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Sectoral Employment Effects of Trade and Productivity in a Small Open Economy

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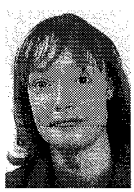

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ABSTRACT

This paper assesses the impact of trade and technology on Belgian industrial employment. A framework is developed which incorporates employment effects of (i) export expansion (ii) import competition and (iii) labour saving productivity improvements. In this context, evidence is found for the hypothesis that international trade induces adjustments in technology.

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I. INTRODUCTION

In recent years, a growing number of articles investigate the impact of international trade on labour markets. Most of the papers focus on the US experience and view international trade specialisation as one possible explanation why relative wages and employment prospects of unskilled workers have deteriorated. Although dissenting opinions exist (Wood (1994)), the consensus view is that international trade only plays a minor role and that the primary driving force of US labour markets trends is skill-biased technological change (Berman, Bound and Griliches (1994), Krugman and Lawrence (1996)).

This paper studies the impact of international trade on sectoral employment in Belgium. There are three valid reasons for doing so. First, Belgium is one of the most open economies in the world economy with an export/GDP ratio of 88% in 2000 compared to 10% in the US[1]. Krugman (1995) among others argues that the evolution of exports and imports cannot explain US labour market developments because the US economy is just not open enough for trade to matter a lot. Turning this argument around, we expect significant employment effects from trade in Belgium. In other words, trade is likely to be relevant for Belgian employment. This hypothesis is widely shared by Belgian policy-makers and business representatives who experience living in an international environment as a fact of everyday life.

The second motivation for considering Belgium is that it represents a typical example of a European economy with rigid labour markets. In 2001, the Belgian unemployment rate stood at 6.9%[2]. Minimum wages, strong unions and other institutional features prevent wages from going down in order to bring down unemployment (Van Pouck and Van Rompuy (1995)). As pointed out by several authors (Davis (1998), Nickell and Bell (1996)) employment levels rather than relative wages will absorb trade shocks in those circumstances. Moreover, the reallocation between sectors in Belgium and several others European countries is slow and quite limited due to insufficient labour mobility and generous unemployment benefits (see Decressin and Fatas (1995), for a comparison of the US and the European experience). This justifies a detailed look at trade-related employment changes at the sectoral level and would imply that the assumption of full labour mobility in conventional trade models serves at best as a long-run approximation. In the Belgian case, it is also important to consider hiring and firing costs which make changes in employment more difficult.

A third and final reason for considering Belgium concerns the dichotomy between technical change and international trade that underlies the debate on US labour market developments. International trade and technological progress are seen as mutually exclusive explanations of employment changes. In Belgium however, business leaders and company surveys usually emphasise the link between international trade and the introduction of new technologies and production methods (see Abraham and Konings (1999)). Export expansion gives rise to productivity gains and in the case of import competition companies may end up restructuring. Theoretically speaking, this means that trade variables influence productivity and therefore indirectly affect employment. Hence, a distinction should be made between direct and technology-induced indirect effects of trade on employment. An innovation of this paper is to develop a framework that allows us to empirically distinguish between those direct and indirect effects.

The remainder of the paper is structured as follows. In the next paragraph, we analyse the relation between trade, technology and labour markets based on the existing theoretical and empirical literature. In Section II, we derive a European model for employment adjustments that serves as the basis for the empirical work. The third section presents the estimation results. The paper ends with a summary of the main insights.

II. REVIEW OF THE LITERATURE

The Hecksher-Ohlin-Samuelson (HOS) theory is the most common framework to address the employment effects of trade. This theory is based on assumptions of perfect intersectoral mobility of all production factors and full employment[3]. International trade leads – through a world-wide equalisation of product prices – to a specialisation according the relative abundance of production factors.

In a stylised version of the model that is typically applied to industrialised countries like Belgium, two types of labour (skilled and unskilled) are employed in a skill-intensive export sector and an import-competing sector with relatively more unskilled labour.

From a sectoral perspective, an expansion of trade leads to an increase in demand for goods of the export sector which creates new jobs in this sector. We define the positive relation between an expansion of export demand and total sectoral employment as the *export demand effect.*

On the other hand, the import-competing sector experiences increased competition from countries with a relative abundance of cheap unskilled labour. Due to import competition, jobs are lost. The negative impact of import competition on total sectoral employment is called the *import competition effect* in this paper.

In the HOS framework, laid-off workers reallocate from the import competing to the export sector maintaining full employment of skilled and unskilled labour at the expense of declining relative wages for unskilled workers. This is clearly a less suitable assumption for Belgium and several other unionised European countries that are characterised by downward wage rigidity and low inter-sectoral labour mobility.

Building on the work of Brecher (1974), Davis (1998) considers trade between the US economy with flexible wages and Europe where a minimum wage results in unemployment of unskilled labour. In such a setting, trade primarily causes adjustments in (un)employment rather than in relative wages. More specifically, rising imports of unskilled-intensive products result in lay-offs of unskilled workers who remain unemployed afterwards. As a consequence, import competition results in an increase of the employment ratio of skilled versus unskilled workers in the economy. We label this adjustment as the *human capital effect of international trade.*

The import competition and export demand effects arise naturally in a theoretical framework that analyses the role of unions in the transmission of trade shocks (Brander and Spencer (1988), Driffil and van der Ploeg (1995) Gaston and Treffler (1995) Huizinga (1993), Mezzetti and Dinopoulos (1991), Naylor (1998) and Vandenbussche and Konings (1998)). While the theoretical set-up of the model varies, these papers are cast in terms of inter-firm rivalry in one industry. Import competition takes the form of a decline in output or market share of the domestic firm with respect to its foreign competitor(s). In a straightforward way, this leads to the domestic reduction in the sectoral employment level captured by the import competition effect. The export demand effect follows from the fact that trade integration offers domestic firms the opportunity to penetrate in the foreign market, raising exports and sectoral employment in the home country.

Turning to the impact of technology on employment, the type of technological progress matters a lot. The trade-related literature pays most attention to the hypothesis of skill-biased technological progress due to the introduction of new information technologies. Companies rely more on educated employees and have less need for unskilled workers. This raises the relative employment of skilled versus unskilled workers and hence amounts to a *human capital effect of technology* in all sectors where skill-biased technologies are introduced. If such technological progress is widespread, changes in the skill intensity of most industries will be observed, even if little HOS-driven inter-sectoral reallocation takes place.

Essential in the Belgian context is *labour-saving* technological progress. The high labour costs in the Belgian economy are compensated by cost reductions initiated by process innovation where new labour-saving production processes are introduced. Usually, this involves investments in new machines. These investment costs in new machines are, in contrast to the labour costs, fixed costs for the Belgian companies and are spread over a large production scale. Consequently, the companies' average costs decline (Abraham and Verret (1996)). The induced gains in productivity go hand in hand with falling total employment at the time where the firms adopt the new technology. Likely, labour-saving technological progress will be more pronounced in some sectors than in others. Often the labour-saving technologies are biased against unskilled workers, in which case the reduction in employment is borne by this group of employees. By contrast, technological progress can also be *labour-augmenting*. Investments in R&D may yield new and/or higher quality products which strengthen the position of companies on the home and the world markets and hence create jobs.

To a large extent the empirical literature measures the contribution of international trade to (i) the declining relative wage of unskilled versus skilled labour that is observed in the US and (ii) the shift in labour demand from unskilled to skilled workers in the US and several European countries including Belgium.

