Comparative advantage, multi-product firms and trade liberalisation : An empirical test

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Abstract

This paper investigates how economies of scope in multi-product firms interact with comparative advantage in determining the effect of trade liberalisation on resource reallocation, using Belgian manufacturing firm- and firm-product-level data over the period 1997-2007. We first provide evidence on industry integration induced by multi-product firms producing simultaneously in multiple industries and on the extent to which industry integration occurs between industries that have different degrees of comparative advantage. We then examine the impact of opening up trade with low-wage countries on both inter- and intra-industry resource reallocation, taking into account heterogeneity in the integration rate across sectors and industries. Our results indicate that, within more closely integrated sectors, trade liberalisation with low-wage countries leads to less reallocation from low-skill-intensity (comparative-disadvantage) industries to high-skill-intensity (comparative-advantage) industries, both in terms of employment and output. We also find that more integrated industries experience less skill upgrading after trade liberalisation with low-wage countries. Furthermore, we find that within sectors with a low integration rate, trade liberalisation with low-wage countries induces relatively more aggregate TFP and average firm output growth in comparative-advantage industries than in comparative-disadvantage industries, in line with the prediction of Bernard, Redding and Schott (2007), while the opposite is true in highly integrated sectors. Decomposition of the industry-level aggregate TFP changes reveals that the result is mainly driven by reallocation between incumbent firms within industries. Overall, the results are highly consistent with the predictions of the Song and Zhu (2010) model.

Key words: trade liberalisation, industry integration, comparative advantage, firm heterogeneity, microeconomic panel data, Total Factor Productivity.

JEL code : F11, F12, F14, L23.

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1. Introduction

How will resources be reallocated after trade liberalization? Various characteristics of the economy may matter in this process. The neoclassical Hecksher-Ohlin model (Ohlin, 1967) emphasises country and industry characteristics, i.e., the endowment of countries and the factor intensity of industries. Something that has been ignored by this framework is firm-level characteristics. Recent development in trade literature has shifted the focus to such firm-specific features, especially the existence of within-industry firm heterogeneity in productivity (e.g., Melitz2003) and the prevalence of multi-product firms in the market (Bernard, Redding and Schott, 2010; Bernard, Van Beveren, and Vandenbussche, 2010; Mayer, Melitz and Ottaviano, 2010; Eckel and Neary, 2010; Nocke and Yeaple, 2008; etc.). But this literature has so far mostly ignored comparative advantages by considering only one factor of production. Bernard, Redding and Schott (2007) (BRS hereafter) were the first to integrate comparative advantage into a Melitz-type heterogeneous firm model, but they do not consider multi-product firms. In this paper, we want to empirically investigate the implications of the existence of multi-product firms for industry-level resource reallocation during trade liberalisation. This research is guided by the model of Song and Zhu (2010) (SZ hereafter), in which they integrate endowment-driven comparative-advantage, within-industry firm heterogeneity and multi-product firms that produce in both comparative-advantage and comparative-disadvantage industries into one model, in order to investigate how these factors interact with each other in determining the effect of trade liberalisation on resource reallocation and income redistribution.[1]

The important role of multi-product firms both in the domestic and the international market has attracted the attention of trade economists only recently (for a survey on this literature, see Mayer, Melitz and Ottaviano, 2010). The focus of this literature so far has been on within-firm across-product differences in productivity and within-firm reallocation from low-productivity products to high-productivity ones. In this paper, we instead take an *industry-level* viewpoint to investigate the implications of the presence of multi-product firms for *industry-level* resource reallocation during trade liberalisation, especially when there are multi-product firms which simultaneously produce in industries with different degrees of comparative advantage.[2] In this paper, we call the phenomenon of firms producing simultaneously in different industries 'industry integration', which is presumably induced by the existence of economies of scope. We will use 'industry integration', 'the existence of multi-product firms' and 'the existence of scope economies' inter-changeably in this paper.

Why might multi-product firms matter in determining the effects of trade liberalisation on industry-level resource reallocation? The intuition is that the existence of multi-product firms which produce simultaneously in industries with different degrees of comparative advantage introduces a

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[1] Bernard, Redding and Schott (2006) also provide a model that incorporates both comparative advantage and multi-product firms, but in their model, multi-product firms only produce within the same industry, i.e., all the products they produce have the same skill intensity. So, their model has no kind of interaction between comparative-advantage and multi-product firms as shown in the SZ model.

[2] In Section 3.4, we provide evidence of the existence of multi-product firms that produce simultaneously in industries with a different degree of comparative advantage in Belgian manufacturing sectors.

trade-off between *scope economies* and *specialisation economies*[3] for a country that is facing trade liberalisation. The existence of multi-product firms indicates the existence of economies of scope in carrying out different activities within firm boundary.[4] If there are economies of scope for firms to carry out together activities both with and without comparative advantage (or with different degrees of comparative advantage), then, compared with a situation where there are no scope economies, trade liberalisation should induce less reallocation from comparative-disadvantage activities to comparative-advantage activities, since such reallocation implies more specialisation and less use of scope economies.[5] Since different sectors (in this paper, we define sectors at the 2-digit NACE code level, and industries at the 4-digit NACE code level, while products are defined at either 6-digit or 8-digit Prodcom code level) may have different degrees of integration, the above analysis implies that more integrated sectors should be less affected by trade liberalisation, which is an implication of the SZ model. In this paper, using Belgian manufacturing firm-product-level data, we find supportive evidence for this implication.

Additional implications of industry integration for within-industry reallocation can be derived if we consider within-industry firm heterogeneity. As revealed by the heterogeneous firm literature, trade liberalisation induces within-industry reallocation from low-productivity firms to high-productivity firms which boosts industry-level aggregate productivity.[6] BRS (2007) add a Hechscher-Ohlin type of comparative advantage to the Melitz model and find that, after trade liberalisation, comparative-advantage industries will experience more intra-industry reallocation than comparative-disadvantage industries because trade liberalisation encourages more entry into the comparative-advantage industries which in turn intensifies competition and makes it harder for low-productivity firms to survive in these industries. SZ (2010) introduce multi-product firms into the BRS model. They show that if multi-product firms have a big enough presence in the market, the BRS results will be mitigated or even reversed. This is because, as explained above, industry integration reduces the benefits of resource reallocation from comparative-disadvantage industries to comparative-advantage industries following trade liberalisation, which implies that the relative increase in the number of new entrants into the comparative-advantage industries is also mitigated. Meanwhile, the import competition faced by comparative-disadvantage industries after trade liberalisation is harsher than that faced by comparative-advantage industries. Thus, if industry integration is important enough in the market, the net effect of trade liberalisation on within-industry reallocation may be more pronounced in comparative-disadvantage industries. We will test both the predictions of the BRS model and the SZ model in this paper.

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3 By specialisation economies, we mean the benefit from each country specialising in their comparative advantage activities. By economies of scope we mean the benefit from producing products in different industries.

4 For a survey on the economic motivations of multi-product firms, see Bailey (1982).

5 Firms may make use of both scope and specialisation economies by becoming multinationals, but it is commonly acknowledged that FDI requires much higher entry costs than importing or exporting, thus the cost of specialisation for more integrated industries is still higher.

6 For the theoretical model, see Melitz (2003); for empirical evidence, see, for example, Pavcnik (2002) and Bernard, Jensen and Schott (2006b).

We use Belgian manufacturing firm-level data from the period 1997-2007, complemented by information on firm-product level output from the industrial production survey of Belgian manufacturing firms - the Prodcom dataset. We focus on trade liberalisation with low-wage countries. The main results are as follows. We find that, in more integrated sectors, trade liberalisation with low-wage countries induces less inter-industry reallocation both in terms of employment and output, and less skill upgrading after trade liberalisation in more integrated industries. For within-industry resource reallocation, we find that, within poorly integrated sectors, opening up trade with low-wage countries induces relatively more average total factor productivity (TFP) and average output growth in high-skill-intensity industries than in low-skill-intensity industries, while the opposite is true in highly integrated sectors. By further decomposing the aggregate TFP changes into parts that can be attributed to different channels (i.e., through either within-firm productivity upgrading, between-firm reallocation or firm entry and exit, respectively), we find that the results are mainly driven by reallocation across incumbent firms. Overall, the results are highly consistent with the predictions of the SZ model. The predictions of the BRS model are also confirmed if we only look at sectors with relatively low integration rate.

Our research contributes to three areas of literature. First, we contribute to the neoclassical trade theory by showing that comparative advantage matters differently in sectors with different degrees of integration. Second, we contribute to the heterogeneous-firm literature (Melitz, 2003; Bernard, Redding and Schott, 2007; etc.) by providing empirical evidence that the impact of trade liberalisation on within-industry reallocation differs across industries with varying degrees of comparative advantage.[7] We further show that the nature of this difference may differ depending on the integration rate of sectors. Third, we contribute to the recently developed literature of multi-product firms by showing the important role played by multi-product firms in determining industry-level resource reallocation following trade liberalisation. So far, this literature has mainly focused on within-firm reallocations. Finally, our findings may also contribute to the long-running debate about the effect of globalisation on the rising income inequality in developed countries. So far, most research in the literature has found limited evidence for the effect of trade with low-wage countries on the increasing relative demand for skilled workers in developed countries (e.g., Berman, Bound and Griliches, 1994), at least during the 1990s period surveyed. Our findings in this paper point to the possibility that these previous results in the literature may suffer from the bias induced by their ignoring the role of industry integration. If we focus on industries with a low integration rate, then the impact of trade with low-wage countries will have a more significant effect on the increase in relative demand for skilled workers at the industry level.

Our work is closest in spirit to Hausmann and Klinger (2007) and Hidalgo, Klinger, Barabasi and Hausmann (2007) who develop the concept of 'product space' and study how it conditions the development of nations and the evolution of revealed comparative advantage of countries. They

[7] There has been some small empirical literature that tries to test the implications of the BRS model, such as Bru, Groizard and Marques (2010) and Rungi (2010). The differences between our paper and theirs are that we use firm-level data and focus on trade liberalisation with low-wage countries, and that they do not consider the role of multi-product firms.

use 'product space' to refer to the network of relatedness between products and show that this 'product space' is quite heterogeneous in the sense that the interrelation between different products varies considerably. Using international trade data, they show that countries tend to develop new products that are most closely related to the products they have been already exporting. Our work is similar to theirs in the sense that we also study how the relatedness between products (industries) affects the pattern of countries' specialisation. But our work also differs from theirs in several ways. First, we focus on a specific kind of link between products, i.e., the relatedness induced by the activity of multi-product firms, while their concept of relatedness is much wider and can be induced by many reasons, e.g., two products may be related because they require similar institutional infrastructure at the country level. Accordingly, we measure our concept of relatedness, i.e., the integration rate, basing on the co-production of products by firms, while they define relatedness on the basis of countries' co-exporting of products. Finally, the problem we focus on here is also quite different from theirs. We look at how industries respond to trade liberalisation, while they focus on the long-run development of countries.

The rest of the paper is organised as follows. Section 2 briefly introduces the model and sets out the theoretical predictions that will be tested in this paper. Section 3 describes the data and the construction of the main variables used in the analysis. In Section 4, we report evidence on the prevalence of multi-product firms in Belgian manufacturing and evaluate to what extent these firms produce in industries that differ in skill intensity. Our main findings about the impact of trade liberalisation on industry-level outcomes are presented in Section 5. Section 6 concludes.

2. Theory

This research is guided by the SZ model which builds on the BRS model. The BRS model is the first that features both Hechscher-Ohlin-type comparative advantage and firm heterogeneity in the spirit of Melitz (2003). They consider a world of two countries, two factors and two industries. Countries differ in relative factor abundance, industries differ in relative factor intensity and firms within each industry are heterogeneous in terms of productivity and each of them produces a single differentiated variety. The market structure is of monopolistic competition. Firms have to pay a fixed entry cost (which is sunk after entry) to move into each industry. After trade liberalisation, resource reallocation will occur both across industries due to comparative advantage and across firms within the same industry due to productivity differences. The size of the comparative-advantage industry (CA industry hereafter) will increase relative to that of the comparative-disadvantage industry (CD industry hereafter) after trade liberalisation. As a result of this inter-industry reallocation, the relative demand for the abundant factor will increase and so will the relative wage of the abundant factor. These results are the same as that of the H-O model. For within-industry reallocation, trade liberalisation induces low-productivity firms to contract or directly exit the market and high-productivity firms to expand in both CA and CD industries. As a result, the industry-level aggregate productivity of both CA and CD industries will rise. But this within-industry creative destruction will be more pronounced in CA industries, as trade liberalisation encourages more entry into CA industry which in turn intensifies competition and makes low-productivity firms harder to survive in

CA industry. Thus the aggregate productivity gain from trade liberalisation will be higher in CA industry than in CD industry, which magnifies *ex ante* comparative advantage and creates additional welfare gains from trade liberalisation.

One limitation of the BRS model (as well as the traditional H-O model) is that they only allow firms to produce in one industry with one product, while in reality there is evidence of multi-product or multi-industry firms and, as has been shown by their own work (Bernard, Redding and Schott, 2010 and 2011), multi-product firms play a central role in both domestic and international markets. The SZ model introduces multi-product firms to the BRS model, i.e., after entering one industry, firms can choose to move into the second industry by paying an extra entry cost. In equilibrium, only firms with relatively high productivity will choose to become multi-industry firms. The key parameter of the SZ model is the extra entry cost firms have to pay for going into a second industry. If this extra entry cost is infinite, i.e., all firms will only choose to produce in one industry, then the SZ model becomes the same as the BRS model. If the extra entry cost is non-infinite, then there will be multi-industry firms and the model will deviate from the BRS model. The smaller the extra entry cost (i.e., greater economies of scope), the wider the deviation will be.

