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MARGINAL INTRA INDUSTRY TRADE

EXPANSION AND PRODUCTIVITY GROWTH

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ABSTRACT: We use the concept of marginal intra-industry trade (MIIT) to analyse the effect of trade expansion on labour productivity growth across 23 EU countries and 94 manufacturing sectors in 1995-2005. The highest MIIT index values are found in sectors producing differentiated goods as well as in science and scale-intensive sectors, while the lowest are found in resource and labour-intensive sectors. Thus specialisation in sectors characterised by traditional comparative advantage has been associated with slower productivity growth. The results indicate that a trade-flow expansion characterised by intra-industry trade (high MIIT) is associated with faster productivity growth also after we control for the size in trade flow changes. Especially the increase in imports seems important. The analysis is mostly done using random-effects linear model specifications but further evidence is presented using several other estimation methods.

KEY WORDS: productivity, growth, marginal intra-industry trade

JEL codes: J24, F1, C23

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TIIVISTELMÄ: Tutkimuksessa käytetään marginaalisen ristikkäiskaupan (MIIT) käsitettä analysoitaessa ulkomaankaupan kasvun merkitystä työvoiman tuottavuuden kasvulle 23 EU-maassa ja 94 teollisuuden toimialalla vuosina 1995–2005. Korkeimmat MIIT-indeksin arvot ovat toimialoilla, jotka tuottavat differentioituja hyödykkeitä tai ovat tiede- tai skaalaintensiivisiä. Alimmat MIIT-indeksiarvot ovat resurssi- ja työvoimaintensiivisillä toimialoilla. Siten erikoistuminen perinteisen suhteellisen edun toimialoille on liittynyt hitaampaan tuottavuuden kasvuun. Tulokset osoittavat, että toimialoilla, joilla on nopeampi tuottavuuden kasvu, myös ulkomaankaupan kasvu on perustunut ristikkäiskauppaan. Erityisesti tuonnin kasvu on ollut tärkeä tekijä tässä. Analyysi tehdään lähinnä satunnaisvaikutusten RE-malleilla, mutta myös muita estimointimenetelmiä käytetään varmistamaan tulosten luotettavuutta.

AVAINSANAT: tuottavuus, kasvu, marginaalinen ristikkäiskauppa

JEL-koodit: J24, F1, C23

1 Introduction

As is already well established in empirical research, one of the principal developments in international trade in the relatively recent past is the increase, especially between industrialised countries, of intra-industry trade (IIT). In other words, there has been an increase in the simultaneous exports and imports between two countries of products that fall into the same product category in trade classifications. Thus for example Germany exports cars to France and France exports cars to Germany.

IIT is not based on the traditional theory of comparative advantage, where countries specialise in those industries that use intensively the factor of production that the country is abundant with. Even available technology is relatively universal, spreading through trade and foreign direct investment, so it does not create a comparative advantage between industrialised countries. Instead, IIT is related to increasing returns to scale and imperfect competition. Product differentiation of industrialised goods makes the goods imperfect substitutes for one another, and thus German and French cars are different enough for people to wish to purchase them in both countries.

A more recent twist is the internationalisation of production phases, where companies locate or outsource parts of their production even at the level of individual tasks[1] to other countries, for example to benefit from lower labour costs. Lower transportation costs and advances in communication technologies have made this administratively and technically more manageable and economically more viable. The foreign direct investment flows between the EU15 countries and the new EU member countries, or the former transition economies, of Central Europe are partly due to this rearrangement. Of course, the same logic works at the global scale too, not just in Europe.

The development has also raised worries in the EU15 countries about the possible disappearance of jobs. However, even though some jobs have moved to other countries, these have typically been jobs with relatively low value added, and new job opportunities have opened up in their stead. Moving lower value added jobs has raised companies' profits, raising tax revenues and investment possibilities in the home country. This too is changing, of course, as the new member countries are developing further and catching up with the EU15 countries.

We will analyse how the increase in trade flows is associated with productivity growth in different manufacturing sectors in Europe. Specifically, we will use the concept of marginal intra-industry trade (MIIT) first suggested by Hamilton and Kniest (1991) and thereafter modified by, among others, Brülhart (1994). The MIIT-index shows how large a share of the change in

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1 See e.g. Grossman and Rossi-Hansberg (2006).

total trade flows is intra-industry trade as opposed to inter-industry trade. Namely we will concentrate on MIIT-based trade expansion.

The analysis is performed for 94 sectors of manufacturing industries at the 3-digit level of the NACE Rev. 1 classification and 23 EU countries over the period 1995-2005. Four countries and nine sectors where excluded because of insufficient data. The new member countries enter for the years 1999-2005. There are deficiencies in the form of missing data, the seriousness of which varies between countries and sectors. Still, we have more than 12,300 observations in more than 1,930 groups.

We estimate the impact of MIIT and other variables on labour productivity growth using primarily a random-effects linear model. This analysis is complemented with a number of alternative estimations including fixed-effects and population-averaged linear models, GLS, and 2SLS.

We hypothesise that an MIIT-based trade expansion increases competition and thereby leads to productivity growth. This could happen through existing companies investing more in product and process development and/or through the exit of the least competitive companies from the market. This means that structural changes may be taking place inside the sector due to competitive pressures. The dissemination of within-sector information and innovations may be enhanced through intra-industry trade. In reality, of course, a part of the MIIT is actually intra-firm trade, a result of foreign direct investment. This too may raise productivity growth through structural change and specialisation.

We find that the sectors where trade expansion has occurred in terms of intra-industry trade, also labour productivity growth has been the fastest. In other words, these sectors have been outgrowing sectors that rely on the country's traditional comparative advantage and sectors with decreasing foreign trade. In the analysis we control for the relative increase in trade flows, which turns out to be statistically significant, especially the change in imports. This supports the argument that an increase in competition forces productivity up.