There is no consensus on a common methodological approach in empirical work (for a survey see Slaughter and Swagel (1997)). Product price studies relate relative wages and relative employment changes to the international price evolution of unskilled-labour-intensive and skilled-intensive goods. The adjustments in good prices are assumed to reflect the impact of trade specialisation and trade integration[4]. In the factor content approach the amounts of skilled and unskilled labour embodied in export and import flows are computed using input-output tables[5]. Finally, Berman, Bound and Griliches (1994) attribute employment reallocation of low- to high-skill industries to trade specialisation while skill-biased technological progress is assumed to change skill demands within industries.

In spite of the different methodologies, the findings of the various studies are quite robust (see Slaughter and Swagel (1997) and Slaughter (1998) for a survey of the empirical results). International trade only explains a modest part of the evolution of relative wages and relative employment of skilled versus unskilled labour. Skill-biased technological progress appears to be the main driving force. In our terminology, there is no evidence for the human capital effect of international trade but the human capital effect of technology seems to play an important role.

Few studies concentrate on the trade-related total employment changes at the sectoral level but focus rather on the relative position of skilled and unskilled workers. Exceptions are Revenga (1992) for the US and Neven and Wyplosz (1999) for the German, French, Italian and UK manufacturing sector who use a product price methodology and focus on the import competition effect. Revenga finds a statistically significant but small impact of import prices on sectoral employment. Neven and Wyplosz find no clear pattern for the HOS effect of import competition on employment but they do observe a drastic restructuring in unskilled labour intensive industries. The work by Freeman and Revenga (1999) and by Larre (1995) draw a direct link between trade flows and employment in OECD countries. This has the advantage of not having to use international price data which are often of lower quality than the reported trade volumes (see Slaughter and Swagel (1997), p.17-18). Like most of the empirical research, those studies find only small labour market adjustments to international trade.

A growing literature looks at the relation between international trade and productivity. As one of the first, Wood (1994) asserted that international competition leads firms in the advanced economies to raise productivity by focusing on labour-saving innovations. This implies that there is an indirect negative employment effect which we call in this paper *the productivity effect of international trade on employment.*

Looking at this reasoning more carefully, the trade-related productivity effect on employment requires: (i) exports and/or import competition affect technology (measured by productivity) and (ii) this increase in productivity affects employment. Note that, in principle, the first condition can go in both directions. On the one hand, domestic companies may not be able to cope with foreign competition. In this case, internal restructuring in the form of lay-offs does not keep up with the decline in sales so that domestic firms are confronted with falling productivity. This situation is plausible with large hiring and firing costs which are present in the European economies (see Bertola (1990), Grubb and Wells (1993), Bentolila and Bertola (1990), Garibaldi (1998) and Booth (1997)). Such hiring and firing costs unambiguously decrease employment variation in response to various economic shocks. On the other hand, trade may induce firms to successfully introduce productivity-enhancing technologies. For the US, Bernard and Jensen ((1999a) and (1999b)) find no evidence for a positive impact of exports on productivity. Causality goes in the other direction: more productive firms become better exporters. Although the regression results of Lawrence (2000) are very sensitive to specification and estimation technique, import competition has a positive impact on US total factor productivity (TFP). The impact is even larger in unskilled-intensive industries and on average stronger in industries competing with developing countries. With studies for Europe lacking, we further explore the link between international trade and productivity. We also go a step further by explicitly computing the employment effects of trade-related productivity changes.

III. A EUROPEAN MODEL FOR TRADE ADJUSTMENTS

A. *The set-up of the model*

In the following pages, we propose a European model for employment adjustments which explicitly relates changes in labour and total factor productivity to exports and imports in addition to capturing the export demand and import competition effects on sectoral employment. This model serves as a background for the empirical analysis which is the primary focus of this paper. We consider one representative sector for which a model of monopolistic competition is constructed. Product differentiation is consistent with the observation that the EU-countries' trade with each other and the rest of the world is mainly of the intra-industry type. In our derivations, the subscript i refers to a specific country. Assume that there are m countries. In each country, there are n_i identical firms in the representative industry. Therefore, firms within the same country charge the same price.

The worldwide real consumption (X) of the products of a representative industry is expressed in a Dixit-Stiglitz framework. In the following expression, X_i refers to the sectoral production of country i. Because of the assumption of n_i identical firms in the sector of this country i, X_i equals $n_i x_i$ where x_i denotes the production of an individual firm. σ (with $\sigma > 1$) is the elasticity of substitution.

$$X = \left(\sum_{i=1}^{m} X_i^{(\sigma-1)/\sigma} \right)^{\sigma/(\sigma-1)} = \left(\sum_{i=1}^{m} (n_i . x_i)^{(\sigma-1)/\sigma} \right)^{\sigma/(\sigma-1)} \tag{1}$$

Standard utility maximisation (see Dixit and Stiglitz (1977)) yields the following demand function for the output of country i:

$$X_i = n_i . x_i = \left(\frac{p_i}{P} \right)^{-\sigma} . \frac{E}{P} \tag{2}$$

with p_i as the price which prevails for all firms in country $i, P = \left(\sum_{i=1}^{m} p_i^{1-\sigma} \right)^{\frac{1}{1-\sigma}}$ as the price index of manufacturing consumption and $E = p_i X_i$ as the worldwide expenditures on the products of the representative sector. The inverse demand function is then equal to:

$$p_i = \frac{E}{X} \left(\frac{X_i}{X} \right)^{-1/\sigma} = \frac{E}{X} \left(\frac{n_i . x_i}{X} \right)^{-1/\sigma} \tag{3}$$

Next, we turn to the supply side of the model. Total costs of an individual firm in country i are the sum of fixed costs (F_i) and variable costs C_i. The variable costs are determined by the cost of labour (w_i) and capital (r_i). For the variable cost function, a Constant Returns to Scale Cobb-Douglas function is used (see Varian (1984), p. 29).

Therefore, the total costs C_i^{tot} are:

$$C_i^{tot} = F_i + C_i = F_i + K_i.A_i^{-1}.w_i^{\gamma_i}.r_i^{1-\gamma_i} x_i \qquad (4)$$

where $K_i = \gamma_i^{-\gamma_i}.(1-\gamma_i)^{(\gamma_i - 1)}$

In this expression, A_i refers to technological progress and K_i refers to a constant. When using expression (4), declining average costs and economies of scale are introduced. The profits of an individual firm are given by: $\pi_i = p_i x_i - C_i^{tot}$. From expression (3) and assuming that firms are sufficiently small so that they are not able to influence aggregate production when their individual production rises, the perceived elasticity of demand equals σ. When c_i denotes marginal costs, the first order condition reduces to:

$$p_i.\left(1 - \frac{1}{\sigma}\right) = c_i \qquad (5)$$

with $c_i = K_i.A_i^{-1}.w_i^{\gamma_i}.r_i^{1-\gamma_i}$.

Combining expressions (3) and (5) gives the equilibrium sectoral demand/output of a representative sector in country i:

$$X_i = \left(\frac{\sigma}{\sigma - 1}\right)^{-\sigma}.c_i^{-\sigma}.E^{\sigma}.X^{1-\sigma} \qquad (6)$$

For deriving the conditional labour demand (l_i) of an individual firm, we apply Shepard's lemma to (4):

$$l_i = K_i.A_i^{-1}.\gamma_i.w_i^{\gamma_i - 1}.r_i^{1-\gamma_i}.x_i \qquad (7)$$

Because firms within a sector are identical, total sectoral employment equals $L_i = n_i.l_i$:

$$L_i = K_i.A_i^{-1}.\gamma_i.w_i^{\gamma_i - 1}.r_i^{1-\gamma_i}.X_i \qquad (8)$$

Substituting (6) into (8) and using the expression for c_i, labour demand of a representative sector reduces to:

$$\ln(L_i) = G_i + \sigma.\ln(E) - (\sigma - 1).\ln(X) \quad (9)$$
$$- (\gamma_i(\sigma - 1) + 1)\ln(w_i) - (1 - \gamma_i).(\sigma - 1).\ln(r_i)$$
$$+ (\sigma - 1).\ln(A_i)$$

with

$$G_i = (1 - \sigma).\ln(K_i) + \ln(\gamma_i) - \sigma.\ln(\sigma) + \sigma.\ln(\sigma - 1)$$

B. *The export demand effect*

In equation (9), the variable E captures the effect of an expansion in worldwide expenditures on sectoral employment. According to the theoretical model where σ is larger than 1, we expect that an increase in this variable positively influences sectoral labour demand. For the purpose of this paper, we relate this variable E to the export demand effect discussed earlier. For this reason, we measure E by total sectoral real exports (*EXP*).