SZ prove that if there is scope economies for firms to produce both in CA and CD industries, many of the BRS results will be mitigated or even reversed. First, they show that in the presence of multi-product firms, the inter-industry reallocation effect of trade liberalisation will be more moderate compared with that in the BRS model. As the extra entry cost for firms to move into a second industry goes down, this mitigation effect will become more and more pronounced. Second, for within-industry reallocation, they show that there will be a similar mitigation effect, i.e. as the extra entry cost goes down, the relative increase of the aggregate productivity of the CA industry will be mitigated. Furthermore, when the extra entry cost is low enough, the aggregate productivity of the CD industry will increase even more than that of the CA industry and thus the BRS result is reversed.

The intuition for the SZ results is as follows. First, as in the BRS model, trade liberalisation brings more entrants into the CA industry due to the greater export opportunities in this industry, which increases the equilibrium relative number of firms producing in CA industry and the productivity cut-off for firms to survive in this industry. Second, due to the non-infinite extra entry cost for firms to move into a second industry, some of the new entrants into the CA industry will also go into the CD industry. It is this second mechanism that makes the SZ results different from the BRS results. As the extra entry cost moves down, the second mechanism will become more and more important, which mitigates inter-industry reallocation of resources and intensifies intra-industry reallocation in the CD industry, since there will be more and more shifts of firms from the CA industry over to the CD industry. When the extra entry cost is so low that the number of new entrants induced by trade liberalisation is not so much higher in the CA industry than in the CD industry, the CD industry will experience more aggregate productivity increases since it faces more import competition.

Despite the different results, we consider the SZ model more of a complement rather than a substitute to the BRS model, since economies of scope may play less important roles in some sectors than in others (Chandler, 1990). For sectors where economies of scope play no role at all, the SZ model is equivalent to the BRS model.

Based on the BRS model and the SZ model, we can have the following testable hypotheses:[8]

Hypothesis 1: After trade liberalisation, total employment and total output of CD industries will decrease, while that of CA industries will increase, but in sectors with high degree of integration, the difference in employment and output growth between CA and CD industries will be mitigated.

Hypothesis 1 is concerned with the effect of trade liberalization on inter-industry reallocation which is measured by employment and output changes. Hypothesis 1 is not qualitatively different from the implications of the neoclassical trade theory. The difference here is that we consider sector heterogeneity in terms of integration rate. In the SZ model, the lower the extra entry cost is, the more multi-product firms there will be in equilibrium. In other words, when economies of scope are greater in one sector, there will be more multi-product firms in that sector. We will create a measure for the integration rate in the next section. Finally, while we distinguish between CA and CD industries in theory, we will use a continuous measure for comparative advantage in the empirical evaluation of the model. Since we focus on trade liberalisation with low-wage countries in this paper, we consider industry-level skill intensity as our measure of comparative advantage.

Hypothesis 2: After trade liberalisation with low-wage countries, more integrated sectors (or industries) should experience less skill upgrading.

Hypothesis 2 is an implication of hypothesis 1. Since trade liberalisation with low-wage countries induces less reallocation of employment from low-skill-intensity (CD) to high-skill-intensity (CA) industries in more integrated sectors, skill upgrading should also be less significant. The mitigated skill upgrading implies that the unskilled workers in more integrated sectors should be less affected by trade liberalisation with low-wage countries. Thus, to some extent, industry integration acts as a shelter for unskilled workers.

Hypothesis 3: After trade liberalisation, the aggregate productivity and average firm output of all industries will rise. Within each sector, the aggregate productivity and average firm output of CA industries may increase less or more than that of CD industries, depending on the degree of integration of that sector. Within more integrated sectors, the aggregate productivity and average firm output of CA industries is less likely to increase more than that of CD industries. This 'integration effect' should be more significant for the changes in aggregate productivity that are induced by reallocation between firms.

8 The SZ model also provides some predictions concerning within-firm adjustments following trade liberalisation. In this paper, we only focus on industry-level resource reallocation and leave the test of firm-level implications of the SZ model for future research work.

Hypothesis 3 is concerned with within-industry reallocation. We use both aggregate productivity and average firm output to measure the extent of within-industry reallocation. Since more productive firms tend to be larger, the exit of low-productivity firms also implies the exit of smaller firms, which results in an increase in both average productivity and average firm output in each industry. In the empirical test, we will decompose aggregate productivity changes into three components, i.e., within-firm change in productivity, the change induced by reallocation between incumbent firms and the change induced by firm entry and exit. We expect that trade liberalisation should generate aggregate productivity growth mainly through inducing reallocation between firms rather than through productivity upgrading within firms, since there will be no within-firm productivity changes according to the theoretical model.

3. Data

To test the hypotheses, we use data for Belgian manufacturing firms during the period 1997-2007. We will explain in this section how the dataset is constructed and how the main variables (trade liberalisation, industry-level comparative advantage and sector/industry integration rate, and industry-level TFP) are measured.

3.a. Construction of the dataset

The dataset has been obtained after merging several sources of information. The Central Balance Sheet Office of the National Bank of Belgium (NBB) provides us with firms' annual accounts, which include information on both the inputs and output of firms, with which (after aggregation from firm level data) we can measure industry-level employment, output, skill intensity, and TFP, which will be used as dependent and/or independent variables in our regressions. As annual accounts only report firms' industry affiliation according to their main activities (i.e., the 4-digit NACE Rev.1.1 industry where a firm's primary activity takes place), we use the survey on industrial production (Prodcom) to obtain information on production by firm and by product (at 8-digit Prodcom code level)[9], with which we are able to construct a measure for sector/industry integration rate. To measure trade liberalisation, we use 4-digit NACE industry-level trade data from the ComExt Intra- and Extra-European Trade Data from Eurostat.

Annual account data has been annualised. Missing values were extrapolated, and NACE codes were harmonised (if a firm's main industry changes for only less than two years, we will dismiss such changes). The sample period starts in 1997 and ends in 2007.[10] Firms' output and capital stock are deflated by NACE 2-digit level price indices.

The Prodcom database covers the population of firms that have declared their production activities between 1995 and 2008. The data contains firms' production activities at the firm-product

9 Information on service output is not available in Prodcom.

10 The sample is restricted in order to have a consistent employment series, as the reporting rule in the annual accounts for a number of variables related to workforce was modified in 1996, but did not become fully effective until 1997.

level in each year.[11] We harmonised Prodcom codes over years using Eurostat concordance tables.[12] Our main purpose of using the Prodcom data is to construct an integration rate index (see Section 3.d) for which we only need information on the Prodcom codes of the products each firm produces, measurement error should be less of a concern. Nevertheless, we do need information on firms' output in each product to estimate skill intensity by industry (see Section 4.b) and for a robustness test (see Section 5.d). In that case, we have trimmed the data to ensure consistency between Prodcom data and annual accounts figures which we will explain latter.

In the rest of the paper, we distinguish between four levels of aggregation. First, the product level refers to a 6- or 8-digit Prodcom code, the first four digits of which are the same as the NACE code. Second, the industry level refers to the 4-digit NACE classification. Third, the sector level is defined at the 2-digit NACE level. Fourth, for estimating the production function, we define it at the NACE 31 branch level, which is higher than 2-digit sector level in NACE classification.[13]

3.b. Measurement of industry-level trade liberalisation

We use changes in the trade share of low-wage countries to measure industry-level trade liberalisation with low-wage countries where low-wage trade share is defined as:

$$\text{TRADSHARE}_{\text{jt}}^{\text{L}} = \frac{M_{jt}^{L}+X_{jt}^{L}}{M_{jt}+X_{jt}}$$

where M_{jt}^{L} (X_{jt}^{L}) is imports (exports) of industry *j* from (to) low-wage countries in year t, while M_{jt} (X_{jt}) is imports (exports) of industry *j* from (to) all countries in year t. Low-wage countries are defined as countries with less than 10% of Belgian per capita GDP (average over 1994-2009, see Table A1 in Appendix for the list of low-wage countries).[14] We expect that a higher low-wage trade share indicates a higher degree of trade liberalisation with low-wage countries in that industry. In Section 5.d, we also use industry-level simple average tariff changes as an alternative measure for trade liberalisation.

11 Between 1995 and 2007, all firms employing at least 10 people and with primary manufacturing activity were required to report to Prodcom. Firms with primary activity outside the manufacturing sector were only required to report if they employed at least 20 people. Firms with less than 10 employees (or less than 20 if their primary activity is outside the manufacturing sector) are only required to report if their turnover exceeds a minimum threshold (which has increased over time). The Prodcom survey is obligatory and its underlying legislation is EU-based. All EU Member States (and some EFTA countries and future accession countries) are bound by the Prodcom Regulation. For a more detailed description on the Prodcom database, see Bernard, Van Beveren, and Vandenbussche (2010).

12 Prodcom classification of each year is converted to that of the last one observed in our sample. In the event of one-to-many conversions: if the firm produces in one product category in t that has been split into many product categories in *t*+1, constant shares of production across products in *t* and *t*+1 are assumed. In case the firm no longer produces in that category in *t*+1, the average production shares across all others firms is used. We thank Emmanuel Dhyne for providing us with the correspondence codes.

13 There are 14 branches (DA to DN) for manufacturing in NACE system, while the number of 2-digit sectors in manufacturing is 23 (15-37).

14 We also tried different income cut-offs in defining low-wage countries, see Section 5.d.

As shown in Figure 1, the trade share of low-wage countries in Belgian manufacturing was growing during the sample period, but especially after 2002, which may due to the effect of China's entering the World Trade Organisation (WTO) in 2001. The share of imports from low-wage countries was growing faster than export share of low-wage countries. The evolution of the low-wage trade share by 2-digit sector is reported in Table A2 in the Appendix.

Figure 1: Trade share of low-wage countries in Belgian manufacturing.

3.c. Measurement of industry-level comparative advantage

Since we focus on trade liberalisation with low-wage countries, following Bernard, Jensen and Schott (2006a), we use industry-level skill intensity as a measure for comparative advantage. We assume that Belgium has more comparative advantage in more skill-intensive industries relative to low-wage countries. Industry skill intensity is measured by the share of while-collar workers in total employment, which is aggregated from firm-level data, while firms are classified to 4-digit NACE industries according to their main activity.[15] We do not use capital intensity as a measure of comparative advantage, because capital is much more mobile than workers in the global market and thus makes it less of a given endowment for a country (Wood, 1995).

3.d. Measurement of sector- and industry-level integration rate

We construct the following measure for sector level integration rate:

$$M_s = \frac{N_s^f - 1}{N_s - 1}$$

where N_s^f is the average number of industries that firms[16] in sector s produce in (as reported in the Prodcom dataset), while N_s is the total number of industries in sector s. To make sure that

15 To be consistent with the construction of other variables used in the regressions in Section 5, we do not use the industry skill intensity estimates that are estimated by using the methodology introduced in Section 4.b.

16 In this calculation of the integration rate, if a firm produces in more than one sector, then it is regarded as a separate firm in each sector.

integration rates for all sectors are between 0 and 1, we subtract 1 from both the denominator and the nominator.[17] The information on the number of industries that each firm produces in each sector can be obtained from the Prodcom database. Table 1 shows the integration rates by 2-digit NACE sector. We can see that integration rate varies substantially across sectors.

Table 1 - Integration rate by sector

NACE 2	*Number of firms*	*Industries per firm*	*Number of industries*	*Integration rate*
Food & beverages	1081	1.5	33	.016
Tobacco	16	1	1	NA
Textiles	506	1.2	11	.018
Apparel	171	1.6	6	.125
Leather products	33	1.1	3	.059
Wood products	323	1.2	6	.036
Paper products	200	1.2	7	.036
Publishing	555	1.3	13	.027
Coke, petroleum & nuclear	5	1	3	0
Chemicals	423	1.8	20	.043
Rubber & plastic	478	1.2	7	.038
Non-metallic mineral	441	1.1	25	.006
Basic metals	164	1.3	16	.02
Fabricated metal products	1146	1.2	16	.01
Machinery and equipment	713	1.3	20	.016
Office machinery & computer	32	1.1	2	.049
Electrical machinery	252	1.1	7	.017
Radio, TV & communication	49	1.1	3	.046
Medical, precision & optical	148	1.1	5	.016
Motor vehicles	144	1.1	3	.067
Other transport equipment	74	1.1	8	.009
Furniture etc.	476	1.4	13	.034

Note: The calculation of all the numbers reported in this table are based on Prodcom, thus the number of industries may differ from the true number of industries according to the NACE Rev. 1.1 classification.

Industry-level integration rate is defined similarly:

$$M_j = \frac{N_j^f - 1}{N_j \;\; - 1}$$

where N_j^f is the average number of (6 or 8 digit) products that firms in industry j produce, while N_j is the total number of (6 or 8 digit) products in industry j. We define product in two alternative ways, i.e. either at 6-digit or 8-digit Prodcom code level.