In line with these results, we find that the share of MIIT in trade expansion has been the smallest in resource and labour-intensive sectors that can be argued to be based on traditional comparative advantage. MIIT has been more dominant in scale- and science-intensive sectors and those producing differentiated goods. Given the results from the productivity growth vs. MIIT analysis, this is further evidence of the importance of specialising in high-tech sectors and differentiated goods where intra-industry trade is growing the fastest.

Next we will first review some literature on trade and growth in Section 2, and discuss the concept of marginal intra-industry trade in Section 3 and our data in Section 4. In Section 5 we perform an estimation on the relationship between the level of productivity and IIT to provide some background information. In Section 6 we construct our methodology for our analysis on productivity growth and MIIT, and Section 7 reports the respective econometric analysis. Section 8 concludes with the summary and conclusions.

2 Trade and growth

There is a large literature that analyses linkages between trade and economic growth. This is not as straightforward as one might think even though it is clear that participating in the world market, as opposed to closing all borders to trade, supports a country's economic development. For one, economic output is typically measured as value added, but trade is measured in gross value terms. The value added of the traded product may have been fully produced in the country in question or it may have been largely created in other countries and the product is only, for example, packed in the country of interest. If, say, arbitrage trade that entails only relatively little domestic value added grows strongly, there may be only very little growth in GDP as a result.

Badinger and Breuss (2008) include geographic components into their model and analyse trade and growth in 14 OECD countries and 15 manufacturing sectors. They find that trade openness as measured in terms of the ratio of exports and production increases productivity also when country-fixed effects are controlled for. Badinger and Breuss use the level of labour productivity as the dependent variable, while employment, trade ratio (measured in terms of exports, imports or both), and country size (population and area) are the independent variables. They construct an instrumental variable for trade using a variety of geographic variables following Frankel and Romer (1999)[2]. The analysis of productivity growth, however, is done for total manufacturing only. There the dependent variables are the change in the trade ratio and the change in population. The analysis is done for the difference between 1995 and 2000. The effect of the change in the trade ratio on productivity growth is found to be positive. Felbermayr (2005) uses the system-GMM approach to analyse the relationship between trade share and GDP per capita. He, too, finds that there is a robust and positive effect of trade on income.

Petersson (2002) has an approach more similar to ours. He divides sectors into resource-based, labour-intensive, scale-intensive, and those producing differentiated (including science-based) goods, and analyses intra-

[2] Frankel and Romer (1999) introduced geographic components into their analysis of the effects of trade on GDP growth in 150 countries. As variables they used the countries' sizes, their distances from one another, whether they share a border, and whether they are landlocked. According to their results, trade has a positive effect on income, The effect is quantitatively large and robust, but statistically only moderately significant. However, Felbermayr (2005) argues that Frankel and Romer's (1999) model may be misspecified, because it makes the implicit assumption that all countries are in their respective steady states.

industry trade adjustment in South Africa's trade with its main trading partners. He finds that IIT and MIIT are positively correlated with labour productivity.

Many studies analyse the interaction between exporting and productivity growth at the firm level. Recent studies include, among others, Bernard and Jensen (2004), Hansson and Lundin (2004), Kimura and Kiyota (2006), Bernard et al. (2007), and Wagner (2007). See also Greenaway and Kneller (2005 and 2007) for reviews of the literature. In these studies exports are typically analysed as a dummy variable in that a firm either is or is not exporting. The main result is that exporting firms are more productive than firms operating in the domestic market only, but also that exporting firms had been more productive already before they started to export. This could mean that exporting does not affect productivity. On the other hand, some firms may seek to raise their productivity in order to enter export markets, and the rise would not have taken place in the first place without the intent to export in the near future (see e.g. Lopéz, 2005, for a discussion).

3 Marginal intra-industry trade

The concept of marginal intra-industry trade (MIIT) was first suggested by Hamilton and Kniest (1991). The way it is calculated has since been modified by, among others, Brülhart (1994), and we will use his measurement of MIIT. The index shows to what extent the change in trade flows in sector i is of the intra-industry type. MIIT is given by

$$MIIT_i = 1 - \frac{|\Delta x_i - \Delta m_i|}{|\Delta x_i| + |\Delta m_i|} \qquad (1)$$

where x is exports and m is imports of products produced by the sector, and Δ stands for the difference between two consecutive years. The index goes from 0 to 1. Its value is equal to 0 when marginal trade is fully inter-industry and 1 when it is fully IIT.

We calculate MIIT for products produced by some manufacturing sector, not from the trade that the firms in the sector are engaged in. The latter can include, among other things, the imports of intermediate and investment goods produced by firms in some other sector. Another thing is that a firm identified as belonging to some sector i can also produce goods belonging to some other sector. This is probably a minor problem, however.

A more significant problem is that MIIT is symmetrical. It receives positive values when both exports and imports increase but also when both decrease. If either increases and the other decreases, $MIIT = 0$. The problem for our analysis is the case where both trade flows decrease. This can hardly be considered a situation where competition increases. Thus we will control for this by including a dummy μ whenever we have $\Delta x_i < 0$ and $\Delta m_i < 0$.

Another factor to be taken into account is the fact that MIIT does not depend on the size of the trade increase. An increase by one euro in both exports and imports returns the same MIIT index value as an increase of a million euros. We will control for the relative increase in trade in the estimations.

MIIT is different from a simple difference in the IIT index proposed by Grubel and Lloyd (1971). The Grubel-Lloyd index is given by

$$GL = 1 - \frac{|x_i - m_i|}{x_i + m_i}. \tag{2}$$

According to Brülhart (1994), the use of ΔGL, instead of the MIIT index, is not adequate in a dynamic setting. Brülhart argues that a rise in the Grubel-Lloyd index could be due to either an erosion of a net-exporting position or a balancing of a sectoral deficit. Indeed, ΔGL and MIIT can behave very differently depending on the relative levels of and changes in exports and imports. Thus MIIT does not really have a level equivalent.