C. *The import competition effect*

In our model, enhanced foreign competition is captured by an increase in the sectoral output of a foreign country j. With the aid of equations (1) and (9), we compute the impact of increased foreign output on sectoral employment of country i:

$$\frac{\delta \ln(L_i)}{\delta \ln(X_j)} = \frac{\delta \ln(L_i)}{\delta \ln(X)} \cdot \frac{\delta \ln(X)}{\delta \ln(X_j)} = -(\sigma - 1).\left(\frac{P_j.X_j}{E}\right)^{(\sigma-1)/\sigma} < 0 \quad (10)$$

As seen in the above equation, this effect is negative. Moreover, the higher the foreign market share (as measured by $P_j X_j / E$), the stronger the negative impact on domestic sectoral employment. In our empirical work, we measure foreign import competition by the import penetration ratio which is defined as imports divided by the difference between production and net exports.

D. *The productivity-related and total effects of international trade on employment*

In our theoretical model, A_i measures the impact of technology on employment. In our empirical work, we want to distinguish between the cases of labour-saving and labour-augmenting technological progress. In addition, we need an indicator that captures the role of technology. Following a similar methodology as Card et al. (1999), we measure the A_i-variable of expression (9) by two productivity variables in the regression equation for sectoral employment. The first variable we use is value added per worker (VA) which reflects gains in average labour productivity. The other variable, total factor productivity (TFP)[6], measures gains that raise productivity of all production factors. Let $PROD_i$ represent the variable used (VA_i or TFP_i) to predict the A_i-variable of equation (9):

$$(\sigma - 1).\ln(A_i) = \lambda.\ln(PROD_i) + \varepsilon_i \tag{11}$$

Based on equations (9) and (11), we specify the sectoral employment equation:

$$\ln(EMPL_{it}) = \alpha_{i1} + \beta_1.\ln(EXP_{it}) + \chi_1.\ln(IMP_{it}) \tag{12}$$

$$+ \eta_1.\ln(WAGE_{it}) + \lambda_1.\ln(PROD_{it}) + u_{1it}$$

In this expression, i and t now denote industry and time respectively, a_{i1} refers to a dummy which captures omitted industry specific effects and u_{1it} is the error term which represents a combination of the error term of expression (11) and other error terms due to estimation of equation (12). This regression equation provides an estimate of the impact of productivity on employment which is one aspect of the productivity effect of international trade on employment. When λ is positive, increases in productivity are labour-augmenting. If λ is negative, we obtain the case of labour-saving productivity increases[7].

The other aspect of the productivity effect of international trade on employment concerns the impact of trade integration on productivity.

For this purpose, we introduce a second equation where productivity is regressed upon trade and other variables:

$$\ln(PROD_{it}) = \alpha_{i2} + \beta_2 . \ln(EXP_{it}) + \chi_2 . \ln(IMP_{it}) \quad (13)$$

$$+ \delta_2 . \ln(RD_{it}) + \Phi_2 . PAT_{it} + \varphi_2 . \ln(CAP_{it}) + u_{2it}$$

Our main focus in equation (13) is on the regression coefficients for the export and import variable. These coefficients can be positive or negative depending on whether companies successfully improve productivity when faced with international competition or are instead struggling with internal restructuring. The *CAP* variable refers to the capital stock per employee and is included because labour-saving technologies are usually accompanied by investment in new machinery[8]. *RD* are R&D expenditures per employee which act as an input indicator of innovation and *PAT* are the relative granted patents which are a measure for innovative output[9].

Combining the two aspects just mentioned yields the productivity effects of international trade on employment. For this purpose, it is useful to substitute equation (13) into equation (12):

$$\ln(EMPL_{it}) = \alpha_i + \beta . \ln(EXP_{it}) + \chi . \ln(IMP_{it}) \quad (14)$$

$$\eta . \ln(WAGE_{it}) + \delta . \ln(RD_{it}) + \Phi . PAT_{it}$$

$$\varphi . \ln(CAP_{it}) + u_{it}$$

with

$$\alpha_i = \alpha_{i1} + \lambda_1 . \alpha_{i2},\ \beta = \beta_1 + \lambda_1 . \beta_2,\ \chi = \chi_1 + \lambda_1 . \chi_2,\ \eta = \eta_1,\ \delta = \lambda_1 . \delta_2,$$

$$\Phi = \lambda_1 . \Phi_2,\ \varphi = \lambda_1 . \varphi_2 \text{ and } u_{it} = u_{1it} + \lambda_1 . u_{2it}$$

In this equation, the effect of an increase in export demand on employment which occurs via an increase in productivity equals $\lambda_1 . \beta_2$ Analogously, $\lambda_1 \chi_2$ refers to the productivity effect of increased import competition on employment. Equation (14) also yields the total impact of export demand on employment as measured by the β coefficient.

This total effect is the sum of the export demand effect, β_1, and the productivity effect of the exports on employment, $\lambda_1.\beta_2$. Similarly, χ captures the total impact of import competition on trade and consists of the direct (χ_1) and the productivity induced effects ($\lambda_1.\chi_2$) of import competition on sectoral employment.

E. *The human capital effect*

To estimate the human capital effect we consider the employment ratio of skilled and unskilled workers (*RELEMPL*) as the dependent variable of the employment equation. Hence, we estimate:

$$\ln(RELEMPL_{it}) = \alpha_{i1}' + \beta_1' . \ln(EXP_{it}) + \chi_1' . \ln(IMP_{it}) \qquad (15)$$

$$+ \eta_1' . \ln(RELWAGE_{it}) + \lambda_1'(PROD_{it}) + u_{it}$$

If export growth or sharper import competition causes a shift towards more skilled labour, β_1' and χ_1' will be positive. In our terminology, this means that there is evidence for a human capital effect of international trade. A human capital effect of technology is observed when technological progress is biased against unskilled labour in which case λ_1' carries a positive sign.

IV. AN EMPIRICAL INVESTIGATION

A. *Data description and econometric methodology*

We estimate regression equations (12), (13) and (15) for the entire sample of industries. In addition, we classify industries as (i) technology-intensive sectors (ii) skill or non-skill intensive sectors (iii) import competing sectors (iv) industries with strong export orientation and (v) scale-intensive sectors. The motivation for sectoral differentiation based on technology, skill, import and export orientation should be clear from the discussion in Section II. Scale-intensive sectors account for a substantial share of Belgian industrial production. They produce large output volumes to exploit economies of scale. To do so, they invest heavily in labour-saving and capital-intensive production methods. A detailed description of the sectoral classification is found in Appendix A.

Our data set covers 9 sectors of the Belgian manufacturing industry classified according the "International Standard Industrial Classification" (I.S.I.C.) during the period 1978-1994. The sources and construction of the data are discussed in Appendix A. Except import penetration and relative granted patents, all variables are deflated.