17 As the minimum of N_j^f is 1, if we do not subtract 1 from the nominator, then the minimum integration rate will be above 0. Accordingly, we have to subtract 1 in the denominator also, otherwise the maximum of integration rate will be below 1.

The advantage of using the above integration rate definition, instead of simply using the share of multi-industry (multi-product) firms in each sector (industry), is that we take into account firm heterogeneity in the number of industries (products) they produce in. For example, if two sectors have the same share of multi-industry firms, but in one sector each multi-industry firm on average produces across 3 industries, while in the other sector each multi-industry firm on average only produces in 2 industries, then the first sector should be regarded as more integrated (assuming that the total number of industries in the two sectors is the same). This is captured by our measure of integration rate but not by the share of multi-industry firms.

One drawback of this measure is that it does not distinguish between integration between industries with different degrees of comparative advantage and that between industries with a similar degree of comparative advantage. However, this measurement problem should only bias the results against our hypotheses (i.e. to find insignificant results). Another drawback of this measure is that it ignores inter-sector integration, i.e. the integration induced by multi-sector firms. We provide an alternative measure of industry integration which avoids these drawbacks as a robustness test in Section 5.d.

3.e. Measurement and decomposition of TFP (changes)

The data used to estimate TFP is based on annual accounts data on firms' value added, capital stock at the beginning of the year, white-collar and blue-collar workers (average number over the year in full-time equivalents) over the period 1997-2007. We restrict the sample to observations where value added, intermediate inputs, number of blue-collar and white-collar workers are positive, and the capital stock exceeds €100. We trim the data for outliers by restricting the sample to observations where apparent labour productivity (value-added over employment), the investment-capital ratio, capital intensity (the capital-labour ratio), value added growth rate and employment growth rate lie within the inter-percentile range of P1-P99. Lastly, in order to run the TFP estimation procedure, we restrict the sample to firms that are observed over at least two consecutive years.

Production function coefficients are estimated using the Levinsohn and Petrin (2003) procedure, with age and selection correction. We estimate the TFP distinguishing between two labour inputs, namely blue-collar workers and white-collar workers. The production function coefficients are estimated at the broad NACE 31 branch level (which is higher than the 2-digit NACE sector level). This includes 14 manufacturing branches, from which we exclude branches DC (leather and footwear) and DF (coke, refined petroleum products and nuclear fuel) owing to a lack of observations. Table A3 in the Appendix reports the estimated production function coefficients together with their standard errors.

Firm-level TFP is constructed for the entire sample of observations where the relevant value added and production factors are positive, using the estimated production function coefficients. Based on firm-level TFP, we obtain industry-level aggregate TFP. In order to be as close as possible to the aggregate TFP that would be estimated from aggregate data, we consider the level of firm-specific TFP and use value added shares as weights.[18] As explained above, to distinguish between the effect of trade liberalisation on within-firm TFP changes and that on between-firm reallocations, we break down aggregate TFP following the Foster, Haltiwanger and Krizan (2001) decomposition. More precisely, we decompose the weighted aggregate TFP growth into five components (we work with 5-year difference as in the regressions in Section 5):

$$\sum_{i\in S}(\omega_{it}tfp_{it} - \omega_{it-5}tfp_{it-5}) =$$

$$\sum_{i\in I_S}\omega_{it-5}(tfp_{it} - tfp_{it-5}) + \sum_{i\in I_S}(\omega_{it} - \omega_{it-5})(tfp_{it-5} - \overline{tfp_{st-5}}) + \sum_{i\in I_S}(\omega_{it} - \omega_{it-5})(tfp_{it} - tfp_{it-5})$$

$$+\sum_{i\in N_S}\omega_{it}(tfp_{it} - \overline{tfp_{st-5}}) - \sum_{i\in X_S}\omega_{it-5}(tfp_{it-5} - \overline{tfp_{st-5}}) \quad (1)$$

where S denotes the industry, I_S incumbents (i.e. firms that are present in t and t-5 in industry s), N_S entrants (i.e. firms that are present in t but not in t-5 in industry s), X_S exiters (i.e. firms that are present in t-5 but not in t in industry s), and $\overline{tfp_{st-5}}$ denotes the industry level weighted average TFP in t-5, and ω_{it} the weights of value added share.

Equation (1) decomposes aggregate TFP changes into (1) the within component which is due to TFP growth within incumbent firms, (2) the between component resulting from changes in market shares of incumbent firms, (3) the cross term that is positive when firms that experience TFP growth also increase their market shares, (4) the impact of new entrants, which is positive when entering firms have higher TFP than the lagged industry average, (5) the impact of exiters, which is positive if exiting firms have lower TFP than the lagged industry average.

Given the focus of the paper, and following Fernandes (2007), we focus on three components: TFP changes due to within-incumbent-firm growth (component (1) in equation (1)), TFP changes due to market share changes across incumbent firms (the sum of components (2) and (3) of equation (1)), and the net entry component (the sum of components (4) and (5) of equation (1)). We define firm entry on the basis of the first year that a firm is observed and firm exit based on the last year it is observed, excluding the first and last year of the sample period in this analysis. In addition, since firms may switch the industry of their main activity, we account for industry entry and industry exit in the decomposition. At the level of the whole manufacturing sector, as shown in Figure 2, the two first components dominate TFP growth over the period (note that, for example, 2002 on the horizontal axis denotes changes between 2002 and 1997), which is consistent with the findings in Fernandes (2007).

[18] Foster, Haltiwanger and Krizan (2001) consider the log of firm-level TFP and use employment shares as weights, while Pavcnik (2002), Eslava, Haltiwanger, Kugler and Kugler (2010) and Fernandes (2007) use the output shares as weights.

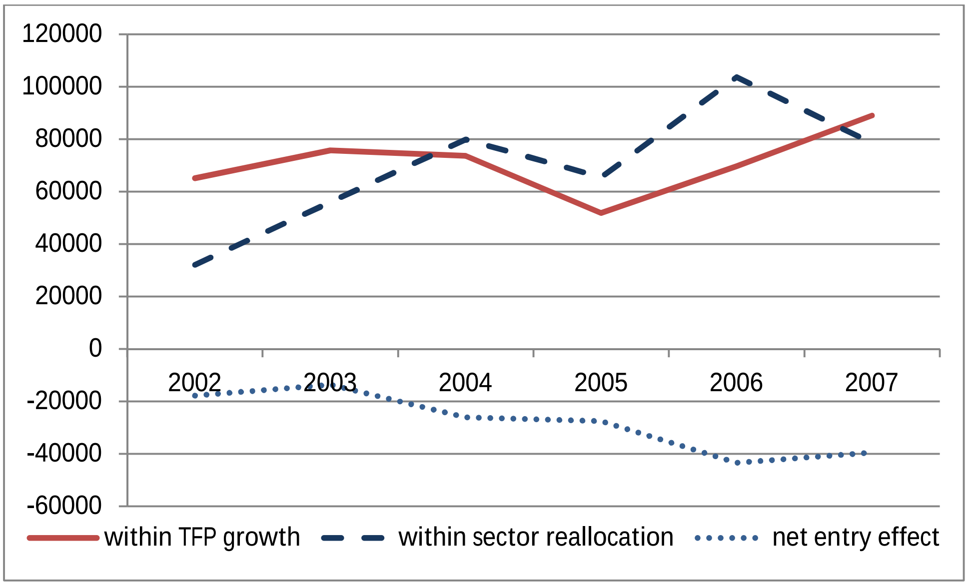

Figure 2: The decomposition of TFP growth for Belgian manufacturing (in euro).

4. Multi-product firms and within firm variation in skill intensity

4.a. Evidence on the prevalence of multi-product firms

As the focus of this paper is the industry integration induced by the existence of multi-product firms, we provide evidence for the importance of multi-product firms in the market in this section. As shown by Bernard, Redding and Schott (2010) and Bernard, Van Beveren and Vandenbussche (2010), multi-product firms are prevalent in the market. Table 2 provides information on multi-product firms in Belgian manufacturing. Firms that produce more than one 6-digit (8-digit) product account for 45% (51%) of the total number of manufacturing firms in 1997, while multi-industry and multi-sector firms account for 28% and 13% respectively. These numbers are highly comparable with those for the US manufacturing industry as reported in Table 1 of Bernard, Redding and Schott (2010). In terms of output share, the prevalence of multi-product firms is even more evident. Multi-product firms account for around 70% of total manufacturing output (consistently with Bernard, Van Beveren and Vandenbussche; 2010), while multi-industry and multi-sector firms account for 50% and 31%, respectively.

Table 2 - Prevalence of firms producing multiple products, in industries and sectors in 1997

Type of firm	Percentage of total number of firms	Percentage of output	Mean products, industries or sectors per firm
Multi-product (8 digit)	51	75	4.4
Multi-product (6 digit)	45	68	3.5
Multi-industry	28	50	2.9
Multi-sector	13	31	2.3

Note: Calculation is based on Prodcom data.

4.b. Evaluation of within-firm variation in skill intensity

The key assumption of the SZ model is that there are multi-product firms which produce simultaneously in industries with different degrees of comparative advantage. To test this assumption, it is not sufficient to provide evidence that multi-product firms are prevalent in the market, as we also have to give evidence that, in reality, multi-product firms do very often produce in industries with different factor intensity. As we only have information on firm-level skill intensity instead of firm-industry-level skill intensity, we estimate the latter using the following strategy.

The question we examine here is whether multi-product firms simultaneously produce in industries that have different skill intensities. One way to answer this question is to compute the percentage of variance in firm-industry skill intensity that can not be explained by the variation in firm-level average skill intensities, or 1- $\frac{\sigma_{\text{betweenfirm}}}{\sigma_{\text{total}}}$, where σ_{total} is the total variance in firm-industry skill intensity and $\sigma_{\text{betweenfirm}}$ is the between-firm variation in firm-industry skill intensity (or the variation of average skill intensity across firms). This can be obtained as 1-R^2 from the regression of firm-industry skill intensities (skill_i^j) on firm fixed effects:

$$\text{skill}_i^j = \delta_i + \varepsilon_{ij} \quad (2)$$

where δ_i is firm fixed effect.[19]

Unfortunately, our dataset provides us with information on firm skill intensity $skill_{it}$ (from annual accounts data) but not on firm-industry skill intensity skill_i^j. To obtain estimates of skill_i^j, we use the following relationship between the two:

$$\text{skill}_{it} = \sum_{j=1}^{n_i} \text{skill}_i^j \omega_{it}^j \quad (3)$$

where ω_{it}^j is the share of employment of firm *i* used in industry *j* at time *t*, n_i is the number of industries that firm *i* produce in. Since we do not have data on ω_{it}^j, we use output share data from Prodcom to approximate it.[20] Then, we can estimate the average skill intensity by industry across firms, skill^j , by running the following regression: [21]

$$\text{skill}_{it} = \sum_{j=1}^{n} \alpha^j \ \varphi_{it}^j + \varepsilon_{it} \quad (4)$$

where φ_{it}^j is the production share of firm *i* in industry *j* at time *t*, n is the number of all available industries in the market (if a firm does not produce in one industry, then its output share in that industry is zero). The coefficients α^j provide estimates of skill^j which are reported in Table A4 in

19 The R^2 of this regression captures the degree of variance explained by heterogeneity between firms.;1-R^2 provides the percentage of variance in skill intensity explained by within firm heterogeneity, $1 - R^2 = \frac{\sigma_{within\,firm}}{\sigma_{total}}$

20 As mentioned above, firms whose total output as recorded in Prodcom deviates from that recorded in the annual accounts data have been dropped.

21 Industries that only have less than 50 firm-year pair observations in the Prodcom dataset are excluded from the regression, as the skill intensity of such industries cannot be reliability estimated (if we include them, the resulted estimates of their skill intensity are not significant).

the Appendix. By estimating industry skill intensity this way, we not only use the information from single-industry firms (as Bernard, Redding and Schott, 2010, do), but also information from multi-product firms.[22] The standard error of $skill^j$ in equation (4) depends, among others, on heterogeneity in the skill intensity across firms for each industry.[23] Based on this estimation for industry skill intensities, Table 3 reports the mean and standard deviation of industry skill intensities by sector, i.e. the average and standard deviation of industry-level estimates described above. From the standard deviation, we can see that industry skill intensities are more heterogeneous in some sectors than in others.

Table 3 - Mean and standard deviation of industry skill intensity by sector

NACE 2	*Mean of industry skill intensity*	*Standard deviation*
Food & beverages	0.28	0.11
Tobacco	0.34	NA
Textiles	0.17	0.05
Apparel	0.23	0.03
Leather products	0.13	0.03
Wood products	0.18	0.06
Paper products	0.25	0.02
Publishing	0.67	0.33
Coke, petroleum & nuclear	NA	NA
Chemicals	0.50	0.14
Rubber & plastic	0.26	0.04
Non-metallic mineral	0.27	0.17
Basic metals	0.20	0.05
Fabricated metal products	0.23	0.04
Machinery and equipment	0.31	0.06
Office machinery & computer	0.78	NA
Electrical machinery	0.39	0.07
Radio, TV & communication	0.32	NA
Medical, precision & optical	0.58	0.17
Motor vehicles	0.18	0.03
Other transport equipment	0.31	0.19
Furniture etc.	0.22	0.04
Total	0.32	0.18

22 Equation (4) can be viewed as a generalisation of the approach based solely on single-product firms. Indeed, restricting the sample to single product firms, estimating equation (4) would be equivalent to estimating product-skill intensity as the average across firms of skill intensity of single-product firms.