Referred to as the smooth-adjustment hypothesis, trade flow changes of the intra-industry type have been found to cause less adjustment costs in the labour market than inter-industry trade flow changes, see e.g. Brülhart and Elliott (2002), Cabral and Silva (2006), and Brülhart, Elliott and Lindley (2006). This is because the costs of reallocation of resources are lower within a sector than between sectors. We will now analyse whether there is also a relationship with labour productivity growth.

Bastos and Cabral (2007) analyse MIIT and divide the IIT expansion in two: trade flows that contribute to strengthen the country's previous specialisation and flows that work in the opposite direction. According to their results for 20 OECD countries and 26 manufacturing industries, trade liberalisation and expansion in 1980-2000 reinforced the previous specialisation of countries with larger markets in industries with increasing returns to scale. Their results indicate that the changes in trade patterns were explained by initial endowments of, but not the changes in, human capital and industry-specific changes in labour productivity and labour costs.

4 Data

We use data for 1995-2005. The countries included are the EU27 countries. However, there were not enough data for Estonia, Greece, Luxembourg and Malta, so these four are left out of the analysis. Furthermore, the new member countries do not have trade data for 1995-1998. We use total trade flows, not just intra-EU trade.

The data are at the 3-digit level of the NACE Rev. 1 division and there are 94 manufacturing sectors after nine sectors[3] had to be left out because of lack of data. This gives us a maximum of 20,022 observations in the trade data, and 17,823 observations for MIIT. In all, we have 5,342 zero-values for the MIIT index. These are cases where imports have increased and exports have decreased, or vice versa. Furthermore, there are 2,360 cases where both exports and imports decrease from the preceding year. This latter is 13 per cent of the total number of observations for MIIT. In the estimations we will add a dummy for these cases. We have 10,121 observations with $MIIT > 0$ with both exports and imports increasing.

Then there are deficiencies in the form of missing data (especially value added and employment), the seriousness of which varies between countries and sectors. At the end we have more than 12,300 observations in more than 1,930 groups in the productivity growth estimations, i.e. on average 6.4 observations per group.

The value added data (in millions of euros) and employment are taken from the Structural Business Statistics published by the Eurostat. The volume of value added is calculated using sector-specific producer price indices provided by the Eurostat. Also investment is in real terms, deflated with the said producer price index. On the other hand, the trade data are in nominal values.

The international tariff regime is the same for all EU15 countries during the analysed time period. It is slightly different for the new member countries that joined in 2004 and 2007. Even though most of the trade barriers between the EU15 and the new member countries were removed already before the enlargement, with food products a major exception, there remained different barriers with the rest of the world. Nevertheless, we will assume that this has no bearing on the results, or is filtered out by the dummies.

Using sector-specific data, we cannot take into account the heterogeneity of firms within sectors and the changes therein during the analysed time period. Typically, firms that export have higher average productivity than firms that do not export (see e.g. Bernard et al., 2007), although it is less clear that the former should necessarily have faster productivity growth. On the other hand, they may grow faster in size, which will lead to higher average productivity in the sector, see Bernard and Jensen (2004).

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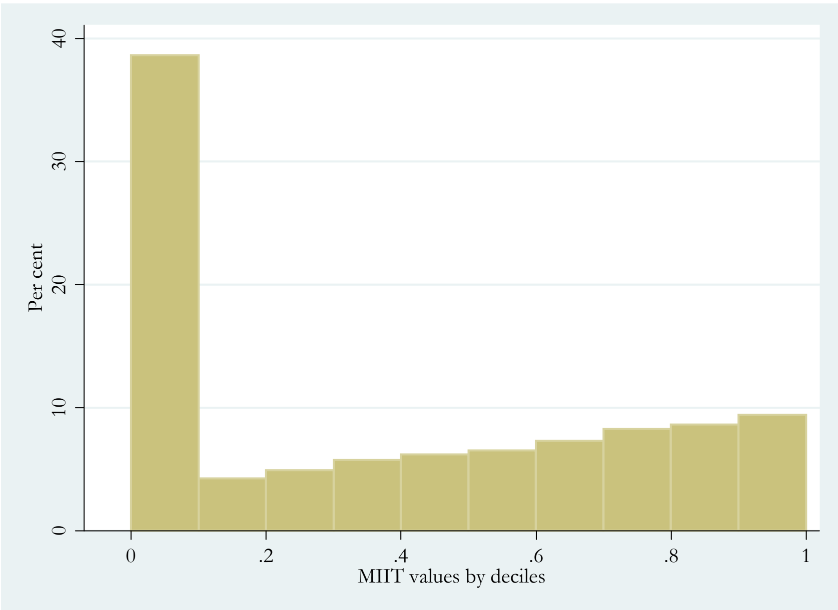
[3] The excluded sectors are: finishing of textiles (NACE code 173); reproduction of recorded media (223); casting of metals (275); forging, pressing, stamping and roll forming of metal, and powder metallurgy (284); treatment and coating of metals, and general mechanical engineering (285); manufacture of industrial process control equipment (333); manufacture of other transport equipment n.e.c. (355); recycling of metal waste and scrap (371); and recycling of non-metal waste and scrap (372).

Now let us see how MIIT has developed in our 23 countries and 94 manufacturing sectors. Graph 1 shows how the number of sectors is spread out across the MIIT range. We have removed the cases where both exports and imports have declined so that the graph gives more accurate background information in view of the estimations.