Like other trade-related empirical work (e.g. Coe and Helpman (1995)), we first need to confirm whether our data are nonstationary. When the data are nonstationary, we need to use first differences for our estimations. However, using first differences when variables turn out to be cointegrated would be counterproductive, since the long-term relationship between these variables would become obscured (Greene (1997)). We therefore performed several unit root and cointegration tests. First, we computed Dickey-Fuller (DF) and Augmented Dickey-Fuller (ADF) tests for the data of the individual industries. In general, these DF and ADF-tests show that the hypothesis of the presence of a unit root cannot be rejected. However, the power of these tests is very low since we are dealing with only seventeen annual observations in our panel. The work of Im et al. (1996) shows DF and ADF tests which are quite easy to compute when working with panels with a small time and cross-section dimension. Their tests are based on the mean of the unit root statistics of the individual industries. Using the unit root and cointegration tests based on the work of these authors, it turns out that in general the hypothesis of the presence of a unit root of the different variables could not be rejected. Moreover, the cointegration tests showed that the error terms of the regressions are nonstationary most of the time. We however decided to give the regression results as well in levels as in first differences (see Appendix B, C and D) since the econometrics on unit root and cointegration tests for panel data is still in progress and our emphasis is on the theoretical model and the interpretation of the estimated coefficients.

The employment and productivity regression equations constitute a recursive model because the productivity equation does not contain any endogenous variables from the labour demand equation, while this latter equation contains endogenous variables coming from the former equation. More specifically, the employment equation depends on productivity which in turn is explained by a set of exogenous explanatory variables. To capture in the employment equation *only the productivity changes that are explained by import penetration, export demand, capital intensity and technology variables,* we use a two stage least squares approach by substituting the fitted values of the productivity measure obtained by the regression results of equation (13) into equation (12). We furthermore use a fixed effects approach. We deal with an exhaustive sample and Hausman tests show that this fixed effects approach is, in comparison with the random effects, appropriate (Matyas and Sevestre (1996)).

Early regression results pointed to autocorrelation. In order to combine two stage least squares with a correction for autocorrelation, we use the methodology of Fair (1970). The productivity equation is estimated with the aid of a Cochrane-Orcutt iterative technique. In order to estimate the labour demand equation, we first estimate equation (13) without a correction for autocorrelation. The fitted values of this equation are then substituted in equation (12). Then, this equation is also estimated with a Cochrane-Orcutt iterative method. When using this approach, the standard errors of the employment equation are corrected for the use of the generated regressors from the first stage.

To check the robustness of our results, we performed several consistency checks which are not reported but can be obtained from the authors. We estimated regressions taking lags of several explanatory variables. In our view, this was most of all necessary for the R&D variable because investments in R&D take a long time to mature. In general, our results did not significantly change when lagged variables were introduced so that we present the estimation results without any lags.

B. *The export demand effect*

One important theme of this paper is the contribution of international trade to total sectoral employment in the Belgian economy. Tables B.1., B.2., B.3. And B.4. (see Appendix B) show the results for regression equation (12) expressed in levels and first differences when using value added or total factor productivity as the productivity variable. The estimated results of these tables are quite satisfactory. Estimated coefficients of the export demand, import penetration, productivity and labour cost variables usually carry the expected signs and are in most cases statistically significant at the conventional confidence levels.

Table 1 focuses on the export demand effect in greater detail by presenting the regression coefficients for β_1 in equation (12), using various estimation techniques. This table shows evidence of a robust export demand effect. For the full industry sample and estimations in levels (first differences), the elasticity of employment with respect to exports is 0.16 (0.31) and 0.09 (0.20) depending on whether respectively value added per employee or total factor productivity is used as the productivity variable. When using either the estimation results in levels or in first differences, statistically significant regression coefficients for exports are in general higher when VA is used as the productivity variable. Comparing elasticities across the sectoral disaggregates, strong export demand effects are found in the unskilled-intensive and import competing sectors.

To get an idea of the importance of the export demand effect, we compute the accumulated export-induced employment creation in the Belgian manufacturing industry. Tentatively applying an elasticity of 0.16 to the observed growth in real exports in the period 1978-1994, we obtain an accumulated employment creation of manufacturing of 158,169 jobs for the whole period considered. This amounts to 19% of the average manufacturing work force of 810,294 people during this period. This number is substantial and it is therefore unfortunate that the sectoral employment effects of export expansion receive scant attention in the trade-related literature.

TABLE 1

The export demand effect

	VA		TFP	
	levels	first differences	levels	first differences
All industries	0.16**	0.31**	0.09**	0.20*
Unskilled sectors	0.20**	0.54**	0.15*	0.25*
Skill-intensive sectors	0.15**	0.12**	0.11**	–0.51
Export-oriented sectors	0.09**	0.37	0.09**	0.18
Import competing sectors	0.20**	0.28	0.20**	0.19
R&D-oriented sectors	–0.15**	0.85	–0.11**	0.28*
Scale-intensive sectors	0.12**	0.44	0.12**	0.20*

** significance at the 5% level (two-tailed test)

* significance at the 10% level (two-tailed test)

C. *The import competition effect*

Turning to the import competition effect in Table 2, job destruction due to import competition takes place but is in general less dramatic. When value added per worker is used in the estimations in levels (first differences), an increase in import penetration by 10% causes total sectoral employment to decrease by 0.4% (7.7%). For all industries together, the estimated regression coefficients are smaller when total factor productivity is used and even lose statistical significance for the estimations in levels. Regarding sectoral variation, differences between estimation techniques prevent a clear picture. Statistically significant regression coefficients range from −0.23 for export-oriented sectors to −0.03 for the import competing sectors when using estimations in levels. Turning to estimations in first differences, the statistically significant coefficients lie between −0.50 for the unskilled-intensive sectors and −0.11 for the import competing sectors.

Focusing again on the magnitude of the employment adjustments involved, we tentatively apply an elasticity to the observed growth in the import penetration ratio of −0.04. Noting that in Belgium import penetration in manufacturing grew by 49% from 1978-1994, import competition costs the jobs of 16,034 workers or 1% of the average manufacturing labour force during this period. Although some differences between the different estimation techniques are present, this

TABLE 2
The import competition effect

	VA		TFP	
	levels	first differences	levels	first differences
All industries	−0.04**	−0.77**	0.04	−0.15**
Unskilled sectors	−0.03	−0.50**	0.03	−0.14
Skill-intensive sectors	−0.04*	−0.03	−0.01	0.69
Export-oriented sectors	0.02	−0.32	−0.23**	−0.13
Import competing sectors	−0.03*	−0.11**	−0.06*	−0.09
R&D-oriented sectors	−0.02	−0.82	−0.01	−0.18
Scale-intensive sectors	−0.005	−0.34	−0.20**	−0.13

** significance at the 5% level (two-tailed test)
* significance at the 10% level (two-tailed test)

finding fits well within the basic thrust of the literature that import competition is not the main driving force of employment adjustments.

D. *Trade and productivity*

In the analysis of the productivity effects of international trade and employment, one important condition is related to the impact of exports and imports on productivity. The regression results of the productivity equation (13) are given in Tables C.1., C.2., C.3. and C.4. and are summarised in Tables 3 and 4. From Table 3, exports emerge as a statistically significant source of productivity gains in all cases. The elasticity of VA and TFP with respect to exports are respectively 0.33 (0.37) and 0.82 (0.83) when estimations in levels (first differences) are taken. The ranking of the sectoral aggregates varies depending on which estimation method and productivity variable was chosen. Interesting and plausible are the consistently higher coefficients when the total factor productivity variable is used. Export growth appears to raise the efficiency of both capital and labour such that the adjustment in labour productivity captures only one third to half of the gains in total factor productivity.