23 It may also depend on measurement errors, such as that resulting from using output shares instead of employment shares.

A necessary (but not sufficient) condition for multi-product firms to produce in industries that have different skill intensities is that skill intensities do vary across industries. In order to assess this assumption, we conduct pairwise F-tests on the null hypothesis that $\alpha^j = \alpha^k$ for $j \neq k$ in equation (4). The null hypothesis is rejected in 69% of the cases.

Now we can turn to the evaluation of the extent to which multi-product firms produce in industries with different skill intensity. We approximate $skill_i^j$ by α^j and estimate the following equation for multi-industry firms:

$$\widehat{skill_i^j} = \delta_i + \varepsilon_{ij} \qquad (5)$$

This raises a number of issues. First and most importantly, $1\text{-}R^2$ of this equation will no longer represent $1\text{-}\frac{\sigma_{betweenfirm}}{\sigma_{total}}$. Indeed, the total variance of $\widehat{skill_i^j}$ is lower than σ_{total} since we remove all between-firm heterogeneity in industry skill intensity. For the same reason, we may expect that the between-firm variance is also smaller than in the case of equation (2). However, we have no indication as to how this may affect the size of $1\text{-}R^2$ estimated in equation (5) compared to the true within firm variation in skill intensity $1\text{-}\frac{\sigma_{betweenfirm}}{\sigma_{total}}$. Both over- and under-estimation are possible. Thus we take no prior position on which scenario is more possible and take the result as preliminary evidence for within firm heterogeneity in skill intensity.

The second problem associated with this equation is that $\widehat{skill_i^j}$ is not observed but estimated, which raises the question about to what extent the estimation of $1\text{-} R^2$ relies on the sample used. To address this problem, we use a bootstrap procedure. At each replication, we randomly select a sample of firms from the original sample (with the same sample size), and estimate $skill_i^j$ as α^j from equation (4), and then estimate equation (5). We run 1000 such replications, and then calculate the bootstrap mean and standard errors for $1\text{-}R^2$.

We restrict the analysis to multi-industry firms here, since by definition the within-firm variance of skill intensity is equal to zero for single-industry firms. This reduces the sample by more than one half, as the number of observations diminishes from 94 255 to 43 770. Using the bootstrap estimates of the mean and standard error of $1\text{-}R^2$, the 5% confidence interval for $1\text{-} R^2$ is 0.33 to 0.35, which means that about one-third of the total variation in firm-industry skill intensity among multi-industry firms takes place within firms, which is substantial since we are here comparing skill intensity across all manufacturing firms, i.e., including firms in low-skill-intensive industries like textiles and that in high-skill-intensive industries like computer and office machinery, thus it is expected to find larger between firm variation in skill intensity.

5. Empirical results

In this section, we examine the relationships between trade liberalisation with low-wage countries and industry-level outcomes described by Hypothesis 1 to 3 in Section 2. We conduct our analysis of trade liberalisation at the (four-digit NACE) industry level. We examine the impact of trade liberalisation, taking into account comparative advantage and industry integration, on a set of aggregate industry-level variables, including employment and output (measured by value added) growth, skill upgrading, average productivity and firm output growth, and components of productivity changes that capture reallocation effects and within-firm productivity changes. We use a difference specification (with 5-year difference), as in Bernard, Jensen and Schott (2006b), Bloom, Draca and Van Reenen (2011), De Loecker (forthcoming) and Trefler (2004).

The econometric specification for testing Hypothesis 1 and 3 is:

$$\Delta Y_{jt} = \alpha_0 + \alpha_1 S_j^0 + \alpha_2 \Delta TRADE_{jt}^L + \alpha_3 \Delta TRADE_{jt}^L \times S_j^0 + \alpha_4 \Delta TRADE_{jt}^L \times M_s^0 + \alpha_5 \Delta TRADE_{jt}^L \times S_j^0 \times M_s^0 + \delta_t + \delta_s + \varepsilon_{jt} \quad (6)$$

where ΔY_{jt} is the average annualised change of various measures of outcomes (log employment, log value added, log TFP and log average value added of firms) of industry j between year t-5 and t. $\Delta TRADE_{jt}^L$ is the average annualised change in low-wage trade share between year t-5, and t. S_j^0 is a measure of initial comparative advantage of industry j relative to low-wage countries, i.e., share of white-collar workers in industry j in year 1997. M_s^0 is a measure of initial (1997) integration rate of sector s to which industry j belongs. The reason to use initial values for both skill intensity and integration rate is to avoid potential endogeneity problems, as trade liberalisation may induce skill intensity and the integration rate to change over time. δ_t and δ_s are time and two-digit NACE sector fixed effects, respectively. Both Hypothesis 1 and 3 imply that α_3 should be positive, and α_5 should be negative, i.e. within each sector, industries with higher skill intensity tend to enjoy more growth in their employment, output, TFP, etc. during trade liberalisation with low-wage countries as long as the integration rate of the sector is relatively low (H-O model and BRS model), but this difference between comparative-advantage and comparative-disadvantage industries will be mitigated or even reversed as the sector integration rate rises (SZ model).

If trade liberalisation with low-wage countries leads to less inter-industry reallocation in more integrated sectors, the skill upgrading induced by more free trade should also be smaller in these sectors. Ideally, we should test this implication at 2-digit NACE sector level, since we are studying resource reallocation at industry-level in equation (6). But as the number of 2-digit NACE sectors is too limited,[24] sector-level regressions may not be reliable. Thus we run the regressions at industry level, since similar reasoning should also apply to industry skill upgrading:

$$\Delta S_{jt} = \beta_0 + \beta_1 M_j^0 + \beta_2 \Delta TRADE_{jt}^L + \beta_3 \Delta TRADE_{jt}^L \times M_j^0 + \delta_t + \delta_s + \varepsilon_{jt} \quad (7)$$

where ΔS_{jt} is average annualised change of skill intensity of industry j between year t-5 and t. M_j^0 is a measure of integration rate of industry j in year 1997. We expect that in more integrated industries, as in more integrated sectors, trade liberalisation with low-wage countries induces less

24 There are only 17 two-digit sectors left in our final regression sample.

reallocation from low-skill-intensity activities to high-skill-intensity activities, thus resulting in less skill upgrading. As implied by Hypothesis 2, in equation (7), β_2 should be positive and β_3 should be negative, i.e., trade liberalisation with low-wage countries should induce skill upgrading in all industries, but this effect should be less pronounced in more closely integrated industries.

We have trimmed the sample in several ways. First, to obtain the firm-level sample, we drop firms with discontinuous spells during the sample period and also leave out firms that have missing or non-positive values for any of the key variables (value added, capital, employment, white- and blue-collar workers) in any of the years. Based on the firm-level sample, we aggregate all the variables to industry level.[25] In all the regressions, we further trimmed the industry-level sample according to the following criteria. First, we drop all the two-digit NACE sectors that include less than three four-digit NACE industries,[26] as the measurement of integration rate for such sectors may not be reliable (if total number of industries is one, as in the case of sector 16, integration rate is not even defined).[27] Sectors 16, 23 and 30 have been dropped according to this criterion. Second, following Bernard, Jensen and Schott (2006b), all the industries classified as 'n.e.c' (not else classified) have been excluded, including sector 36. Third, sector 37 (recycling) is dropped as in many other research papers for this sector is normally considered to be different from other manufacturing sectors in nature. Finally, only industries with on average more than 10 firms observed over the sample period have been included in the regressions (the results are robust to using 20 firms as the cut-off). This is because we are interested in both between- and within-industry reallocation induced by trade liberalisation. If there are too few firms in a industry, then there is not much room for within-industry (between-firm) reallocation. Also, the market structure in both the BRS and the SZ models is assumed to be monopolistic competition which requires large number of firms within each industry.

5.a. Employment and output growth

The basic implication of the SZ model is that industry integration reduces the effect of trade liberalisation on resource reallocation from comparative-disadvantage activities to comparative-advantage activities (Hypothesis 1). We test this implication here by looking at the effect of opening up trade with low-wage countries on employment and output reallocation between low- and high-skill-intensity industries. OLS results of equation (6) for employment (column (1)-(4)) and output (column (5)-(8)) growth are reported in Table 4. Column (1) and (5) show the results of regressions without any interaction term. Trade liberalisation with low-wage countries imposes a negative effect on both industry-level employment growth and output growth, which is consistent with the finding of

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25 An alternative would have been to use sector-level variables from Belgian national accounts statistics, or from databases such as EU KLEMS. However, the latter does not report all variables of interest. In particular, there is no information on the number of white-collar workers. Further, the TFP decomposition can only be constructed based on firm-level data. We opt for a common sample for the variables we examine. Therefore, we construct sector-level variables from our firm-level panel dataset.

26 This is based on observations in the Prodcom data. But overall, the Prodcom survey covers all 2-digit NACE sectors and 227 out of 240 4-digit NACE industries. The main discrepancy is due to the fact that industries 1711-1717 and 1721-1725 are only reported as 1710 and 1720 in Prodcom.

27 Similarly, when using industry-level integration rates, we restrict the sample to industries with on average more than 2 products and more than 10 firms observed in the Prodcom data during the sample period.

Mion, Vandenbussche and Zhu (2010) that import competition from China and other low-wage countries reduces firm employment growth in Belgian manufacturing. In column (2) and (6), we add interactions of low-wage trade share changes with industry skill intensity. The interaction term coefficient is positive (although not statistically significant, as in Berman, Bond and Griliches, 1994), which indicates that more skill-intensive industries experience less employment and output decline when opening up trade with low-wage countries. Our results are also consistent with those of Bloom, Draca and Van Reenen (2011) who find that, in 12 EU countries, employment declines more in high-tech industries than in low-tech industries, in response to Chinese import competition. Mion, Vandenbussche and Zhu (2010) find similar results for Belgium manufacturing. In fact, if the skill intensity of an industry is high enough, it may even experience an increase in employment and output. These results are consistent with the predictions of the neoclassical trade theory, since compared with low-wage countries, Belgium should have more comparative advantage in more skill-intensive industries.

While these results are quite intuitive and reasonable, they hide important heterogeneities across sectors. As shown in column (4) and (8), where we take into account interactions of low-wage trade share changes with both industry skill intensity and the sector integration rate, the precision of the estimates improves and the size of the coefficients for trade share change and its interaction with industry skill intensity become much larger, which indicates that, if the sector integration rate is low, the difference between the impact of trade liberalisation on comparative-disadvantage industries and that on comparative-advantage industries is much larger than indicated by the coefficients in column (2) and (4). The interaction term of trade liberalisation with both industry skill intensity and the sector integration rate has a highly significant and negative coefficient both in column (4) and (8), which indicates that, as the sector integration rate goes up, the difference between the effect of trade liberalisation on low-skill-intensity and high-skill-intensity industries will become smaller, in line with the predictions of the SZ model.

Note that our finding of an insignificant coefficient for the interaction term in column (2) echoes that of Berman, Bound and Griliches (1994) for US manufacturing over the 1980s (they find that trade is associated with only small employment reallocation effects). Our results in column (4) suggest that this average finding masks differences across industries. Focusing on poorly integrated sectors, the employment reallocation effects of trade with low-wage countries is much larger and significant.

Table 4 - Employment and output growth

	Employment growth				Output growth			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Industry skill Intensity		0.01	0.01	0.02		0.02	0.02	0.02
		(0.03)	(0.03)	(0.03)		(0.03)	(0.03)	(0.03)
Change in low-wage trade share	-0.49	-0.88	-0.87	-4.57**	-0.79**	-1.38	-1.27	-7.24***
	(0.32)	(1.13)	(1.17)	(1.82)	(0.38)	(1.29)	(1.32)	(2.19)
× industry skill Intensity		1.83	1.86	20.80**		2.80	3.03	33.56***
		(5.06)	(4.99)	(8.07)		(5.70)	(5.62)	(9.83)
× sector integration rate			-0.84	96.78***			-6.94	150.42***
			(7.12)	(35.50)			(14.01)	(46.24)
× industry skill intensity × sector integration rate				-494.6***				-797.3***
				(185.5)				(238.5)
Sector fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	516	516	516	516	516	516	516	516
R^2	0.22	0.22	0.22	0.24	0.17	0.17	0.17	0.21

Notes: Industry-level OLS results. Dependent variables are average annualised change of log employment (column (1) to (4)) and log output (column (5) to (8)) between year t-5 to t. Output is measured by value added. The second regressor is the average annualised changes of trade share of low-wage countries between year t-5 and t. Industry skill intensity is the share of white-collar workers in year 1997; sector integration rate is the 1997 integration rate of the sector where the industry belongs. Sector fixed effects are for two-digit NACE sectors. "*, **, ***" indicate a significance level of 10%, 5% and 1%, respectively. Robust standard errors are in parentheses.

