively, while sdC, sdD, and sdR, are theirs standard-deviations.

Table 12: Job Creaction and Job Destruction by Year and Technological Sector

	High		Med-High		Med-Low		Low	
Year	C	D	C	D	C	D	C	D
1989	0.204	0.120	0.172	0.074	0.163	0.092	0.186	0.086
1990	0.118	0.071	0.092	0.096	0.117	0.097	0.131	0.095
1991	0.151	0.145	0.131	0.127	0.105	0.107	0.111	0.107
1992	0.094	0.129	0.090	0.098	0.098	0.106	0.096	0.122
1993	0.092	0.130	0.111	0.138	0.082	0.116	0.076	0.138
1994	0.231	0.163	0.110	0.147	0.113	0.190	0.128	0.166
1995	0.065	0.076	0.132	0.089	0.092	0.097	0.090	0.111
1996	0.127	0.066	0.097	0.103	0.098	0.094	0.088	0.108
1997	0.063	0.077	0.103	0.063	0.112	0.087	0.107	0.098
1998	0.118	0.184	0.105	0.068	0.117	0.094	0.097	0.097
1999	0.120	0.095	0.124	0.093	0.108	0.086	0.093	0.100
2000	0.102	0.086	0.139	0.107	0.116	0.099	0.095	0.111
2001	0.132	0.153	0.093	0.132	0.132	0.109	0.120	0.135
2002	0.136	0.151	0.078	0.112	0.098	0.110	0.096	0.140
2003	0.049	0.095	0.053	0.102	0.080	0.128	0.082	0.131
2004	0.071	0.075	0.058	0.095	0.082	0.109	0.074	0.120
2005	0.088	0.075	0.057	0.094	0.081	0.105	0.074	0.124
2006	0.090	0.138	0.060	0.091	0.081	0.102	0.076	0.124

Note: Authors' computations based on Portugal (1988-2006). C and D are rates of job creation and destruction. High, Med-High, Med-Low and Low refer to the OECD technology level classification.

Table 13: Trade Opennes by Sector and Year

Sector	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
food, bev. & tobacco	0.21	0.20	0.21	0.22	0.22	0.22	0.24	0.26	0.26	0.27	0.28	0.30	0.31	0.31	0.31	0.31	0.31	0.32	0.34
text., leather & foot.	0.36	0.37	0.40	0.40	0.41	0.40	0.41	0.42	0.42	0.43	0.43	0.44	0.45	0.46	0.46	0.45	0.45	0.46	0.46
wood & cork	0.32	0.32	0.32	0.30	0.30	0.29	0.31	0.30	0.32	0.33	0.32	0.33	0.35	0.35	0.35	0.34	0.34	0.34	0.35
pulp, paper, print.	0.28	0.29	0.29	0.29	0.30	0.31	0.31	0.33	0.32	0.33	0.33	0.34	0.36	0.36	0.36	0.37	0.35	0.34	0.35
chemicals, ex. pharm.	0.42	0.42	0.45	0.47	0.48	0.49	0.53	0.54	0.55	0.56	0.57	0.60	0.60	0.60	0.62	0.61	0.61	0.63	0.63
pharmaceuticals	0.42	0.38	0.39	0.37	0.39	0.41	0.43	0.47	0.48	0.46	0.53	0.56	0.59	0.63	0.63	0.65	0.66	0.65	0.67
rubber and plast. prod.	0.27	0.29	0.33	0.36	0.39	0.40	0.43	0.46	0.47	0.49	0.49	0.50	0.51	0.50	0.52	0.52	0.51	0.49	0.50
other non-met. min. prod.	0.18	0.18	0.19	0.19	0.19	0.19	0.20	0.21	0.21	0.21	0.21	0.22	0.22	0.22	0.23	0.24	0.24	0.27	0.27
iron and steel	0.48	0.47	0.47	0.54	0.54	0.49	0.59	0.57	0.58	0.58	0.61	0.64	0.62	0.63	0.65	0.62	0.63	0.62	n.a.
non-ferrous metals	0.51	0.52	0.52	0.56	0.58	0.57	0.57	0.64	0.64	0.67	0.67	0.69	0.75	0.74	0.73	0.73	0.71	0.74	n.a.
fab. metal prod., ex. mach.	0.19	0.19	0.21	0.22	0.23	0.21	0.23	0.26	0.28	0.28	0.29	0.30	0.31	0.31	0.32	0.31	0.32	0.33	0.34
machinery & equip.	0.62	0.63	0.64	0.63	0.64	0.62	0.60	0.60	0.62	0.63	0.62	0.63	0.64	0.64	0.61	0.61	0.61	0.62	0.62
office, account. & comp.	0.96	0.96	0.93	0.91	0.94	0.91	0.86	0.88	0.88	0.86	0.87	0.86	0.90	0.93	0.91	0.92	0.92	0.92	0.92
electrical mach.	0.40	0.44	0.50	0.53	0.54	0.55	0.56	0.54	0.56	0.56	0.55	0.56	0.58	0.55	0.57	0.57	0.56	0.56	0.56
radio, tv & com.	0.56	0.57	0.58	0.58	0.59	0.56	0.56	0.60	0.58	0.61	0.64	0.65	0.65	0.65	0.64	0.64	0.62	0.62	0.64
medical & opt. inst.	0.73	0.72	0.76	0.71	0.71	0.68	0.66	0.65	0.65	0.67	0.68	0.71	0.75	0.72	0.70	0.68	0.68	0.70	0.69
motor vehicles	0.71	0.69	0.67	0.67	0.70	0.69	0.70	0.64	0.63	0.63	0.66	0.68	0.69	0.68	0.67	0.67	0.68	0.68	0.67
build & rep. of ships	0.26	0.44	0.40	0.18	0.38	0.35	0.36	0.29	0.28	0.34	0.25	0.21	0.25	0.23	0.24	0.26	0.37	0.30	0.25
railroad equip. & trans.	0.17	0.18	0.60	0.66	0.70	0.74	0.51	0.51	0.44	0.45	0.50	0.55	0.39	0.40	0.37	0.38	0.38	0.39	0.41
manufacturing nec	0.30	0.32	0.33	0.34	0.31	0.29	0.28	0.28	0.29	0.31	0.31	0.33	0.33	0.33	0.34	0.36	0.37	0.38	0.39