Our evidence for productivity gains from export growth are in contrast with Bernard and Jensen 's claim that in US manufacturing the causality goes the other way around. To further check their

TABLE 3
The productivity effect of exports

	VA		TFP	
	levels	first differences	levels	first differences
All industries	0.33**	0.37**	0.82**	0.83**
Unskilled sectors	0.46**	0.49**	0.83**	0.86**
Skill-intensive sectors	0.29**	0.34*	0.83**	0.83**
Export-oriented sectors	0.27**	0.29**	0.88**	0.88**
Import competing sectors	0.38**	0.41**	0.84**	0.83**
R&D-oriented sectors	0.35**	0.37*	0.93**	0.97**
Scale-intensive sectors	0.33**	0.35**	0.94**	0.97**

** significance at the 5% level (two-tailed test)
* significance at the 10% level (two-tailed test)

hypothesis in our data set, we ran Granger causality tests (see Appendix D) which however show that the link between exporting and productivity is not clear-cut for the Belgian economy[10].

Turning to the productivity effect of import penetration (see Table 4), we obtain negative regression coefficients that are also statistically significant in all cases. Large negative effects are found in the unskilled-intensive, the export-oriented and the R&D-intensive sectors. Opposite to Wood's hypothesis, we conclude that increased import competition causes a loss in productivity. This supports the view that companies are unable to scale down their factor use at the same rate as rising foreign competition reduces their scales. Restructuring is a difficult process in Belgium.

As Lawrence (2000) points out, our results might reflect reverse causation as the link between international trade and productivity can go in both directions. Import and export competition can trigger higher productivity, while in the mean time sectors confronted with falling (growing) productivity may tend to have high levels of import competition (exports). One way to deal with this reverse causation is the use of an instrumental variables (IV) approach. As suggested by the HOS theory, skill- and capital intensity form appropriate instruments (see Lawrence (1999)). Because of data limitations, we have taken the lagged trade variables as instruments. The consistency checks indicate that the regression coefficients of the trade variables are no longer

TABLE 4

The productivity effect of import competition

	VA		TFP	
	levels	first differences	levels	first differences
All industries	−0.15**	−0.17**	−0.35**	−0.34**
Unskilled sectors	−0.43**	−0.52**	−0.47**	−0.48**
Skill-intensive sectors	−0.10**	−0.11**	−0.33**	−0.33**
Export-oriented sectors	−0.25**	−0.34**	−0.66**	−0.67**
Import competing sectors	−0.12**	−0.10*	−0.22**	−0.18**
R&D-oriented sectors	−0.34**	−0.40**	−0.58**	−0.59**
Scale-intensive sectors	−0.26**	−0.37**	−0.64**	−0.65**

** significance at the 5% level (two-tailed test)
* significance at the 10% level (two-tailed test)

significant, especially when using estimations in first differences. As the standard errors of the IV-estimates are quite high, the obtained regression results might be attributed to the use of weak instruments[11].

E. *Productivity and employment*

The second condition for a meaningful productivity effect of trade on employment concerns the employment adjustment to productivity changes. To capture this relationship, we estimate equation (12) where we instrument the productivity variable by using the fitted values for VA and TFP from the productivity regression (13). Based on the results in Appendix B, Table 5 presents the relevant information. We obtain moderate to strong negative regression coefficients for the productivity effect on employment when value added per worker is used as the productivity variable, in particular when the employment equation is estimated in first differences. With a few exceptions, we do not find a statistically significant relationship between employment and productivity when TFP is considered. Apparently, shocks that raise labour productivity are labour-saving, most of all in the export- and R&D-oriented sectors. But factor neutral productivity changes do not destroy jobs.

F. *Productivity-related and total effects of international trade on employment*

In Table 6 we bring together direct and productivity-induced employment adjustments to export demand. We first reproduce our earlier estimates for the export demand where VA is used as the productivity variable. Subsequently, we compute the elasticities that measure the productivity effect of exports and import competition on employment from the parameter values reported in earlier tables[12]. Since only changes in labour productivity affect employment, we only report estimates for the value added per worker productivity variable. Finally, we calculate the total elasticities of respectively export demand and import competition on employment by summing up the figures in the previous two columns.

Table 6 makes an interesting point. Export growth raises labour productivity which offsets part of the employment created by rising export demand. For the level estimates, export-induced gains in labour

TABLE 5
Productivity and employment

	VA		TFP	
	levels	first differences	levels	first differences
All industries	−0.10**	−0.71**	0.04	−0.15
Unskilled sectors	−0.15**	−1.07**	0.03	−0.14
Skill-intensive sectors	−0.09	−0.16**	−0.01	0.69
Export-oriented sectors	−0.23**	−1.15	−0.23**	−0.13
Import competing sectors	−0.06*	−0.44**	−0.06*	−0.09
R&D-oriented sectors	−0.19**	−2.26	0.01	−0.18
Scale-intensive sectors	−0.20**	−1.10	−0.20**	−0.13

** significance at the 5% level (two-tailed test)
* significance at the 10% level (two-tailed test)

TABLE 6
The productivity and total effects of exports on employment with VA

	levels			first differences		
	export demand effect	productivity-related effect	total effect	export demand effect	productivity-related effect	total effect
All industries	0.16	−0.03	0.13	0.31	−0.26	0.05
Unskilled-intensive	0.20	−0.06	0.14	0.54	−0.52	0.02
Skill-intensive	0.15	−0.02	0.13	0.12	−0.05	−0.07
Export-oriented	0.09	−0.06	0.03	0.37	−0.33	0.03
Import competing	0.20	−0.02	0.18	0.28	−0.18	0.10
R&D-oriented	0.15	−0.06	0.09	0.85	−0.83	−0.02
Scale-intensive	0.12	−0.06	0.11	0.44	−0.38	0.06

productivity destroy approximately one out of five jobs created by export expansion in all industries. The other level estimates vary according sectoral aggregates. In the export-oriented and scale-intensive sectors, about half of the jobs gained by the export demand effect are lost because of the export-related productivity effect. These productivity effects are much stronger when using first differences in the estimations. This reduces considerably the positive employment effects of an expansion in export demand.

In Table 7 we provide similar information for the import competition variable. The positive productivity effect of import competition on employment is not as intuitive as the jobs lost when exporting firms adopt more efficient technologies. Most plausibly, we are capturing the lay-offs prevented by the inability of companies – when faced with stronger import competition – to smoothly readjust their labour force to falling output levels. In a number of cases, the productivity effect is relatively large in comparison with the import competition effect. This explains why the total effect of import competition is positive in a number of sectoral disaggregates.

G. *The human capital effect*

Appendix E reports the estimation results for regression equation (15) which explain the relative employment of skilled versus unskilled employees as (imperfectly) measured by non-production and production workers. On the whole, the regressions do not reform as well as the total employment equations. Import penetration, export expansion

TABLE 7

The productivity and total effects of import competition on employment with VA

	levels			first differences		
	import competition effect	productivity-related effect	total effect	import competition effect	productivity-related effect	total effect
All industries	−0.04	0.01	−0.03	−0.77	0.12	−0.65
Unskilled-intensive	−0.03	0.06	0.03	−0.50	0.55	0.05
Skill-intensive	−0.04	0.009	−0.03	−0.03	0.01	−0.02
Export-oriented	0.02	0.05	0.07	−0.32	0.39	0.07
Import competing	−0.03	0.007	−0.02	−0.11	0.04	0.07
R&D-oriented	−0.02	0.06	0.04	−0.82	0.90	0.08
Scale-intensive	−0.005	0.05	−0.04	−0.34	0.40	0.06

and the productivity variables do not explain a major share of the relative employment evolution of skilled and unskilled workers. In fact, the relative wage cost of the two types of workers, as measured by the RELWAGE variable, plays a greater role in their employment prospects.