To illustrate the results in a more intuitive way, we provide here a numerical example of how the effect of trade liberalisation on employment growth may depend on industry skill intensity as well as the sector integration rate. Suppose that the trade share of low-wage countries increases by 1 percentage point per year from t-5 to t, how will this affect an industry's employment growth? Using the coefficients from column (4) of Table 4, we can calculate the effects for different industries in different sectors. As shown in the third column of Table 5, if this industry is within a sector with a low integration rate (0.01) and very little skill intensity (0.1), then the average annual growth rate of its total employment will be -1.8% from t-5 to t, while, in contrast, if its skill intensity is 0.6, then it will experience annual growth of 7.1%. These two growth rates become -0.9% and 3.1%, respectively, in a sector with a medium-level integration rate of 0.03. Thus, a higher integration rate makes the effect of trade liberalisation more similar for industries with different factor intensities within a sector, or in other words, comparative advantage becomes less important in more integrated sectors. The same conclusion holds for output growth as shown in the fourth column of Table 5.

Table 5 -The effect of an annual increase of 1 percentage point in low-wage trade share

Sector integration rate	Industry skill intensity	Employment growth	Output growth	TFP growth	Average output growth
0.01	0.1	-1.8%	-2.9%	-10.5%	-3.1%
	0.6	7.1%	10.8%	69.2%	8.4%
0.03	0.1	-0.9%	-1.6%	-3.4%	-1.8%
	0.6	3.1%	4.3%	36.17%	1.9%

Notes: This table reports how industries adjust to an 1 percentage point annual increase of low-wage trade share from t-5 to t. The calculation is based on the coefficients in column (4) and (8) of Table 4 and 6. The growth rates in the last four columns are annual growth rates.

5.b. Skill upgrading

One implication of the results in Table 4 is that trade liberalisation with low-wage countries should induce less skill upgrading in more integrated sectors (Hypothesis 2), since the relative growth of more skill-intensive industries is less pronounced in more integrated sectors during trade liberalisation with low-wage countries. As explained earlier, the same implication should apply to industry-level skill upgrading. OLS results of equation (7) for industry-level skill upgrading are reported in Table 6. In column (1), we do not include the interaction term. The positive coefficient of low-wage trade share change indicates that more trade with low-wage countries is associated with more skill upgrading, consistent with Mion, Vandenbussche and Zhu (2010) and Forlani, Monfort and Vandenbussche (2008), but the coefficient is not statistically significant. In column (2) and (3), we interact the change in trade share with industry integration rate, where integration rate is defined on 6-digit Prodcom product in column (2) and on 8-digit Prodcom product in column (3). As the calculation of industry integration rates is based on the Prodcom data, we restrict the sample, for both the regressions in column (2) and (3), to industries with on average more than 2 products and more than 10 firms observed in the Prodcom data during the sample period in order to have reliable measures of integration rate.

The results show that, once the interaction term is included, the coefficient of low-wage trade share changes becomes larger and statistically significant and the coefficient of its interaction with industry integration rate is negative and significant. This result indicates that trade liberalisation with low-wage countries is associated with more skill upgrading in less-integrated industries, something which confirms the prediction of Hypothesis 2. The results are robust to using the two alternative definitions of integration rate.

Our result may again explain former evidence of little impact of trade liberalisation with low-wage countries on skill upgrading (or the increase in relative wages of skilled workers; see Berman, Bod and Griliches, 1994). Ignoring sector or industry heterogeneity in the integration rate, the estimated coefficient on trade with low-wage countries is insignificant. However, the figures reported in columns (2) and (3) suggest that in poorly integrated sectors or industries, trade with low-wage countries may account for a larger proportion of the observed skill upgrading in manufacturing industries.

Table 6 - Skill upgrading

	Skill upgrading		
	(1)	(2)	(3)
Industry integration rate 1		-0.00	
		(0.01)	
Industry integration rate 2			-0.01
			(0.01)
Change in low-wage trade share	0.05	0.11**	0.09**
	(0.03)	(0.05)	(0.04)
× industry integration rate 1		-1.25*	
		(0.70)	
× industry integration rate 2			-0.58
			(0.37)
Sector fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Observations	516	414	456
R^2	0.47	0.52	0.51

Note: Industry-level OLS results. Dependent variables are average annualised change of share of white-collars between year t-5 to t. The third regressor is the average annualised change in trade share of low-wage countries between year t-5 and t. Industry integration rate 1 and 2 measure integration rate in 1997 at the four-digit NACE industry level, with products defined at six-digit Prodcom code level for rate 1 and eight-digit Prodcom code level for rate 2. Sector fixed effects are for two-digit NACE sectors. "*, **, ***" indicate the significance level of 10%, 5% and 1%, respectively. Robust standard errors are in parentheses.

5.c. Aggregate TFP and average output growth

OLS results of equation (6) for industry-level aggregate TFP (column (1)-(4)) and average firm output (column (5)-(8)) growth are reported in Table 7, which provides tests for Hypothesis 3 concerning within-industry reallocation. First, let us focus on the results in column (4) and (8). We can see that all the interaction terms have the expected signs. Trade liberalisation with low-wage countries generates more TFP and average firm output growth in more skill-intensive industries (which is consistent with the predictions of the BRS model), given that the sector integration is not too deep. Trefler (2004) also found that trade liberalisation between US and Canada induced more productivity growth in export-oriented sectors (i.e., comparative-advantage sectors) in US manufacturing. As sector integration rate increases, the difference between low- and high-skill-intensity industries is smaller, or even reversed if the integration rate is high enough. These results are consistent with Hypothesis 3. A similar numerical calculation example as in Section 5.a is given in the last two columns of Table 5.

However, the coefficient of the non-interaction term, i.e. the change in low-wage trade share itself, is not as expected. Column (1) and (5) show that trade liberalisation with low-wage countries actually (on average) reduces TFP and average firm output growth, which is puzzling given the findings of other research (e.g., Pavcnik, 2002 and Bernard, Jensen and Schott, 2006; and Fernandes, 2007; who found that trade liberalisation increases industry level TFP). This result may be because of that we focus on trade liberalisation with low-wage countries here, which may have a stronger decreasing effect on industry-level prices than trade liberalisation with non-low-wage countries. Since the output data we are using here are only deflated by price index at the 2-digit NACE sector level, the within-sector and between-industries heterogeneity in price changes is not controlled for, thus industries experiencing a bigger increase in low-wage trade share may experience a greater fall in prices, which is reflected as a decrease in measured TFP. The problem may also plague the estimates of the coefficients for the interaction term between trade share change and industry skill intensity, since the price effect of trade liberalisation with low-wage countries may differ across industries with different degrees of comparative advantage. Nevertheless, the negative and significant coefficient for the interaction term of trade share change with both industry skill intensity and sector integration rate is harder to be explained away by this price effect, as there is no reason to believe the price effect is correlated with the sector integration rate.

Table 7 - TFP and average output growth

	TFP growth				Average output growth			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Industry skill Intensity		0.40***	0.40***	0.34***		-0.01	-0.01	-0.00
		(0.10)	(0.10)	(0.10)		(0.03)	(0.03)	(0.03)
Change in low-wage trade share	-1.99	-11.66***	-11.40***	-33.99***	-1.03***	-1.20	-1.01	-6.76***
	(1.34)	(3.57)	(3.44)	(7.35)	(0.35)	(1.18)	(1.207)	(1.65)
× industry skill Intensity		46.73***	47.05***	165.6***		0.78	1.16	30.54***
		(15.83)	(16.07)	(36.19)		(5.62)	(5.56)	(8.02)
× sector integration Rate			-14.24	757.7***			-11.52	139.90***
			(65.507)	(225.65)			(17.17)	(42.03)
× industry skill intensity × sector integration rate				-4,018***				-767***
				(1,138)				(216.14)
Sector fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	502	502	502	502	516	516	516	516
R^2	0.12	0.16	0.16	0.18	0.14	0.14	0.14	0.19

Notes: Industry-level OLS results. Dependent variables are average annualised change in log-weighted average TFP (column (1) to (4)) and log average output (column (5) to (6)) between year *t*-5 to *t*. The second regressor is the average annualized changes of trade share of low-wage countries between year *t*-5 and *t*. Industry skill intensity is the share of white-collar workers in year 1997; sector integration rate is the 1997 integration rate for the sector where the industry belongs. Sector fixed effects are for two-digit NACE sectors. "*, **, ***" indicate a significance level of 10%, 5% and 1%, respectively. Robust standard errors are in parentheses.

To further understand the mechanisms through which trade liberalisation induces aggregate productivity changes, we decompose the changes in industry-level TFP into three components: the part due to within-firm changes, the part due to reallocation between incumbent firms and that due to net entry, as explained in Section 3.e. Table 8 reports the regression results for this decomposition. The dependent variables here are within-firm TFP change (column (1)), TFP change induced by between-incumbent-firm reallocation (column (2)) and TFP change induced by entry and exit (column (3)), respectively. The changes are measured as changes in the levels of aggregate TFP rather than in logs,[28] unlike the case in Table 7. The results suggest that the effect of opening up trade with low-wage countries on within-firm TFP change is qualitatively quite similar as that on between-firm reallocation (both reallocation between incumbent firms and that through entry and exit). Nevertheless, the aggregate TFP changes that trade liberalisation with low-wage countries brings about seem to have been mainly driven by reallocation between incumbent firms. The size of the coefficients for the equation of firm net entry is smaller and barely significant. The results in column (2) show that, when the sector integration rate is low (lower than (i.e., larger than 10.07/333.5=0.030 in this case), trade liberalisation with low-wage countries is associated with more between-firm reallocation (from low-productivity incumbent firms to high-productivity incumbent firms) in more skill-intensive industries, while the opposite is true when the sector integration rate is higher than 0.030.[29]

Table 8 - Decomposition of TFP change

	TFP change decomposition		
	(1) within	(2) between	(3) net entry
Industry skill intensity	0.05***	0.01	0.01
	(0.01)	(0.01)	(0.01)
Change in low-wage trade share	-0.19	-1.79***	-0.49*
	(0.74)	(0.47)	(0.30)
× industry skill intensity	0.26	9.07***	2.83*
	(3.90)	(2.42)	(1.62)
× sector integration rate	1.93	61.75***	4.99
	(31.49)	(18.09)	(7.02)
× industry skill intensity × sector integration rate	-15.67	-333.50***	-25.34
	(159.55)	(97.36)	(38.82)
Sector fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Observations	502	502	502
R^2	0.21	0.23	0.20

Notes: Industry-level OLS results. Dependent variable is the average annualised changes (divided by 1000,000 to reduce the size of the coefficients for ease of exposition) between year t-5 and t in aggregate TFP that is due to: within-firm TFP change, reallocation between incumbent firms and net entry, respectively. Outliers in aggregate TFP changes (the largest and smallest 1%) are excluded from the sample. The second regressor is the average annualised changes of trade share of low-wage countries between year t-5 and t. Industry skill intensity is the share of white-collar workers in year 1997; sector integration rate is the 1997 integration rate of the sector where the industry belongs. Sector fixed effects are for two-digit NACE sectors. "*, **, ***" indicate significance levels of 10%, 5% and 1%, respectively. Robust standard errors are in parentheses.

28 Since industry-level TFP is aggregated from firm-level TFP in levels (rather than in logs), the decomposition should also be based on the levels.

29 This result is less likely to be driven by the above-mentioned price effect problem, since the price effect of trade liberalisation should mainly work through reducing measured firm-level TFP which is captured as within-firm TFP changes in our decomposition.

5.d. Robustness tests

5.d.1. Using import tariffs to measure trade liberalisation

One major concern with the regression results reported above is that we use changes in trade share to measure trade liberalisation, which may raise concerns about endogeneity problems, especially since we are using contemporaneous changes in trade share to explain changes in dependent variables. The fact that our major interests lie on the interactions of trade share changes with initial industry skill intensity and initial sector (industry) integration rate should have already mitigated some of the concerns. Nevertheless, to further address this concern, we use changes in tariff rate to measure trade liberalisation. The advantage of using tariff to measure trade liberalization is that it is more exogenous than trade flows, especially in the case of Belgium, where tariff rates are set at EU level. Unfortunately, we only have detailed data on import tariff, but not on export tariff. Although changes in import tariff are normally positively correlated with changes in export tariff (as argued by Bernard, Jensen and Schott (2006)), using import tariff alone gives relatively more weight to the import-increasing side of trade liberalisation and less to the export-increasing side. This is particularly a concern when testing Hypothesis 3 which relies on the fact that trade liberalization induces more export opportunity in comparative advantage industries. If we only look at import competition side of trade liberalisation, then both in the BRS model and the SZ model, there is no reason to expect comparative advantage industries to experience more productivity growth after trade liberalisation. On the contrary, we should expect that aggregate productivity in comparative-disadvantage industries to increase more since they should face more import competition than comparative-advantage industries. Meanwhile, Hypothesis 1 and 2, should still hold even if we only consider import competition, e.g., more import competition from low-wage countries should induce more employment decrease in comparative-disadvantage industries,[30] while this relative decrease in employment should be mitigated in more integrated sectors where there are more economies of scope for firms to carry out comparative-disadvantage activities together with comparative-advantage activities.

Results are reported in Table A5 to A8 in the Appendix (note that now trade liberalisation increases when tariff decreases, so the expected signs of the coefficients are the opposite of those we have seen above). Industry-level import tariff rate is defined as simple average tariff of products (CN 8-digit) in that industry. Product-level tariff comes from the online customs tariff database, also called the TARIC, provided by European Commission. We also distinguish between low-wage and non-low-wage countries and control for import tariff for non-low-wage countries in the regressions. Overall, the results are consistent with the results using trade share changes as trade liberalization measure in the sense that sector integration and its interaction with comparative advantage work in the same direction as in the previous tables. But in most of the cases, results are less significant.