Note: Authors' computations. Trade openness was computed according to the formula $(X+M)/(GO+X+M)$, as described in Section 3.2.

Table 14: Descriptive statistics for the year 2006

Sector	$\Delta Emp.$	$\Delta Hours$	C	D	R	$\Delta ExRate$	$\Delta ExRate * O$	$\Delta ShareImp$	$Open$
food products, beverages and tobacco	0.004	0.028	0.079	0.079	0.158	-0.001	-0.000	0.011	0.324
textiles, textile products, leather and footwear	-0.050	-0.009	0.079	0.135	0.213	-0.005	-0.002	0.035	0.459
wood and products of wood and cork	-0.040	-0.028	0.076	0.109	0.185	-0.005	-0.002	0.007	0.342
pulp, paper, paper products, printing and publishing	-0.041	0.025	0.061	0.083	0.144	-0.004	-0.001	0.008	0.341
chemicals excluding pharmaceuticals	-0.030	0.020	0.057	0.081	0.137	-0.004	-0.002	0.013	0.628
pharmaceuticals	-0.164	0.108	0.051	0.121	0.171	-0.008	-0.005	0.003	0.648
rubber and plastics products	-0.034	0.001	0.059	0.060	0.119	-0.004	-0.002	0.018	0.494
other non-metallic mineral products	-0.058	-0.024	0.057	0.108	0.165	-0.001	-0.000	0.021	0.265
iron and steel	0.086	0.020	0.057	0.038	0.095	0.005	0.003	0.011	0.619
non-ferrous metals	0.014	0.066	0.081	0.069	0.150	-0.005	-0.004	-0.003	0.741
fabricated metal products, except machinery and equipment	-0.009	-0.003	0.105	0.097	0.202	-0.003	-0.001	0.017	0.327
machinery and equipment, nec	-0.017	0.009	0.076	0.071	0.147	-0.007	-0.005	0.011	0.624
office, accounting and computing machinery	0.006	0.113	0.199	0.143	0.342	-0.016	-0.014	0.018	0.921
electrical machinery and apparatus, nec	-0.086	-0.039	0.058	0.109	0.167	-0.004	-0.002	0.012	0.559
radio, television and communication equipment	-0.073	0.074	0.116	0.194	0.310	-0.019	-0.012	0.028	0.625
medical, precision and optical instruments, watches and clocks	0.036	0.108	0.090	0.079	0.169	-0.012	-0.009	0.006	0.700
motor vehicles, trailers and semi-trailers	-0.035	0.000	0.046	0.077	0.123	-0.006	-0.004	0.007	0.678
building and repairing of ships and boats	0.072	0.028	0.185	0.129	0.315	0.004	0.001	0.014	0.302
railroad equipment and transport equipment nec	0.039	-0.043	0.056	0.055	0.111	-0.013	-0.005	-0.001	0.393
manufacturing nec	-0.010	-0.012	0.080	0.123	0.203	-0.004	-0.002	0.014	0.376

Note: Authors' computations; $\Delta Emp.$ stands for annual change in sectoral employment.

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