V. CONCLUSION

This paper deals with the sectoral employment effects of international trade in Belgium. It offers several contributions to the rapidly expanding literature on trade, technology and employment.

First, we provide evidence that trade matters for Belgian employment. With this finding, we go against the trust of the US-focused literature which attributes only a secondary role to trade-related labour market adjustments. The fact that Belgium is more open undoubtedly explains part of this result. But we also believe that, in a European context with rigid labour markets and limited inter-sectoral labour reallocation, our modelling of *sectoral* employment adjustments explains why we observe significant trade-related employment effects. Most importantly, our empirical work highlights the importance of export growth as a key engine of job creation. This point is often lost in the literature which focuses heavily on the detrimental impact of increased import competition on employment and wages.

As a second contribution, this paper puts in doubt the distinction between trade and technology as independent sources of employment changes. In Belgium, international trade affects productivity. More specifically, rising export demand increases labour and total productivity, a point frequently made by Belgian business leaders. By contrast, sectors confronted with increased import competition experience a decline in productivity indicating that the reduction in factor use does not keep up with the loss in market share. This scenario of inflexible sectoral restructuring is consistent with the conventional view that European labour markets are rigid and constrained by stringent hiring and firing conditions.

The consequences for employment of this relationship between trade and productivity lead to a third major theme of this paper. We show that employment responds to trade-induced changes in average labour productivity. The possibility of such an indirect technology-related link from international trade to employment was already emphasised by authors such as Wood. Our contribution is to develop and to apply a framework that quantifies this productivity effect of international trade on employment. Perhaps the most striking outcome of this empirical exercise is that part of the employment created by an expansion of export demand is neutralised by the negative employment effect of an export-induced increase in labour productivity. Interestingly, this suggests that export growth rather than import competition encourages the introduction of labour-saving production methods that are so common in European industry.

A fourth and final issue concern the focus on relative instead of total employment adjustments in an economy with imperfectly functioning labour markets. At most, we obtain weak evidence for the trade-related shifts in the relative employment of skilled and unskilled workers that are emphasised in the literature. This may be due to the flaws of using data on production and non-production workers as an indicator for skill. Or it may reflect the fact that workers do not easily reallocate across sectors and remain unemployed for long periods of time.

The results of this paper leave open several paths for future research. One suggestion is to geographically disaggregate trade flows to analyse the contribution of various trading partners to sectoral employment changes. An another promising route is to consider the hypothesis of rigid labour markets by directly analysing data on inter-sectoral employment flows (see Berman et al. (1994)) and on inter-firm labour reallocation (see Antelius and Lundberg (2000)). We intend to address these issues in future work.

APPENDIX A

Our data set covers 9 sectors of the manufacturing sector which are classified according to the "International Standard Industrial Classification" (ISIC) revision 2: food, beverages and tobacco (ISIC 31), textiles, apparel and leather (ISIC 32), wood products and furniture (ISIC 33), paper, paper products and printing (ISIC 34), chemical products (ISIC 35), non-metallic mineral products (ISIC 36), basic metal industries (ISIC 37), fabricated metal products (ISIC 38) and other manufacturing (ISIC 39).

The data for employment, labour costs, import, export, production and value added are obtained from the OECD Stan Database for Industrial Analysis (1997). The data for employment cover the number of employees as well as self-employed, working proprietors and unpaid family workers. The gross wage data per employee cover wages and various supplements such as employer's compulsory pension or medical payments. Except for the import penetration and the relative granted patents, all variables are expressed in constant prices. The deflators are calculated with the aid of value added in current and constant prices per industry.

For productivity, we have two variables: value added per worker and total factor productivity which are transformed into indices where 1990 is the base year. The percentage change of the total factor productivity can be expressed as follows:

$$\dot{A} = (\dot{Q} - \dot{L}) - \alpha.\ (\dot{K} - L) \qquad (16)$$

In this expression, the first term refers to the percentage change in the output-labour ratio. In the second term, α refers to the capital share in production. Therefore, $(1 - \alpha)$ refers to the labour share in production which is calculated as the share of labour costs in value added. For some sectors, labour costs exceed value added due to the existence of e.g. losses in these sectors or because the industry receives significant net subsidies. Therefore, an average is calculated[13]. $(\dot{K} - \dot{L})$ refers to the percentage change in the capital-labour ratio. The gross capital stock data are expressed in 1990 prices and are obtained from the International Sectoral Data Base from the OECD Statistical Compendium 1998/2.

Our patent variable measures the relative granted patents. Under relative granted patents, we understand the granted patents in one industry relative to all granted patents in a certain year. The patent data cover patents within the EPO (European Patent Office). The classification is the International Patent Classification (IPC). The conversion to the ISIC-classification is computed with the aid of the conversion table of Verspagen, van Moergastel and Slabbers (1994). The data for expenditures in R&D are obtained from "Research and Development Expenditure in Industry" of the O.E.C.D. (1995) for the period 1978-1991 and the D.T.W.C. (Dienst voor Wetenschappelijke, Technische en Culturele Aangelegenheden) for the period 1994-1995. The data for 1987-1991 are converted from the I.S.I.C. revision 3 to the I.S.I.C. revision 2 according to the conversion table in O.E.C.D. (1994). For certain industries, no conversion was possible. The data from 1994-1995 are classified according the N.A.C.E.-BEL. They are converted according the same conversion table. With the aid of a spline interpolation technique, missing observations are filled in. Furthermore, the expenditures for R&D are deflated with the aid of the above described deflators.

As a measure for skilled and unskilled labour, the non-manual and manual workers are taken. These data come from the "Rijksdienst voor Sociale Zekerheid" and cover the period 1978-1991.[14] For the wage costs of these workers, we take the total amount of declared wages in a certain year. The amount of declared wages are published in "Het Jaarverslag van de Rijksdienst voor Sociale Zekerheid". The conversion from the N.A.C.E. 70 to the I.SI.C.-classification occurs with the aid of the conversion table of Schumacher (1992). For the sector I.S.I.C. 37 both the codes 21 and 22 of the N.A.C.E. classification are used.

Here, we describe the disaggregation of the total sample of industries. The cutting point occurs at the median.

1. *Skill-intensive and unskilled industries*: The classification according to skill and non-skill intensive sectors is computed with the aid of the ratio of manual versus non-manual workers in 1992. The skill-intensive sectors are: food, beverages and tobacco; paper, paper products and printing; chemical products and other manufacturing.
2. *Export-oriented sectors*: By the export share, we mean the export of a certain industry relative to the export of all industries in 1992. The high exporting sectors are the sectors with the four highest shares: food, beverages and tobacco; chemical products; basic metal industries and fabricated metal products.
3. *Technology-intensive sectors*: The technology intensity of a sector in 1991 is computed as the total expenditures in R&D relative to the production in this sector. The high technology sectors are: chemical products; non-metallic mineral products; basic metal products and fabricated metal products.

4. *Scale-intensive sectors*: The classification according scale intensity is based on an article of the Commission of European Communities (1988). The following sectors are sectors with high economies of scale: paper, paper products and printing; chemical products; basic metal industries and fabricated metal products.
5. *Import competing sectors*: As import competing sectors, we take the four sectors with the highest import penetration ratios in 1992. The import penetration ratio is defined as the imports divided by the difference between production and net exports. These four sectors are: textiles, apparel and leather; fabricated metal products; basic metal industries and other manufacturing.