[30] Mion, Vandenbussche and Zhu (2010) find that import competition from China induces more employment decreasing for firms in low-tech industries in Belgian manufacturing.

5.d.2. Alternative measure of industry integration

As mentioned before, our measure of integration has two drawbacks. First, it only takes into account within-sector integration and ignores between-sector integration. This is not satisfactory because Table 2 shows that multi-sector firms play an important role in manufacturing. Second, it does not take into account the factor intensity of the industries that each industry is integrated with, although integration with a comparative-advantage industry should have a different effect compared with integration with a comparative-disadvantage industry.

To address these problems, we now construct a new measure of industry integration which takes into account both between-sector integration and the skill intensity of the industries that each industry is integrated with. The construction of this measure is a two-step process. First, we construct an index that measures the pairwise relatedness between all the manufacturing industries:

$$R_{ij} = \min\left(\frac{T_{ij}^{i}}{T_i}, \frac{T_{ij}^{j}}{T_j}\right)$$

where T_{ij}^{i} (T_{ij}^{j}) denotes the turnover of industry *i* (*j*) that is produced by multi-product firms which produce both in industry *i* and industry *j*. T_i (T_j) denotes the total turnover of industry *i* (*j*). The turnover data is from the Prodcom database which provides information on firms' turnover by product. This measure of relatedness between two industries is close in spirit to the 'proximity (of two products)' measure used by Hidalgo, Klinger, Barabasi and Hausmann (2007). While our measure is based on the co-production of goods by firms, they based their measure on the 'co-exporting' of goods by countries. Their idea is that if two goods are very often observed to be exported by the same country, then they are more likely to be closely linked to each other in their production process. Our measure directly uses information on co-production of goods within firms, thus is potentially a better measure for the relatedness of two goods in their production. To avoid any potential endogeneity problem, we use the Prodcom data in 1997 to calculate the value of R_{ij}.

Table A9 reports the pairwise relatedness between NACE 2-digit sectors in year 1997. We can see that the relatedness between different sectors is highly heterogeneous. More specifically, there is a clear difference between the so-called 'light industries' (e.g. food, textiles and apparel) and 'heavy industries' (e.g. metal products and machinery). First, the 'light industries' are almost completely unrelated with the 'heavy industries' (except for chemicals). Second, there is much higher inter-sector relatedness within the group of 'heavy industries' than within the group of 'light industries'.

Now, as a second step, we can construct a new measure for each industry about its integration with other industries, based on the relatedness index constructed above:

$$SS_j^0 = \frac{\sum_{i=1, i\neq j}^{n} R_{ij} S_i^0}{\sum_{i=1, i\neq j}^{n} R_{ij}}$$

where S_i^0 is the skill intensity of industry *i* in year 1997 and *n* is the total number of industries in manufacturing. We call this measure 'shadow skill intensity', i.e. it is a measure of weighted average skill intensity of the industries that are integrated with industry *j*. It is clear that this measure not only takes into account between-sector integration, but also the skill intensity of the industries that each industry is integrated with. Note that the calculation of SSj does not consider the skill intensity of industry *j* itself; SSj is the weighted average skill intensity of all the industries that are integrated with industry *j*.

With the new measure of industry integration, we re-write equation (6) as follows:

$$\Delta Y_{jt} = \alpha_0 + \alpha_1 S_j^0 + \alpha_2 SS_j^0 + \alpha_3 \Delta TRADE_{jt}^L + \alpha_4 \Delta TRADE_{jt}^L \times S_j^0 + \alpha_5 \Delta TRADE_{jt}^L \times SS_j^0 + \alpha_6 \Delta TRADE_{jt}^L \times S_j^0 \times SS_j^0 + \delta_t + \delta_s + \varepsilon_{jt} \quad (8)$$

Table A10 reports the estimation results for equation (8). Overall, the results are remarkably consistent with what we have found before. Column (1) and (2) report the results for employment and output growth. Industries with a higher shadow skill intensity experience more (less) employment and output growth (decrease) when facing trade liberalisation with low-wage countries. The skill intensity of the industry itself has a similar effect. The interaction term of trade liberalisation with both own-industry and shadow skill intensity has negative coefficients, which suggests that own-industry and shadow skill intensity act as substitutes for each other, i.e. when shadow skill intensity is high, own-industry skill intensity is less important in determining the impact of trade liberalisation on employment or output growth, and vice versa.

Column (3) and (4) report the results for average TFP and output growth. The implications are similar. Industries with higher own-industry and/or shadow-skill intensity experience higher average TFP and output growth in facing trade liberalisation with low-wage countries, and the two types of skill intensity act as substitutes for each other (i.e. the interaction term of trade liberalisation with both own-industry and shadow-skill intensity also has negative coefficients). The intuition is that, on one hand, trade liberalisation with low-wage countries should encourage relatively more firms to enter industries with higher skill intensity, which boosts competition and makes the average productivity and size of surviving firms higher in these industries; on the other hand, low-skill-intensity industries that are integrated with some of the high-skill-intensity ones will also have similar experience since some of the firms that entered those high-skill-intensity industries will eventually also start producing in these relatively low-skill-intensity industries.

5.d.3. Aggregating from firm-product level data

Another concern with most of the regressions reported above is that all the industry-level dependent variables are aggregated from firm-level data, while the industry affiliation of firms are determined according to their main activities. Thus, for example, the output of a firm that produces in several different industries will all be regarded as coming from the industry where its main activity takes place. This leads to a measurement error problem, which can be potentially problematic as this measurement error may be correlated with the sector integration rate, which is the main point of interest of our research. In more closely integrated sectors, there should be more multi-industry firms and thus the aggregation using firm-level data is more problematic.

To address this problem, we use the firm-product level output information from the Prodcom data to construct measures of industry-level total output and average output that do not suffer from the above-mentioned problem. Prodcom reports firms' output by 8-digit Prodcom product. The first 4 digits of the 8-digit Prodcom code are the same as NACE code, thus we can calculate 4-digit NACE industry-level output by aggregating from the firm-product level data. We trimmed the Prodcom sample to improve consistency between the Prodcom data and the annual accounts data we have been using. First, only firms that are observed both in Prodcom and in the final firm-level sample used for the baseline regressions above are included in the sample. Second, we keep firms whose total output recorded in Prodcom is neither 10% larger nor 10% smaller than their total output recorded in the annual accounts data.[31] As before, we also restrict our sample to industries where at least 10 firms[32] (on average) are observed in the Prodcom dataset over the sample period. One caveat of this approach is that Prodcom only reports firms' turnover by product, but not by value added. Since the turnover of one firm can become the input of another firm within the same industry, the industry-level aggregation of turnover may overestimate the true output of the industry. This measurement error problem should be less important for the measure of average firm turnover, as long as the measurement errors are not too correlated across firms. More importantly, this measurement error is not likely to be correlated with the sector integration rate.

The findings are reported in Table A11 in column (3) and (4). By way of comparison, we also report the results for total and average turnover growth measured from the annual accounts data (i.e. industry-level turnover is aggregated from firm-level turnover where firms are classified under industries according to their main activity) in column (1) and (2). The findings are similar to the baseline results where output is measured by value added. The results in column (3) and (4) show that aggregating from firm-product level data produces similar results as those in column (1) and (2). However, since we are using different samples here, the results are not directly comparable. In column (5) and (6), we report the results of regressions that use the same sample of Prodcom firms as in column (3) and (4), but use a different aggregation approach, i.e. to classify firms' total turnover according to their main activity industries, just as we did with the annual accounts data. The results are again similar, but less significant, due *inter alia* to a smaller number of observations. This experiment reassures us that the significant results we have found in this paper are not driven by the aggregation approach we have used.

5.d.4. Other robustness tests

We have also done some other robustness tests, the results of which are reported in the Appendix. Table A12 and A13 report the results of the robustness test where we redefined the share of trade with low-wage countries as the share of low-wage trade over the sum of total trade and domestic production. By defining trade share this way, we can now also include the trade share of non-low-wage countries in the regressions. The results are basically the same as the baseline results.

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31 About half of the firms are dropped according to this criteria.

32 Again, if a firm produces in more than one 4-digit NACE industries in the Prodcom data, it is counted as one firm in each of the industries in which it produces.

Tables A14 and A15 report the robustness test results after controlling for the changes in trade share of East European Countries (EEC). Over the past decade, integration with EECs is one of the factors that has had major impact on West European economies and this process has gone hand in hand with the general trend towards globalisation. Thus, it may be appropriate to control for trade with EECs in the regressions. However, the results in Table A14 and A15 reveal that the main line of this paper is not affected by this change of specification. The coefficients for low-wage trade share changes and the corresponding interaction terms do not change much. Meanwhile, the coefficients for EEC trade share changes and the corresponding interaction terms are mostly not significant. This may be because that most EECs are much richer than the group of low-wage countries which may make endowment-driven comparative advantage less of a determinant of resource reallocation during trade liberalisation. Nevertheless, the results in Table A.15 show that more integrated industries also experience less skill upgrading when facing trade liberalisation with EECs, which is consistent with Hypothesis 2.

In Table A16 to A21, we experiment different definitions of 'low-wage countries'. For the baseline regressions, we defined low-wage countries as countries with average per capita GDP less than 10% of Belgian per capita GDP over the 1994-2009 period. In Table A16 and A17, we use 5% of Belgian per capita GDP as the cut-off for low-wage countries, while in Table A18 and A19 we use 20% as the cut-off. We can see that our main findings from the baseline regressions are robust to these changes in definition of low-wage countries. More precisely, the results are much more significant when 5% is used as the cut-off, while they are less significant when using 20% as the cut-off. This is not surprising since the former is more 'low-wage' than the latter.

Finally, in Table A20 and A21, we focus on trade with China, which is arguably the largest low-wage country in the world. Mion, Vandenbussche and Zhu (2010) find that trade with China is growing much faster than trade with other low-wage countries in Belgian manufacturing and it is import competition from China rather than that from other low-wage countries that has had a particularly large impact on resource reallocation in Belgian manufacturing. The results in Table A21 and A22 do in fact show that changes in Chinese trade share have had a very significant effect on both inter- and intra-industry resource reallocations. These results point to the possibility that trade with China is really the driving force behind our main findings.

6. Conclusions

In this paper, we examine the role of economies of scope in determining the impact of trade liberalisation on inter- and intra-industry resource reallocation. Using Belgian manufacturing firm- and product-level data, we find that in industries where economies of scope play a more important role (i.e. in more integrated industries), the effect of trade liberalisation on inter-industry reallocation is mitigated. This basic finding has far-reaching implications. First, in more integrated industries, trade liberalisation induces less skill upgrading, which indicates that unskilled workers in such industries are less affected by trade liberalisation with low-wage countries. Since industry integration is a common phenomena in modern economies (as evident by the prevalence of multi-product or multi-industry firms), this may be one of the reasons why former studies have found that trade with low-wage countries has a small or insignificant effect on relative labour demand and relative wage changes in developed countries. Second, industry integration also affects resource reallocation within each industry. In poorly integrated sectors, comparative-advantage industries are more likely to experience higher productivity growth than comparative-disadvantage industries after trade liberalisation, while in highly integrated sectors, the situation may be reversed.

A more general insight from this research work is that, international labour division may not only be constrained by traditional trade costs like transport costs and tariff or non-tariff barriers to trade, but also by some non-traditional costs, such as the loss of economies of scope. In our view, the existence of economies of scope may be just one source of such kind of non-traditional costs of trade. Another potential source is economies of agglomeration, i.e., the benefit from carrying out different kinds of economic activities within a limited geographic district. These may also reduce specialisation across countries since the latter implies less agglomeration within each country. To take these factors into account, especially to take their interaction with comparative advantage into consideration, is, in our view, one promising direction of future research in the field of international trade.

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Appendix

Table A1 - List of low-wage countries

Afghanistan	Eritrea	Lesotho	Senegal
Albania	Ethiopia	Morocco	Suriname
Armenia	Fiji	Moldova	São Tomé and Principe
Angola	Micronesia, Fed. States of	Madagascar	El Salvador
Azerbaijan	Georgia	Marshall Islands	Syrian Arab Republic
Bosnia and Herzegovina	Ghana	Macedonia, FYR	Swaziland
Bangladesh	Gambia, The	Mali	Chad
Burkina Faso	Guinea	Mongolia	Togo
Bulgaria	Guatemala	Mauritania	Thailand
Burundi	Guinea-Bissau	Maldives	Tajikistan
Benin	Guyana	Malawi	Timor-Leste (East Timor)
Bolivia	Honduras	Mozambique	Turkmenistan
Bhutan	Haiti	Namibia	Tunisia
Belarus	Indonesia	Niger	Tonga
Congo, Dem. Rep. of	India	Nigeria	Tanzania
Central African Republic	Iraq	Nicaragua	Ukraine
Congo, Rep.	Iran, Islamic Rep. of	Nepal	Uganda
Cote d'Ivoire	Jordan	Peru	Uzbekistan
Cameroon	Kenya	Papua New Guinea	Vietnam
China	Kyrgyz Republic	Philippines	Vanuatu
Colombia	Cambodia	Pakistan	Samoa
Cape Verde	Kiribati	Paraguay	Yemen, Rep. of
Djibouti	Comoros	Serbia	Zambia
Dominican Republic	Kazakhstan	Rwanda	Zimbabwe
Algeria	Lao P.D.R.	Solomon Islands	
Ecuador	Sri Lanka	Sudan	
Egypt, Arab Rep.	Liberia	Sierra Leone	

Note: Low-wage countries are defined as countries with average GDP per capita less than 10% of Belgium's over 1994-2009.