The data are divided into deciles, arranged in an ascending order of the MIIT index value. Some 35 per cent of the observations are such that *MIIT* = 0. The first bar also includes those *MIIT* values that are smaller than 0.10. This means that in 65 per cent of the cases both exports and imports have increased over the previous year. There is a steady increase in the number of sector-country pairs from low levels of MIIT towards higher levels.

Graph 1 **The per cent frequency of sectors in terms of MIIT using annual data between 1995 and 2005**



Note: Excluding those four EU countries and nine sectors that are not included in this study. Also the cases where both exports and imports have decreased are excluded (see text). Data for the EU15 countries are for 1995-2005 and the data for the new member countries are for 1999-2005.

Next we will review how MIIT has developed on average across different countries and sectors. Tables A1 and A2 in the Appendix show these in simple averages over 1995-2005. For example, a relatively small share of the trade expansion of Cyprus, Ireland, Portugal and Finland has been marginal IIT. The share has been the highest in Belgium, the Czech Republic, France, the Netherlands and Austria.

Looking at individual manufacturing sectors, the average MIIT index value is above 0.6 in the manufacture of plastic products, and above 0.5 in the manufacture of other fabricated metal products, pharmaceuticals, medicinal chemicals and botanical products, electricity distribution and control apparatus, machinery for the production and use of mechanical power (except aircraft, vehicle and cycle engines), medical and surgical equipment and orthopaedic appliances, other food products, basic iron and steel and of ferroalloys (ECSC), and soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations.

On the other hand, average MIIT is below 0.2 in the manufacture of cement, lime and plaster, bricks, tiles and construction products, baked clay, ceramic tiles and flags, processing of nuclear fuel, steam generators, except central heating hot water boilers, and coke oven products.

Using the OECD (1992) division of sectors, we find, again using simple averages across the sectors, that the highest MIIT index values are in sectors producing differentiated goods ($MIIT$ = 0.425), science-intensive sectors (0.410) and scale-intensive sectors (0.408). The lowest MIIT index values are in resource-intensive sectors (0.322) and labour-intensive sectors (0.358).

Using F-tests, we verified that the within variances are the same in all groups. Then using two-tailed homoskedastic t-tests we found that the means of the groups are the same for the three groups with the highest MIIT (differentiated, science-intensive and scale-intensive) on the one hand, and the same for the two groups with the lowest MIIT (resource and labour-intensive) on the other hand, but different otherwise with the exception of labour and science-intensive sectors that also had the same means. This may be affected by the small number (6) of science-intensive sectors. Combining differentiated products and the science-intensive sectors as Petersson (2002) does, this anomaly goes away.

This evidence supports the idea behind MIIT because resource and labour-intensive sectors can be seen to be based on traditional comparative advantage. The former is based on natural resources such as wood and mineral ores, while the latter is based on differences in labour costs across the European nations. Thus it is natural that MIIT is lower in these sectors than in other sectors.

5 IIT and the level of productivity

We will first estimate a level equation with productivity as the dependent variable and IIT as the main independent variable. This estimation will give us background information about whether sectors with high productivity have high or low levels of IIT. We will estimate:

$$\ln\left(Q_{ikt}/L_{ikt}\right) = \beta_1 + \beta_2 IIT_{ikt} + NMC + \sigma_i + \kappa_k + \tau_t + \varepsilon_{ikt}, \qquad (3)$$

where $\ln\left(Q_{ikt}/L_{ikt}\right)$ is the log of productivity measured as value added in constant prices (Q) divided by employment (L) in sector i, country k and year t. On the right-hand side, IIT_{ikt} is intra-industry trade, *NMC* is a dummy variable for those new member countries that joined the EU in either 2004 or 2007, and σ_i, κ_k and τ_t are dummy variables for sector, country and year respectively, and finally ε_{ikt} is the error term.

According to the results shown in Table 1, high levels of IIT are associated with high labour productivity. As expected, the *NMC* dummy has a negative sign, because the new member countries have lower labour productivity than the EU15 countries. When country dummies are used, the *NMC* dummy is not included. The inclusion of the dummies lowers the coefficient on *IIT*. With the full set of dummies, an IIT index value 1 percentage point (0.01 points) higher is associated with 4 per cent higher labour productivity. The first specification that has no dummies does not pass Hausman's test but the other three do.

Table 1 Random-effects linear panel estimations, dependent variable ln(Q/L) in volume terms

Variable	1	2	3	4
Constant	-3.8789*** (.0310)	-3.1531*** (.0245)	-3.1946*** (.0249)	-3.3563*** (.0682)
IIT	.1692*** (.0253)	.1339*** (.0245)	.0491** (.0229)	.0438** (.0211)
NMC	..	-1.6745*** (.0350)	-1.7311*** (.0338)	..
σ	..	..	..	yes
κ	..	..	..	yes
τ	..	..	yes	yes
Hausman	.0000	.0743	.7377	.8537
R^2	.0797	.6270	.6333	.9006

Notes: The estimations pass Hausman's specification test (p-values are reported) with the exception of the first one. The estimations use random effects and robust variance-covariance matrices. There are 14,733 observations in 1,975 groups. Robust standard errors are presented in parentheses. The results for σ, κ and τ are suppressed.

*** = significant at the 1 per cent level, ** = significant at the 5 per cent level, * = significant at the 10 per cent level.