APPENDIX B

TABLE B.1
The regression results of the employment equation with VA estimated in levels

	ln(IMP)	ln(EXP)	ln(WAGE)	ln(VA)	R^2
All industries	−0.04**	0.16**	−0.15**	−0.10**	0.99
	(−2.09)	(5.20)	(−4.55)	(−3.70)	
Unskilled sectors	−0.03	0.20**	−0.16**	−0.15**	0.99
	(−0.50)	(4.11)	(−3.58)	(−3.87)	
Skill-intensive sectors	−0.04*	0.15**	−0.15**	−0.09	0.99
	(−1.86)	(3.25)	(−2.94)	(−2.02)	
Export-oriented sectors	0.02	0.09**	−0.07**	−0.23**	0.99
	(0.47)	(2.50)	(−2.19)	(−4.70)	
Import competing sectors	−0.03*	0.20**	−0.19**	−0.06*	0.99
	(−1.68)	(4.52)	−4.59)	(−1.79)	
R&D-oriented sectors	−0.02	0.15**	−0.11**	−0.19**	0.99
	(−0.42)	(3.22)	(−2.69)	(−4.40)	
Scale-intensive sectors	−0.005	0.12**	−0.10**	−0.20**	0.99
	(−0.09)	(3.02)	(−2.89)	(−4.48)	

** significance at the 5% level (two-tailed test)
* significance at the 10% level (two-tailed test)

TABLE B.2

The regression results of the employment equation with VA estimated in first differences

	ln(IMP)	ln(EXP)	ln(WAGE)	ln(VA)	R^2
All industries	−0.17**	0.31**	−0.04	−0.71**	0.24
	(−3.33)	(3.85)	(−0.77)	(−3.72)	
Unskilled sectors	−0.50	0.54**	−0.007	−1.07**	0.27
	(−3.11)	(3.42)	(−0.08)	(−3.30)	
Skill-intensive sectors	−0.03	0.12**	−0.13**	−0.16**	0.44
	(−1.44)	(2.66)	(−2.56)	(−2.17)	
Export-oriented sectors	−0.32	0.37	−0.03	−1.15	0.27
	(−0.86)	(0.98)	(−0.43)	(−0.85)	
Import competing sectors	−0.11**	0.28	−0.08*	−0.44**	0.36
	(−3.16)	(4.53)	(−1.91)	(−3.74)	
R&D-oriented sectors	−0.82	0.85	−0.04	−2.26	0.18
	(−0.74)	(0.73)	(−0.23)	(−0.67)	
Scale-intensive sectors	−0.34	0.44	−0.09	−1.10	0.28
	(−0.70)	(0.77)	(−1.20)	(−0.65)	

** significance at the 5% level (two-tailed test)
* significance at the 10% level (two-tailed test)

TABLE B.3

The regression results of the employment equation with TFP estimated in levels

	ln(IMP)	ln(EXP)	ln(WAGE)	ln(VA)	R^2
All industries	−0.01	0.09**	−0.15**	0.04	0.99
	(−0.74)	(2.48)	(−4.25)	(−1.61)	
Unskilled sectors	−0.06	0.15**	−0.14**	0.03	0.99
	(−0.98)	(2.38)	(−2.80)	(0.46)	
Skill-intensive sectors	−0.02	0.11**	−0.15*	−0.01	0.99
	(−1.24)	(2.40)	(−2.95)	(−0.39)	
Export-oriented sectors	0.02	0.09**	−0.07**	−0.23**	0.99
	(0.47)	(2.50)	(−2.19)	(−4.70)	
Import competing sectors	−0.03*	0.20**	−0.19**	−0.06*	0.99
	(−1.68)	(4.52)	(−4.59)	(−1.79)	
R&D-oriented sectors	−0.08	0.11**	−0.10**	0.01	0.99
	(−1.34)	(2.04)	(−2.17)	(0.50)	
Scale-intensive sectors	−0.005	0.12**	−0.10**	−0.20**	0.99
	(−0.09)	(3.02)	(−2.89)	(−4.48)	

** significance at the 5% level (two-tailed test)
* significance at the 10% level (two-tailed test)

TABLE B.4

The regression results of the employment equation with TFP estimated in first differences

	ln(IMP)	ln(EXP)	ln(WAGE)	ln(VA)	R^2
All industries	−0.05	0.20**	−0.12**	−0.15	0.55
	(−1.54)	(2.68)	(−4.02)	(−1.61)	
Unskilled sectors	−0.13	0.25*	−0.10**	−0.14	0.62
	(−1.53)	(1.85)	(−2.66)	(−0.84)	
Skill-intensive sectors	0.22	−0.51	−0.14	0.69	0.01
	(0.27)	(−0.25)	(−1.10)	(0.29)	
Export-oriented sectors	−0.07	0.18	−0.07**	−0.13	0.61
	(−0.76)	(1.49)	(−2.02)	(−0.97)	
Import competing sectors	−0.03	0.19	−0.13**	−0.09	0.46
	(−0.48)	(1.08)	(−3.47)	(−0.46)	
R&D-oriented sectors	−0.12	0.28*	−0.10**	−0.18	0.65
	(−1.12)	(1.70)	(−2.62)	(−1.01)	
Scale-intensive sectors	−0.07	0.20	−0.09**	−0.13	0.64
	(−0.53)	(1.12)	(−2.51)	(−0.65)	

** significance at the 5% level (two-tailed test)
* significance at the 10% level (two-tailed test)

TABLE C.1
The regression results of the productivity equation with VA estimated in levels

	ln(IMP)	ln(EXP)	ln(R&D)	PAT	ln(CAP)	R^2
All industries	−0.15**	0.33**	0.01	0.001	0.50**	0.98
	(−4.07)	(7.01)	(0.63)	(0.02)	(6.92)	
Unskilled sectors	−0.43**	0.46**	0.02	0.02	0.65**	0.95
	(−4.35)	(6.45)	(0.73)	(0.27)	(5.16)	
Skill-intensive sectors	−0.10**	0.29**	0.02	0.01	0.44**	0.97
	(−2.46)	(4.26)	(0.59)	(0.13)	(5.21)	
Export-oriented sectors	−0.25**	0.27**	0.02	−0.002	0.29*	0.97
	(−2.67)	(3.81)	(0.49)	(−0.04)	(1.93)	
Import competing sectors	−0.12**	0.38**	−0.009	−0.01	0.69**	0.98
	(−2.56)	(5.42)	(−0.19)	(−0.16)	(5.30)	
R&D-oriented sectors	−0.34**	0.35**	−0.003	0.009	0.38**	0.98
	(−3.37)	(4.73)	(−0.08)	(0.12)	(2.20)	
Scale-intensive sectors	−0.26**	0.33**	−0.01	−0.0003	0.31**	0.98
	(−2.54)	(4.58)	(−0.30)	(−0.004)	(2.30)	

** significance at the 5% level (two-tailed test)
* significance at the 10% level (two-tailed test)

TABLE C.2

The regression results of the productivity equation with VA estimated in first differences

	ln(IMP)	ln(EXP)	ln(R&D)	PAT	ln(CAP)	R^2
All industries	−0.17**	0.37**	0.001	−0.03	0.55**	0.53
	(−4.09)	(8.40)	(0.03)	(−0.31)	(4.23)	
Unskilled sectors	−0.52**	0.49**	0.005	0.003	0.67**	0.54
	(−5.46)	(7.22)	(0.19)	(0.02)	(3.37)	
Skill-intensive sectors	−0.11**	0.34**	−0.009	0.01	0.68**	0.59
	(−2.01)	(5.33)	(−0.19)	(0.10)	(3.51)	
Export-oriented sectors	−0.34**	0.29**	0.009	0.008	0.12	0.37
	(−3.90)	(4.52)	(0.21)	(0.09)	(0.50)	
Import competing sectors	−0.10*	0.41**	−0.04	−0.16	0.88**	0.64
	(−1.82)	(6.45)	(−0.94)	(−0.95)	(4.26)	
R&D-oriented sectors	−0.40**	0.37**	−0.01	0.01	0.17	0.41
	(−4.21)	(5.14)	(−0.47)	(0.12)	(0.64)	
Scale-intensive sectors	−0.37**	0.35**	−0.03	−0.01	0.15	0.40
	(−3.85)	(5.36)	(−0.82)	(−0.13)	(0.66)	