Table A2 - Trade share of low-wage countries by NACE Rev 1.1 2-digit industries

NACE 2	*Low1996*	*Low2001*	*Low2007*
Food & beverages	4	5	5
Tobacco	1	1	2
Textiles	12	12	15
Apparel	16	22	24
Leather products	18	24	26
Wood products	8	9	10
Paper products	1	3	4
Publishing	1	1	2
Coke, petroleum & nuclear	3	3	5
Chemicals	3	3	3
Rubber & plastic	2	4	5
Non-metallic mineral	2	4	7
Basic metals	4	6	11
Fabricated metal products	3	4	7
Machinery and equipment	4	5	8
Office machinery & computer	2	6	12
Electrical machinery	5	6	10
Radio, TV & communication	6	6	14
Medical, precision & optical	3	4	6
Motor vehicles	1	2	2
Other transport equipment	3	1	7
Furniture etc.	13	13	22
Total	5	5	7

Notes: ' Low1996' etc., refers to trade share of low-wage countries in year 1996 etc. Low-income country is defined as country with average per capita GDP lower than 10% of average per capita GDP of Belgium during 1994-2009. The numbers are in percentage.

Table A3 - Estimates of production function coefficients - Levinsohn and Petrin methodology with age and correction for firm exit

	β_{IB}	β_{IW}	β_k	nb obs	nb firms
DA : Food products, beverages and tobacco	0.388	0.255	0.129	5114	821
	(0.01)	(0.01)	(0.02)		
DB : Textiles and textile products	0.325	0.277	0.039	2624	440
	(0.01)	(0.01)	(0.02)		
DD : Wood and products of wood and cork	0.525	0.151	0.066	1043	187
	(0.01)	(0.01)	(0.03)		
DE : Pulp, paper, paper products, printing and publishing	0.205	0.301	0.081	2891	489
	(0.01)	(0.01)	(0.02)		
DG : Chemicals and chemical products	0.178	0.443	0.064	2104	310
	(0.01)	(0.01)	(0.03)		
DH : Rubber and plastic products	0.371	0.263	0.135	1767	271
	(0.01)	(0.01)	(0.02)		
DI : Other non-metallic mineral products	0.440	0.181	0.074	2417	373
	(0.01)	(0.01)	(0.03)		
DJ : Fabricated metal products, except machinery and	0.464	0.204	0.038	5709	925
equipment	(0.01)	(0.01)	(0.01)		
DK : Machinery and equipment, n.e.c.	0.360	0.331	0.073	2187	357
	(0.01)	(0.01)	(0.03)		
DL : Electrical and optical equipment	0.272	0.446	0.081	1521	258
	(0.01)	(0.01)	(0.02)		
DM : Transport equipment	0.463	0.304	0.141	1024	163
	(0.01)	(0.02)	(0.02)		
DN : Manufacturing n.e.c., recycling	0.465	0.206	0.107	2122	350
	(0.01)	(0.01)	(0.02)		

Notes: 30 523 observations and 4 944 firms; standard errors in italic. Estimation according to Levinsohn and Petrin (2003) methodology with age and correction for firm exit.

Table A4 - Estimates of skill intensity by 4-digit NACE Rev.1.1 industry (R^2=0.82)

NACE	*Skill intensity*		*Standard error*	*NACE*	*Skill intensity*		*Standard error*	*NACE*	*Skill intensity*		*Standard error*
1511	0.183	***	0.01	2211	0.877	***	0.01	2822	0.196	***	0.02
1512	0.093	***	0.01	2212	0.904	***	0.02	2830	0.257	***	0.01
1513	0.187	***	0.01	2213	0.925	***	0.01	2840	0.175	***	0.02
1520	0.193	***	0.02	2214	1.096	***	0.13	2851	0.179	***	0.01
1531	0.194	***	0.01	2215	0.633	***	0.04	2852	0.180	***	0.01
1532	0.327	***	0.04	2222	0.295	***	0.00	2862	0.308	***	0.01
1533	0.180	***	0.01	2223	0.105	***	0.02	2863	0.265	***	0.02
1541	0.142	***	0.03	2224	0.461	***	0.01	2873	0.249	***	0.02
1542	0.400	***	0.03	2225	0.703	***	0.03	2874	0.248	***	0.02
1551	-0.422	**	0.20	2411	0.652	***	0.02	2875	0.228	***	0.01
1552	0.167	***	0.02	2412	0.407	***	0.01	2911	0.335	***	0.02
1561	0.368	***	0.01	2413	0.435	***	0.02	2912	0.416	***	0.01
1562	0.386	***	0.02	2414	0.585	***	0.01	2913	0.468	***	0.03
1571	0.460	***	0.01	2415	0.522	***	0.02	2914	0.338	***	0.02
1572	0.377	***	0.03	2416	0.460	***	0.01	2921	0.334	***	0.03
1581	0.264	***	0.01	2417	0.344	***	0.03	2922	0.338	***	0.01
1582	0.150	***	0.01	2420	0.506	***	0.03	2923	0.301	***	0.01
1583	0.333	***	0.02	2430	0.487	***	0.01	2924	0.293	***	0.01
1584	0.206	***	0.01	2441	0.675	***	0.03	2932	0.269	***	0.02
1585	0.339	***	0.03	2442	0.598	***	0.01	2942	0.324	***	0.01
1586	0.487	***	0.02	2451	0.526	***	0.02	2943	0.316	***	0.02
1587	0.273	***	0.02	2452	0.347	***	0.02	2951	0.210	***	0.03
1589	0.397	***	0.02	2462	0.452	***	0.03	2952	0.301	***	0.02
1596	0.387	***	0.01	2463	0.642	***	0.03	2953	0.317	***	0.01
1598	0.343	***	0.02	2466	0.707	***	0.01	2954	0.264	***	0.02
1600	0.345	***	0.02	2470	0.141	***	0.01	2956	0.347	***	0.01
1710	0.118	***	0.01	2513	0.309	***	0.01	2971	0.260	***	0.03
1720	0.190	***	0.01	2521	0.277	***	0.01	2972	0.214	***	0.02
1730	0.180	***	0.01	2522	0.221	***	0.01	3002	0.780	***	0.02
1740	0.245	***	0.01	2523	0.227	***	0.01	3110	0.366	***	0.01
1751	0.157	***	0.01	2524	0.282	***	0.01	3120	0.357	***	0.01
1754	0.224	***	0.01	2612	0.236	***	0.01	3150	0.346	***	0.01
1760	0.157	***	0.02	2615	0.255	***	0.02	3162	0.495	***	0.01
1771	0.126	***	0.04	2640	0.160	***	0.01	3210	0.321	***	0.02
1772	0.091	***	0.02	2661	0.216	***	0.01	3310	0.406	***	0.01
1821	0.219	***	0.02	2663	0.171	***	0.01	3320	0.586	***	0.01
1822	0.257	***	0.01	2664	0.701	***	0.03	3330	0.754	***	0.03
1823	0.200	***	0.02	2666	0.151	***	0.03	3410	0.178	***	0.02
1824	0.242	***	0.02	2670	0.221	***	0.01	3420	0.154	***	0.01
1920	0.153	***	0.04	2682	0.303	***	0.01	3430	0.214	***	0.01
1930	0.114	***	0.04	2710	0.223	***	0.03	3511	0.147	***	0.02
2010	0.151	***	0.01	2722	0.225	***	0.03	3530	0.517	***	0.02
2020	0.172	***	0.01	2734	0.132	***	0.03	3542	0.268	***	0.04
2030	0.178	***	0.01	2742	0.175	***	0.02	3611	0.188	***	0.01
2040	0.133	***	0.02	2743	0.270	***	0.03	3612	0.224	***	0.02
2051	0.276	***	0.02	2744	0.251	***	0.03	3613	0.197	***	0.01
2112	0.273	***	0.02	2751	0.139	***	0.02	3614	0.153	***	0.01
2121	0.232	***	0.01	2811	0.208	***	0.01	3615	0.211	***	0.02
2123	0.246	***	0.03	2812	0.236	***	0.01	3622	0.268	***	0.01
2125	0.244	***	0.01	2821	0.243	***	0.01	3663	0.274	***	0.02

Table A5 - Employment and output growth (using tariff changes as trade liberalisation measure)

	employment growth				output growth			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Industry skill intensity		0.02	0.02	0.03		0.03	0.03	0.03
		(0.03)	(0.03)	(0.03)		(0.03)	(0.03)	(0.03)
Change in tariff rate (non-low-wage)	0.06*	0.06*	0.07**	0.06*	0.04	0.04	0.05	0.04
	(0.03)	(0.03)	(0.04)	(0.04)	(0.04)	(0.04)	(0.05)	(0.04)
Change in tariff rate (low-wage)	0.01	-0.06*	-0.03	0.09*	0.01	-0.04	-0.02	0.13**
	(0.01)	(0.03)	(0.04)	(0.05)	(0.01)	(0.04)	(0.04)	(0.06)
× industry skill intensity		0.28**	0.24*	-0.34		0.22	0.18	-0.52**
		(0.13)	(0.13)	(0.22)		(0.14)	(0.15)	(0.26)
× sector integration rate			-0.92***	-6.47***			-0.90**	-7.49***
			(0.32)	(2.05)			(0.42)	(2.34)
× industry skill intensity × sector integration rate				28.39***				33.71***
				(10.55)				(12.05)
Sector fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	516	516	516	516	516	516	516	516
R^2	0.22	0.23	0.24	0.25	0.16	0.17	0.17	0.18

Notes: Industry-level OLS results. Dependent variables are average annualised change in log employment (column (1)to (4)) and log output (column (5)to (8)) between year t-5 to t. Output is measured by value added. The second and third regressors are the average annualised changes of simple average import tariff for non-low-wage imports and low-wage imports, respectively, between year t-5 and t. Industry skill intensity is the share of white-collar workers in year 1997; sector integration rate is the 1997 integration rate of the sector where the industry belongs. Sector fixed effects are for two-digit NACE sectors. "*, **, ***" indicate a significance level of 10%, 5% and 1%, respectively. Robust standard errors are in parentheses.

Table A6 - Skill upgrading (using tariff changes as trade liberalisation measure)

	Skill upgrading		
	(1)	(2)	(3)
Industry integration rate 1		0.00	
		(0.006)	
Industry integration rate 2			-0.01
			(0.006)
Change in tariff rate (non-low-wage)	0.00	0.00	-0.01
	(0.004)	(0.007)	(0.007)
Change in tariff rate (low-wage)	-0.00	-0.01***	-0.00
	(0.001)	(0.003)	(0.001)
× industry integration rate 1		0.11***	
		(0.032)	
× industry integration rate 2			-0.01
			(0.019)
Sector fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Observations	516	414	456
R^2	0.47	0.53	0.51

Note: Industry-level OLS results. Dependent variables are average annualised change in share of white-collars between year t-5 to t. The third and forth regressors are the average annualised changes of trade weighted import tariff for non-low-wage imports and low-wage imports, respectively, between year t-5 and t. Industry integration rate 1 and 2 measure integration rate in 1997 at the four-digit NACE code level, with products defined at six-digit Prodcom code level for the former and eight-digit Prodcom code level for the later. Sector fixed effects are for two-digit NACE sectors. "*, **, ***" indicate a significance level of 10%, 5% and 1%, respectively. Robust standard errors are in parentheses.

Table A7 - TFP and average output growth (using tariff changes as trade liberalisation measure)

	TFP growth				Average output growth			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Industry skill intensity		0.41***	0.41***	0.41***		-0.00	-0.00	0.00
		(0.10)	(0.10)	(0.10)		(0.03)	(0.03)	(0.03)
Change in tariff rate (non-low-wage)	-0.14	-0.02	-0.03	-0.02	0.00	-0.00	-0.00	-0.02
	(0.14)	(0.15)	(0.15)	(0.15)	(0.04)	(0.04)	(0.04)	(0.04)
Change in tariff rate (low-wage)	-0.05*	0.20	0.18	0.12	0.01	-0.05	-0.04	0.09*
	(0.03)	(0.15)	(0.16)	(0.25)	(0.01)	(0.03)	(0.04)	(0.05)
× industry skill intensity		-1.08*	-1.04*	-0.78		0.23*	0.22*	-0.44*
		(0.59)	(0.60)	(1.13)		(0.12)	(0.13)	(0.24)
× sector integration rate			0.83	3.48			-0.25	-6.48***
			(2.22)	(9.99)			(0.48)	(2.37)
× industry skill intensity × sector integration rate				-13.45				31.81***
				(48.40)				(12.10)
Sector fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	502	502	502	502	516	516	516	516
R^2	0.12	0.15	0.15	0.15	0.12	0.13	0.13	0.14

Notes: Industry-level OLS results. Dependent variables are average annualised change in log-weighted average TFP (column (1) to (4)) and log average output (column (5) to (8)) between year t-5 to t. Outliers in aggregate TFP (level) changes (largest and smallest 1%) are excluded from the sample in column (1) to (4). The second and third regressors are the average annualised changes of trade weighted import tariff for non-low-wage imports and low-wage imports, respectively, between year t-5 and t. Industry skill intensity is the share of white-collar workers in year 1997; sector integration rate is the 1997 integration rate of the sector where the industry belongs. Sector fixed effects are for two-digit NACE sectors. "*, **, ***" indicate a significance level of 10%, 5% and 1%, respectively. Robust standard errors are in parentheses.