6 Methodology for analysis on MIIT and productivity growth

Then we will move on to productivity growth and the MIIT analysis. We will estimate:

$$\begin{aligned}\Delta \ln\left(Q_{ikt}/L_{ikt}\right) &= \beta_1 + \beta_2 MIIT_{ikt} + \beta_3\left(\textit{change in trade flows}\right)\\ &+ NMC + \mu_{ikt} + \sigma_i + \kappa_k + \tau_t + \varepsilon_{ikt},\end{aligned} \quad (4)$$

where $\Delta \ln\left(Q_{ikt}/L_{ikt}\right)$ is the change in labour productivity and $MIIT_{ikt}$ is marginal intra-industry trade. As we are interested in MIIT-based trade expansion, we include a dummy variable μ_{ikt} for those cases when both exports and imports have decreased from the previous year (see above Section 4). We will also control for the relative change in nominal trade flows, either with $\Delta\ln\left(x_{ikt}+m_{ikt}\right)$ or with $\Delta\ln\left(x_{ikt}\right)$ and $\Delta\ln\left(m_{ikt}\right)$. This way we can take into account the magnitude of the trade flow changes. We expect this variable to be important in the analysis.

As an additional test, we combine the information provided by *MIIT* and the relative size of the trade expansion $\Delta\ln\left(x_{ikt}+m_{ikt}\right)$ by multiplying them with each other. Now $MIIT_{ikt}^{\exp}=MIIT_{ikt}*\Delta\ln\left(x_{ikt}+m_{ikt}\right)$ shows the part of the trade expansion (thence the superscript *exp*) characterised by marginal IIT and $nonMIIT_{ikt}^{\exp}=\left(1-MIIT_{ikt}\right)*\Delta\ln\left(x_{ikt}+m_{ikt}\right)$ the part of the expansion that is not:

$$\begin{aligned}\Delta\ln\left(Q_{ikt}/L_{ikt}\right)=\beta_1+\beta_2 MIIT_{ikt}^{\exp}+\beta_2 nonMIIT_{ikt}^{\exp}\\+NMC+\mu_{ikt}+\sigma_i+\kappa_k+\tau_t+\varepsilon_{ikt}.\end{aligned}\tag{5}$$

Furthermore, we will use a model specification in the tradition of the Solow growth model. Value added in each sector is produced according to a Cobb-Douglas production function

$$Q_{ikt}=AK_{ikt}^{\alpha}L_{ikt}^{1-\alpha},\tag{6}$$

where the new variables are total factor productivity A, the physical capital stock K, and the elasticity of output with respect to capital α. Dividing across with L we get

$$\frac{Q_{ikt}}{L_{ikt}}=A\left(\frac{K_{ikt}}{L_{ikt}}\right)^{\alpha}.\tag{7}$$

We then take logs and first differences to get

$$\Delta\ln\left(Q_{ikt}/L_{ikt}\right)=\alpha\Delta\ln\left(K_{ikt}/L_{ikt}\right),\tag{8}$$

assuming that A is a constant. As we do not have data for the capital stocks, nor enough data to estimate them, $\Delta\ln\left(K_{ikt}/L_{ikt}\right)$ will be approximated with $\ln\left(I_{ikt}/L_{ikt}\right)$, where I is gross fixed capital formation. This is equivalent to assuming that the depreciation rate of capital is 1. An increase in investment relative to the labour input is assumed to have a positive effect on capital intensity. Adding further variables as in (4) we get the equation we will estimate:

$$\begin{aligned}\Delta\ln\left(Q_{ikt}/L_{ikt}\right)=\beta_1+\beta_2\ln\left(I_{ikt}/L_{ikt}\right)+\beta_3 MIIT_{ikt}\\+\beta_4\left(\textit{change in trade flows}\right)\\+NMC+\mu_{ikt}+\sigma_i+\kappa_k+\tau_t+\varepsilon_{ikt}.\end{aligned}\tag{9}$$

In what follows we will drop the subscripts for convenience.

We hypothesise that MIIT increases competition and thereby leads to productivity growth. This could happen through existing companies investing more in product and process development. Licandro and Navas-Ruiz (2007) develop an endogenous growth model with two identical economies. As the countries produce the same set of goods, openness to trade increases competition, reduces prices and makes firms innovate more to profit from the increase in market size. Indeed, IIT is typically higher in trade between relatively similar countries. Too fierce competition can, however, also lead to a decrease in R&D if margins are forced down too low. It is also possible that trade exposure forces the least competitive companies to exit from the market thus leading to a rise in average productivity. This means that structural changes may be taking place inside the sector due to competitive pressures. Melitz (2003) has constructed an influential model along these lines.

We do not analyse the direction of causality between MIIT and productivity growth in more detail. More generally, the question whether or not an increase in exports causes GDP growth and/or vice versa is analysed by, among others, Kónya (2006). According to his results for OECD countries in 1960-1997, these countries are divided into all four possible groups of causal links including two-way causality and no causal link.

In Section 7, we will first estimate equations (4) and (5) using random-effects linear panel estimations. Then we will use a variety of methods to check for robustness, namely fixed-effects and population-averaged linear models, GLS with a homoskedastic error structure and with a heteroskedastic but uncorrelated error structure, and instrumental variables 2SLS estimation. The 2SLS specification instruments the investment-to-labour ratio with its change and its lagged level. Finally, we will estimate equation (9) using random-effects linear panel estimations.

7 Estimating MIIT and productivity growth

Table 2 shows our main random-effects estimation results for equation (4). The inclusion of the μ dummy strengthens the results. Excluding all other control variables and dummies, the inclusion of μ raises the coefficient on *MIIT* from 0.0129 to 0.0180 and its t-value from 2.39 to 3.31. When included, the coefficient on μ is -0.0361 and its t-value is -5.67. The specification passes Hausman's test. In what follows we will typically include μ in the specifications. Its negative sign shows that whenever both exports and imports have decreased, productivity developments have been adverse.

The results for real productivity growth show that the coefficient on *MIIT* is positive and statistically significant at either the 5 or 1 per cent level depending on the specification. In the first specification, the coefficient just misses this mark.