** significance at the 5% level (two-tailed test)
* significance at the 10% level (two-tailed test)

TABLE C.3

The regression results of the productivity equation with TFP estimated in levels

	ln(IMP)	ln(EXP)	ln(R&D)	PAT	R^2
All industries	−0.35**	0.82**	0.009	0.01	0.96
	(−11.50)	(21.15)	(0.46)	(0.27)	
Unskilled sectors	−0.47**	0.83**	0.01	−0.02	0.98
	(−7.53)	(18.16)	(0.98)	(−0.55)	
Skill-intensive sectors	−0.33**	0.83**	0.0006	0.13	0.93
	(−7.83)	(12.89)	(0.01)	(1.09)	
Export-oriented sectors	−0.66**	0.88**	0.10**	0.01	0.96
	(−9.66)	(17.14)	(3.03)	(0.31)	
Import competing sectors	−0.22**	0.84**	−0.02	0.007	0.97
	(−6.67)	(19.70)	(−0.76)	(0.12)	
R&D-oriented sectors	−0.58**	0.93**	0.01	0.02	0.97
	(−8.62)	(18.73)	(0.76)	(0.56)	
Scale-intensive sectors	−0.64**	0.94**	0.03	0.01	0.97
	(−9.41)	(20.00)	(1.21)	(0.41)	

** significance at the 5% level (two-tailed test)
* significance at the 10% level (two-tailed test)

TABLE C.4

The regression results of the productivity equation with TFP estimated in first differences

	ln(IMP)	ln(EXP)	ln(R&D)	PAT	R^2
All industries	−0.34**	0.83**	0.01	0.05	0.84
	(−11.52)	(23.95)	(0.79)	(0.62)	
Unskilled sectors	−0.48**	0.86**	0.01	0.02	0.88
	(−8.11)	(20.45)	(1.02)	(0.25)	
Skill-intensive sectors	−0.33**	0.83**	0.01	0.15	0.82
	(−7.61)	(15.02)	(0.37)	(0.89)	
Export-oriented sectors	−0.67**	0.88**	0.10**	0.05	0.90
	(−10.26)	(18.65)	(3.38)	(0.70)	
Import competing sectors	−0.18**	0.83**	−0.04	−0.08	0.92
	(−5.45)	(21.62)	(−1.45)	(−0.74)	
R&D-oriented sectors	−0.59**	0.97**	0.02	0.09	0.91
	(−9.76)	(21.30)	(0.90)	(1.30)	
Scale-intensive sectors	−0.65**	0.97**	0.03	0.06	0.91
	(−10.72)	(23.04)	(1.35)	(1.05)	

** significance at the 5% level (two-tailed test)
* significance at the 10% level (two-tailed test)

TABLE D.1

Granger causality tests between exporting and productivity

	levels				first differences			
	ln(TV)	ln(TFP)	ln(EXP)	ln(EXP)	ln(TV)	ln(TFP)	ln(EXP)	
ln(EXP)								
$\ln(TV)_{t-1}$	0.92**		0.24*		0.18	0.32	0.15	
	(9.08)		(1.80)		(0.71)	(1.49)	(1.17)	
$\ln(TV)_{t-2}$	0.06		−0.07		0.27	0.34	−0.13	
	(0.58)		(−0.49)		(0.94)	(1.51)	(−1.06)	
$\ln(TFP)_{t-1}$		0.83**		−0.01				0.02
		(6.31)		(−0.08)				(0.16)
$\ln(TFP)_{t-2}$		−0.02		−0.10				–
0.18**								
		(−0.14)		(−0.74)				(−2.21)
$\ln(EXP)_{t-1}$	−0.05	0.03	0.77**	0.87**	−0.36**	−0.17	0.86**	0.88**
(−0.83)	(0.26)	(8.26)	(6.71)	(−2.07)	(−0.90)	(8.71)	(6.82)	
$\ln(EXP)_{t-2}$	−0.03	−0.09	−0.11	−0.02	−0.49**	−0.32	−0.08	−0.11
(−0.53)	(−0.80)	(−1.35)	(−0.22)	(−2.81)	(−1.63)	(−0.95)	(−0.97)	
R^2	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
F-test	2.10	0.79	3.89	1.05	6.18**	2.55	1.33	2.47
Observations	135	135	135	135	126	126	126	126

** significance at the 5% level (two-tailed test)

* significance at the 10% level (two-tailed test)

F-test for testing Granger causality

TABLE E.1
The human capital effect

	ln(RELWAGE)	ln(PROD)	ln(IMP)	ln(EXP)	R^2
Estimations with VA					
In levels	−0.39**	0.04	−0.01	0.004	0.99
	(−8.99)	(0.60)	(−0.48)	(0.18)	
In first differences	−0.39**	−0.86	−0.03	0.07	0.99
	(−7.42)	(−0.92)	(−1.06)	(1.05)	
Estimations with TFP					
In levels	−0.03	−0.04*	−0.009	0.009	0.15
	(−1.55)	(−1.67)	(−1.21)	(1.38)	
In first differences	−0.02	−0.25	−0.008	0.02	0.11
	(−1.16)	(−1.57)	(−0.95)	(1.61)	

** significance at the 5% level (two-tailed test)
* significance at the 10% level (two-tailed test)

NOTES

1. These figures are obtained from the OECD Main Economic Indicators (see http://www.oecd.org).
2. National Bank of Belgium, Belgostat data.
3. Davis (1998) drops the hypothesis of full employment by considering minimum wages.
4. Examples of this approach are Lawrence and Slaughter (1993) and Leamer (1996). For a survey see Slaughter (1998).
5. See for instance Borjas, Freeman and Katz (1991) and Wood (1994).
6. The construction of this variable is discussed in Appendix A.
7. According to expression (9), it is also clear that the wage elasticity should be negative. Also remark that the capital costs are omitted from the regression equation. Capital costs can however be captured by time dummies. Introducing these time dummies did not significantly change our results. Therefore, we did not include time dummies in our regression equations.
8. Note that when we use the total factor productivity variable, capital per employee will not be included in the regression equation because this last variable is included in the total factor productivity variable.
9. Under relative granted patents, we understand the granted patents in a certain year relative to the total granted patents in that year. Note that this variable is not expressed in logarithms because for certain years the data show a value of 0. However, as pointed out by Lanjouw et al. (1998) and Griliches (1990), patents are an imperfect measure for innovative output. The main reason is that they protect innovations of different importance.
10. These test were robust to different lag lengths of independent variables in the Granger regression equation.
11. Especially for the data in first differences, the correlation between the current and lagged trade variables is extremely weak. This is a possible indicator of weak instrumental variables. This effect is not estimated directly so that no statistical significance tests can be reported.
12. Another way to calculate the cost shares of capital is to construct a figure for capital services using the concept of user cost of capital (see Griliches and Ringstad (1971)).
13. We have chosen this period, because after this period the classification has changed from the NACE-70 to the NACE-BEL. Conversion between these two classifications is still very difficult.

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