Table 2 **Random-effects linear panel estimations, dependent variable $\Delta\ln(Q/L)$ in volume terms**

	1	2	3	4	5	6
Variable	**Δ(x+m)**	**Δ(x+m)**	**Δx, Δm**	**Δx, Δm**	**MIIT^{exp}**	**MIIT^{exp}**
Constant	.0064 (.0073)	.0199 (.0172	.0078 (.0073)	.0215 (.0173)	.0193*** (.0067)	.0274 (.0171)
MIIT	.0092 (.0057)	.0107* (.0060)	.0115** (.0057)	.0131** (.0061)	..	..
Δln(x+m)	.1069*** (.0208)	.0959*** (.0214)	..	..	..	..
Δln(x)	..	..	.0224 (.0139)	.0170 (.0139)	..	..
Δln(m)	..	..	.0607*** (.0161)	.0540*** (.0169)	..	..
MIIT^{exp}	..	..	..	..	.1632*** (.0341)	.1458*** (.0344)
μ	-.0095 (.0073)	-.0145** (.0074)	-.0140* (.0075)	-.0192** (.0077)	-.0116* (.0070)	-.0157** (.0071)
NMC	.0482*** (.0056)	..	.0492*** (.0056)	..	.0503*** (.0056)	..
σ	no	yes	no	yes	no	yes
κ	no	yes	no	yes	no	yes
τ	yes	yes	yes	yes	yes	yes
Hausman	.5844	.9913	.4644	.5317	.6578	.9290
R^2	.0250	.0413	.0235	.0404	.0235	.0399

Notes: The estimations use random effects and robust variance-covariance matrices. Hausman tests are calculated without vce(robust) and p-values are reported. There are 12,326 observations in 1,933 groups. Robust standard errors are presented in parentheses. The results for σ, κ and τ are suppressed.

*** = significant at the 1 per cent level, ** = significant at the 5 per cent level, * = significant at the 10 per cent level.

The total log change in trade flows is positive and statistically significant meaning that the larger the increase in trade flows, the faster the rise in labour productivity. We also included growth in exports and growth in imports separately, and interestingly only the latter is statistically significant (and positive). This supports the hypothesis that an increase in imports increases competition and forces average productivity up as discussed above.

The dummy for the new member countries, *NMC*, when included, is also always positive and statistically significant reflecting faster productivity growth in these countries than in the EU15 countries. The μ dummy is always statistically significant at the 5 or 10 per cent level (except in the first specification) and its sign is negative as expected. We also multiplied *MIIT* with $\Delta\ln\left(x_{ikt}+m_{ikt}\right)$ and used this as an independent variable denoted by $MIIT^{exp}$. The coefficient on this variable was positive and statistically very significant, as could be expected. The estimations pass Hausman's specification test. We also tested that the time effects are jointly significant. Consequently, including them is appropriate.

According to the results and taking averages of the results for specifications 2 and 4, an MIIT index value 0.10 points higher is associated with a 0.12 percentage points higher growth rate of labour productivity.

In Table 3, we show the results for the estimations for equation (5). Now MIIT is multiplied with the change in trade flows. We also include the non-MIIT trade flow change. Both coefficients are statistically very significant and positive, but the former is larger. We tested for the equality of the coefficients on $MIIT^{exp}$ and $nonMIIT^{exp}$ and found that they are different. This time μ is not significant, so we show the results also without it. The estimations are done using both random effects and fixed effects.

Table 3 **A division of trade flow change into marginal and non-marginal IIT with a test of the equality of their coefficients, dependent variable $\Delta\ln(Q/L)$ in volume terms**

Variable	Random effects	Random effects	Fixed effects	Fixed effects
Constant	.0076 (.0086)	.0157** (.0075)	.0234** (.0093)	.0251*** (.0094)
$MIIT^{exp}$	.1551*** (.0221)	.1487*** (.0235)	.1579*** (.0257)	.1460*** (.0274)
$nonMIIT^{exp}$	.0912*** (.0193)	.0876*** (.0198)	.0783*** (.0219)	.0720*** (.0225)
μ	..	-.0051 (.0064)	..	-.0094 (.0074)
NMC	.0477*** (.0047)	.0477*** (.0047)	..	..
τ	yes	yes	yes	yes
Test H0: $MIIT^{exp}$=$nonMIIT^{exp}$	.0503	.0626	.0348	.0514
Hausman	.6645	.5496	..	..
R^2	.0250	.0251	.0151	.0151

Notes: We reports the p-values for the test of the equality of the coefficients on $MIIT^{exp}=MIIT*\Delta\ln(x+m)$ and $nonMIIT^{exp}=(1-MIIT)*\Delta\ln(x+m)$ as well as for Hausman's test. There are 12,340 observations in 1,933 groups. Standard errors are presented in parentheses. The results for τ are suppressed.

*** = significant at the 1 per cent level, ** = significant at the 5 per cent level, * = significant at the 10 per cent level.

Furthermore, as a simple test of strict exogeneity to detect feedback, as is done in e.g. Yamarik (2008), we tested what effect adding a first-lead of $MIIT^{exp}$ and $nonMIIT^{ex}$ has on the results. Adding these has no discernible effect on other independent variables and the lead variables are statistically not significant themselves. The test statistic does not reject the null of the coefficients on the lead levels being zero.

Table 4 shows additional estimations with a basic set of independent variables. The estimations are fixed-effects and population-averaged linear models, GLS with a homoskedastic (i.i.d.) and heteroskedastic but uncorrelated error structure, and an instrumental variables 2SLS estimation. The last one instruments the investment-to-labour ratio with its lagged level and first difference.

MIIT has a positive sign and is statistically significant at the 5 per cent level, once also at the 1 per cent level. The coefficients on *MIIT* are close to the results presented in Table 2. The coefficient on *MIIT* is smaller in the 2SLS estimation than in the OLS, which is intuitive (see Felbermayr, 2005). The signs and statistical significance of the other variables are as expected.

Table 4 Different panel estimations, dependent variable $\Delta\ln(Q/L)$ in volume terms

Variable	Fixed-effects linear model	Population-averaged linear model	GLS homoskedastic	GLS heteroskedastic	Instrumental variables 2SLS
Constant	.0254*** (.0077)	.0042 (.0073)	.0178** (.0078)	.0179*** (.0025)	.0445** (.0184)
MIIT	.0167** (.0065)	.0111** (.0048)	.0143** (.0057)	.0153*** (.0018)	.0130** (.0058)
ln(I/L)	..	..	..	..	.0063** (.0032)
Δln(x+m)	.1077*** (.0392)	.1037*** (.0327)	.1039*** (.0227)	.0833*** (.0104)	.0902*** (.0236)
NMC	..	.0534*** (.0037)	.0534*** (.0046)	.0567*** (.0015)	.0651*** (.0059)
μ	-.0244*** (.0082)	-.0192*** (.0061)	-.0214*** (.0063)	-.0198*** (.0023)	-.0154** (.0065)
τ	yes	yes	yes	yes	yes
Instrumented	..	..	..	..	ln(*I*/*L*)
R^2	.0099	..	..	..	.0250

Notes: There are 12,340 observations in 1,933 groups, except in the last estimation 11,236 observations and 1,893 groups. Standard errors are presented in parentheses; these are robust in the first two estimations. The results for τ and are suppressed.

*** = significant at the 1 per cent level, ** = significant at the 5 per cent level, * = significant at the 10 per cent level.

Table 5 includes the investment-to-labour ratio as constructed in equation (9). We have only included the estimations that pass Hausman's test. This has required the inclusion of all dummy variables. According to the results, the coefficient on the investment-to-labour ratio is positive and statistically significant at the 1 per cent level. *MIIT* is positive and statistically significant at the 10 per cent level when the control variables for the changes in trade flows are included. The coefficient on $MIIT^{exp}$ is statistically significant at the 1 per cent level.

Table 5 **Random-effects linear panel estimations with investment, dependent variable $\Delta\ln(Q/L)$ in volume terms**

Variable	Δx, Δm + all dummies	$MIIT^{exp}$ + all dummies
Constant	.1235*** (.0318)	.1260*** (.0317)
ln(I/L)	.0203*** (.0050)	.0199*** (.0051)
MIIT	.0101* (.0060)	..
Δln(x)	.0229* (.0126)	..
Δln(m)	.0485*** (.0170)	..
$MIIT^{exp}$	..	.1256*** (.0346)
μ	-.0124* (.0075)	-.0120* (.0071)
σ	yes	yes
κ	yes	yes
τ	yes	yes
Hausman	.7580	.8312
R^2	.0450	.0444

Notes: The estimations use random effects and robust variance-covariance matrices. Hausman tests are calculated without vce(robust) and p-values are reported. There are 11,682 observations in 1,902 groups. Robust standard errors are presented in parentheses. The results for σ, κ and τ are suppressed.

*** = significant at the 1 per cent level, ** = significant at the 5 per cent level, * = significant at the 10 per cent level.

8 Summary and conclusions

Intra-industry trade (IIT) dominates industrialised countries' foreign trade. According to the smooth-adjustment hypothesis, a change in trade flows of the intra-industry type causes less adjustment costs in the labour market than an inter-industry trade-flow change. We can measure to what degree trade-flow changes are IIT in character by using the measurement of marginal intra-industry trade (MIIT) that goes from 0 to 1 as the share of IIT in marginal trade increases.

Using this measurement, we analyse how a marginal intra-industry trade expansion and labour productivity growth across 23 EU countries and 94 manufacturing sectors in 1995-2005 have interrelated. Using simple averages across sectors, we find that the highest MIIT index values are in sectors producing differentiated goods, science-intensive sectors and scale-intensive sectors. The lowest MIIT index values are in resource and labour-intensive sectors. Using F and t-tests, and combining sectors producing differentiated goods with the science-intensive sectors, we show that the within-means are the same for the first three groups on the one hand, and the same for the last two groups on the other hand, but different otherwise. Resource and labour-intensive sectors can be seen to be based on traditional comparative advantage and it is natural that IIT is lower there.

We hypothesise that positive MIIT increases competition and leads to faster labour productivity growth in the sector. According to literature, this could happen through existing companies investing more in product and process development and/or through the exit of the least competitive companies from the market. More productive companies can also raise average productivity in the sector by outgrowing production of less productive companies whose weight thereby decreases.

According to our results of real productivity growth the coefficient on MIIT is positive and statistically significant. We control for the relative size of the trade expansion and the coefficient on this variable has a statistically significant positive sign. Thus the larger the trade expansion, the larger the impact on productivity growth. Especially the increase in imports is found to be important. This supports the argument that increased competition forces productivity up. Because the MIIT index is symmetrical in situations where both exports and imports either increase or decrease, we control for this with a dummy for the latter case. The sign is negative and statistically significant, which strengthens our results.

In the specifications with the full set of dummies for year, country and sector as well as other control variables, an MIIT index value 0.10 points higher is associated with a 0.12 percentage-point higher growth rate of labour productivity.

The results are confirmed using a fixed-effects linear model, a population-averaged linear model, GLS with a homoskedastic (i.i.d.) error structure, GLS with a heteroskedastic but uncorrelated error structure, and an instrumental variables 2SLS estimation.

On the whole, we find that sectors where trade expansion has taken place in terms of intra-industry trade, i.e. high MIIT, labour productivity growth has been faster than in other sectors. On average, these sectors are shown to be sectors producing differentiated goods or to be science or scale-intensive sectors.

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Appendix

Tables A1 and A2 show the share of MIIT in the countries' and sectors' trade-flow changes. The figures are simple averages. The EU15 countries have data for 1995-2005 and the new member countries for 1999-2005. The calculations are by excluding those four EU countries and nine sectors that are not included in this study (see above). The MIIT index value has been suppressed in those cases where both exports and imports decrease.

Table A1 Simple average of MIIT by countries

Country	MIIT	Country	MIIT
EU average	0.375	**Ireland**	0.258
Austria	0.435	**Italy**	0.372
Belgium	0.494	**Lithuania**	0.405
Bulgaria	0.377	**Latvia**	0.348
Cyprus	0.159	**Netherlands**	0.437
Czech Republic	0.479	**Poland**	0.396
Germany	0.409	**Portugal**	0.292
Denmark	0.354	**Romania**	0.339
Spain	0.411	**Sweden**	0.372
Finland	0.305	**Slovenia**	0.413
France	0.455	**Slovakia**	0.417
Hungary	0.347	**United Kingdom**	0.365

Table A2 Simple average of MIIT by sectors

Code	Sector	MIIT
da151	**production, processing and preserving of meat and meat products**	0.350
da152	**processing and preserving of fish and fish products**	0.403
da153	**processing and preserving of fruit and vegetables**	0.362
da154	**vegetable and animal oils and fats**	0.279
da155	**dairy products**	0.396
da156	**grain mill products, starches and starch products**	0.244
da157	**prepared animal feeds**	0.294
da158	**other food products**	0.513
da159	**beverages**	0.383
da160	**tobacco products**	0.259
db171	**preparation and spinning of textile fibres**	0.369
db172	**textile weaving**	0.297
db174	**made-up textile articles, except apparel**	0.351
db175	**other textiles**	0.374
db176	**knitted and crocheted fabrics**	0.263
db177	**knitted and crocheted articles**	0.365
db181	**leather clothes**	0.327

db182	other wearing apparel and accessories	0.379
db183	dressing and dyeing of fur; articles of fur	0.293
dc191	tanning and dressing of leather	0.313
dc192	luggage, handbags and the like, saddlery and harness	0.412
dc193	footwear	0.334
dd201	sawmilling and planing of wood, impregnation of wood	0.341
dd202	veneer sheets; plywood, laminboard, particle board, fibre board and other panels and boards	0.451
dd203	builders' carpentry and joinery	0.341
dd204	wooden containers	0.336
dd205	other products of wood; articles of cork, straw and plaiting materials	0.294
de211	pulp, paper and paperboard	0.396
de212	articles of paper and paperboard	0.359
de221	publishing	0.373
de222	printing and service activities related to printing	0.304
df231	coke oven products	0.141
df232	refined petroleum products	0.376
df233	processing of nuclear fuel	0.159
dg241	basic chemicals	0.476
dg242	pesticides and other agro-chemical products	0.296
dg243	paints, varnishes and similar coatings, printing ink and mastics	0.455
dg244	pharmaceuticals, medicinal chemicals and botanical products	0.547
dg245	soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations	0.503
dg246	other chemical products	0.454
dg247	man-made fibres	0.296
dh251	rubber products	0.496
dh252	plastic products	0.612
di261	glass and glass products	0.460
di262	non-refractory ceramic goods other than for construction purposes; refractory ceramic products	0.333
di263	ceramic tiles and flags	0.177
di264	bricks, tiles and construction products, in baked clay	0.193
di265	cement, lime and plaster	0.198
di266	articles of concrete, plaster and cement	0.283
di267	cutting, shaping and finishing of stone	0.227
di268	other non-metallic mineral products	0.456
dj271	basic iron and steel and of ferroalloys (ECSC)	0.511
dj272	tubes	0.410
dj273	other first processing of iron and steel and production of non-ECSC ferroalloys	0.392
dj274	basic precious and non-ferrous metals	0.436
dj281	structural metal products	0.369
dj282	tanks, reservoirs and containers of metal; central heating radiators and boilers	0.341
dj283	steam generators, except central heating hot water boilers	0.149

dj286	cutlery, tools and general hardware	0.466
dj287	other fabricated metal products	0.562
dk291	machinery for the production and use of mechanical power, except aircraft, vehicle and cycle engines	0.536
dk292	other general purpose machinery	0.465
dk293	agricultural and forestry machinery	0.262
dk294	machine-tools	0.381
dk295	other special purpose machinery	0.386
dk296	weapons and ammunition	0.220
dk297	domestic appliances n.e.c.	0.430
dl300	office machinery and computers	0.402
dl311	electric motors, generators and transformers	0.487
dl312	electricity distribution and control apparatus	0.542
dl313	insulated wire and cable	0.465
dl314	accumulators, primary cells and primary batteries	0.395
dl315	lighting equipment and electric lamps	0.454
dl316	electrical equipment n.e.c.	0.459
dl321	electronic valves and tubes and other electronic components	0.461
dl322	television and radio transmitters and apparatus for line telephony and line telegraphy	0.389
dl323	television and radio receivers, sound or video recording or reproducing apparatus and associated goods	0.471
dl331	medical and surgical equipment and orthopaedic appliances	0.520
dl332	instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process control equipment	0.458
dl334	optical instruments and photographic equipment	0.368
dl335	watches and clocks	0.326
dm341	motor vehicles	0.360
dm342	bodies (coachwork) for motor vehicles; trailers and semi-trailers	0.355
dm343	parts and accessories for motor vehicles and their engines	0.453
dm351	building and repairing of ships and boats	0.251
dm352	railway and tramway locomotives and rolling stock	0.273
dm353	aircraft and spacecraft	0.382
dm354	motorcycles and bicycles	0.398
dn361	furniture	0.420
dn362	jewellery and related articles	0.378
dn363	musical instruments	0.263
dn364	sports goods	0.420
dn365	games and toys	0.372
dn366	miscellaneous manufacturing n.e.c.	0.425

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