Table A8 - Decomposition of TFP change (using tariff changes as trade liberalisation measure)

	TFP change decompostion		
	(1) within	(2) between	(3) net entry
Industry skill intensity	0.05***	0.01*	0.01
	(0.011)	(0.008)	(0.006)
Change in tariff rate (non-low-wage)	-0.02	0.00	0.01*
	(0.011)	(0.006)	(0.004)
Change in tariff rate (low-wage)	-0.01	-0.03	0.01**
	(0.017)	(0.023)	(0.006)
× industry skill intensity	0.03	0.17	-0.06**
	(0.07)	(0.12)	(0.03)
× sector integration rate	0.53	1.70	-0.08
	(0.80)	(1.37)	(0.33)
× industry skill intensity × sector integration rate	-1.41	-8.88	0.24
	(3.70)	(7.11)	(1.76)
Sector fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Observations	502	502	502
R^2	0.21	0.17	0.18

Notes: Industry-level OLS results. Dependent variables of column (1) to (3) are the average annualised changes (divided by 1000,000 to reduce the size of the coefficients for ease of exposition) between year t-5 and t in aggregate TFP that is due to: within-firm TFP change, reallocation between incumbent firms and net entry, respectively. Outliers in aggregate TFP (level) changes (largest and smallest 1%) are excluded from the sample. The second and third regressors are the average annualised changes of trade weighted import tariff for non-low-wage imports and low-wage imports, respectively, between year t-5 and t. Industry skill intensity is the share of white-collar workers in year 1997; sector integration rate is the 1997 integration rate of the sector where the industry belongs. Sector fixed effects are for two-digit NACE sectors. "*, **, ***" indicate a significance level of 10%, 5% and 1%, respectively. Robust standard errors are in parentheses.

Table A9 – Sector relatedness based on coproduction, 1997

Sector	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*24*	*25*	*26*	*27*	*28*	*29*	*30*	*31*	*32*	*33*	*34*	*35*	*36*
15 Food & beverages	1	0	0	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0
16 Tobacco	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17 Textiles	0	0	1	0.02	0	0	0.03	0	0.01	0.02	0	0	0	0	0	0	0	0	0	0	0.02
18 Apparel	0	0	0.02	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19 Leather products	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20 Wood products	0	0	0	0	0	1	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0.03
21 Paper products	0	0	0.03	0	0	0	1	0.03	0.06	0.05	0	0	0	0	0	0	0	0	0	0	0
22 Publishing	0	0	0	0	0	0	0.03	1	0	0	0	0	0	0	0	0	0	0	0	0	0
24 Chemicals	0.1	0	0.01	0	0	0	0.06	0	1	0.15	0.03	0.01	0	0	0	0	0	0	0	0	0
25 Rubber & plastic	0	0	0.02	0	0	0	0.05	0	0.15	1	0.01	0.01	0.05	0.02	0	0.02	0	0.01	0.01	0	0.04
26 Non-metallic mineral	0	0	0	0	0	0	0	0	0.03	0.01	1	0	0	0	0	0	0	0	0	0	0
27 Basic metals	0	0	0	0	0	0	0	0	0.01	0.01	0	1	0.08	0.02	0	0	0	0	0	0	0
28 Fabricated metal products	0	0	0	0	0	0.01	0	0	0	0.05	0	0.08	1	0.07	0	0.04	0	0.02	0.03	0.04	0
29 Machinery and equipment	0	0	0	0	0	0	0	0	0	0.02	0	0.02	0.07	1	0.02	0.15	0	0.02	0.01	0.01	0
30 Office machinery& computer	0	0	0	0	0	0	0	0	0	0	0	0	0	0.02	1	0.03	0.28	0.09	0	0	0
31 Electrical machinery	0	0	0	0	0	0	0	0	0	0.02	0	0	0.04	0.15	0.03	1	0.06	0.16	0	0	0
32 Radio, TV & communication	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.28	0.06	1	0.15	0	0	0
33 Medical, precision & optical	0	0	0	0	0	0	0	0	0	0.01	0	0	0.02	0.02	0.09	0.16	0.15	1	0	0.03	0
34 Motor vehicles	0	0	0	0	0	0	0	0	0	0.01	0	0	0.03	0.01	0	0	0	0	1	0	0
35 Other transport equipment	0	0	0	0	0	0	0	0	0	0	0	0	0.04	0.01	0	0	0	0.03	0	1	0
36 Furniture etc.	0	0	0.02	0	0	0.03	0	0	0	0.04	0	0	0	0	0	0	0	0	0	0	1

Notes: The number in each cell measures the relatedness between the two corresponding sectors based on co-production within firms. For ease of exposition, we set relatedness to zero if it is smaller than 0.01.

Table A10 - Robustness test – alternative measure of industry integration

	Emp. growth	Output growth	TFP growth	Avg. output growth	TFP change decomposition		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
					within	between	net entry
Industry skill intensity	-0.00	0.01	0.07***	-0.01	0.05***	0.02*	0.01
	(0.03)	(0.04)	(0.02)	(0.03)	(0.01)	(0.01)	(0.01)
Shadow industry skill Intensity	0.10**	0.06	0.04	-0.00	-0.01	-0.01	0.02**
	(0.05)	(0.05)	(0.04)	(0.05)	(0.02)	(0.01)	(0.01)
Change in low-wage trade share	-8.71***	-8.93**	-5.26***	-5.48*	-1.31	0.07	-0.06
	(3.21)	(3.82)	(1.99)	(2.98)	(0.86)	(0.69)	(0.62)
× industry skill intensity	28.53**	26.59	23.13***	10.80	5.72	-3.11	1.08
	(14.19)	(16.56)	(8.85)	(13.63)	(4.114)	(3.16)	(3.26)
× shadow industry skill Intensity	23.59***	23.19***	7.40	14.09**	2.72	0.59	-0.68
	(7.25)	(8.57)	(4.92)	(6.75)	(2.16)	(1.71)	(1.69)
× industry skill intensity × shadow industry skill Intensity	-72.83**	-66.02*	-33.14*	-30.41	-13.31	4.17	1.93
	(30.77)	(34.38)	(18.96)	(27.11)	(9.42)	(7.42)	(8.61)
Sector fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	516	516	502	516	502	502	502
R^2	0.26	0.19	0.16	0.15	0.22	0.17	0.21

Notes: Industry-level OLS results. The third regressor is the average annualised changes in trade share of low-wage countries between year t-5 and t. Industry skill intensity is the share of white-collar workers in year 1997; shadow industry skill intensity is the weighted average skill intensity of industries that are integrated with this industry in year 1997. Sector fixed effects are for two-digit NACE sectors. "*, **, ***" indicate a significance level of 10%, 5% and 1%, respectively. Robust standard errors are in parentheses.

Table A11 - Robustness test – using Prodcom data to calculate industry-level output

	Annual account data		Prodcom data 1		Prodcom data 2	
	Turnover growth	Av. turnover growth	Turnover growth	Av. turnover growth	Turnover growth	Av. turnover growth
	(1)	(2)	(3)	(4)	(5)	(6)
Change in low-wage trade share	-7.06***	-7.58***	-14.72**	-14.72***	-14.36**	-7.64
	(2.06)	(1.78)	(6.04)	(4.92)	(6.19)	(5.64)
× industry skill Intensity	33.41***	34.78***	83.85***	84.61***	80.02**	45.32
	(9.21)	(8.44)	(31.13)	(25.78)	(32.27)	(29.68)
× sector integration Rate	142.59***	148.04***	416.87**	651.06***	330.46	337.87
	(46.71)	(43.44)	(195.64)	(168.99)	(205.79)	(220.30)
× industry skill intensity × sector integration rate	-777.53***	-825.35***	-3,115***	-4,156***	-2,506**	-2,249*
	(240.17)	(225.81)	(1,076)	(962)	(1,160)	(1,230)
Sector fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	513	513	204	204	204	204
R^2	0.19	0.21	0.56	0.44	0.56	0.43

Notes: Industry-level OLS results. Dependent variables are average annualised change in log total turnover (column (1), (3) and (5)) and log average firm turnover (column (2), (4) and (6)) between year t-5 to t. For the first two columns, turnover is aggregated from firm-level annual accounts data, where firms are classified to industries according to their main activities. For column (3) and (4), turnover is aggregated from firm-product level data from the Prodcom data. For column (5) and (6), turnover is aggregated from firm level data from the Prodcom data, based on firms' main activity. For column (3) to (6), only industries with on average more than 10 firms observed over the sample period in the Prodcom data are included in the regression. The first regressor is the average annualised changes of low-wage trade share between year t-5 and t. Industry skill intensity is the share of white-collar workers in year 1997; sector integration rate is the 1997 integration rate of the sector where the industry belongs. Sector fixed effects are for two-digit NACE sectors. *, **, *** indicate a significance level of 10\%, 5\% and 1\%, respectively. Robust standard errors are in parentheses.

Table A12 - Robustness test – alternative measure of trade share

	Emp. growth	Output growth	TFP growth	Avg. output growth	TFP change decomposition		
	(1)	(2)	(3)	(4)	(5) within	(6) between	(7) net entry
Industry skill intensity	0.01	0.02	0.36***	0.00	0.04***	0.01	0.02**
	(0.03)	(0.03)	(0.09)	(0.02)	(0.01)	(0.01)	(0.01)
Change in non-low-wage trade share	-0.47**	-0.67***	-3.31***	-0.46**	-0.01	0.05	-0.10**
	(0.22)	(0.26)	(1.04)	(0.22)	(0.07)	(0.05)	(0.04)
Change in low-wage trade share	-6.49**	-10.73***	-45.20***	-10.08***	-0.58	-2.18***	-0.37
	(2.65)	(3.27)	(9.43)	(2.32)	(0.96)	(0.50)	(0.37)
× industry skill intensity	29.77**	51.07***	226.3***	47.71***	1.77	11.51***	2.33
	(11.88)	(15.14)	(48.8)	(11.66)	(5.58)	(2.80)	(2.09)
× sector integration Rate	161.3***	272.3***	1,360***	279.10***	37.52	85.22***	-0.69
	(61.6)	(83.7)	(333)	(73.57)	(42.26)	(22.02)	(11.99)
× industry skill intensity × sector integration rate	-911.9***	-1,485***	-7,214***	-1,497***	-161.7	-472.6***	2.98
	(320.0)	(434)	(1,786)	(383)	(246.0)	(126.4)	(68.46)
Sector fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	564	564	550	564	550	550	550
R^2	0.25	0.23	0.21	0.20	0.22	0.19	0.15

Notes: Industry-level OLS results. The second (third) regressor is the average annualised changes in trade share of non-low-wage (low-wage) countries between year t-5 and t. Here, trade share is measured as (non-)low-wage trade over the sum of total trade and domestic production. Industry skill intensity is the share of white-collar workers in year 1997; sector integration rate is the 1997 integration rate of the sector where the industry belongs. Sector fixed effects are for two-digit NACE sectors. "*, **, ***" indicate a significance level of 10\%, 5\% and 1\%, respectively. Robust standard errors are in parentheses.

Table A13 - Robustness test – alternative measure of trade share (skill upgrading)

	Skill upgrading		
	(1)	(2)	(3)
Industry integration rate 1		-0.00	
		(0.004)	
Industry integration rate 2			-0.01
			(0.005)
Change in non-low-wage trade share	0.01	0.00	-0.00
	(0.02)	(0.02)	(0.02)
Change in low-wage trade share	0.10***	0.14***	0.14***
	(0.04)	(0.05)	(0.05)
× industry integration rate 1		-0.90	
		(0.87)	
× industry integration rate 2			-0.69
			(0.43)
Sector fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Observations	564	438	492
R^2	0.43	0.51	0.51

Notes: Industry-level OLS results. Dependent variables are average annualised change in share of white-collars between year t-5 to t. The third (fourth) regressor is the average annualised changes in trade share of non-low-wage (low-wage) countries between year t-5 and t. Here, trade share is measured as (non-)low-wage trade over the sum of total trade and domestic production. Industry integration rate 1 and 2 measure integration rate in 1997 at the four-digit NACE code level, with products defined at six-digit Prodcom code level for the former and eight-digit Prodcom code level for the later. Sector fixed effects are for two-digit NACE sectors. "*, **, ***" indicate a significance level of 10\%, 5\% and 1\%, respectively. Robust standard errors are in parentheses.

Table A14 - Robustness test – controlling for trade with East European countries

	Empl. growth	Output growth	TFP growth	Av. output growth	TFP change decomposition		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
					within	between	net entry
Industry skill intensity	0.02	0.02	0.29***	-0.01	0.05***	0.01	0.01
	(0.03)	(0.03)	(0.10)	(0.03)	(0.01)	(0.01)	(0.01)
Change in EEC trade Share	2.57	-1.44	-25.13***	-2.94	-0.95	0.64	-0.20
	(3.92)	(4.74)	(12.85)	(3.87)	(0.91)	(0.71)	(0.63)
× industry skill intensity	-9.82	-0.55	-33.92	6.94	0.89	-2.05	-1.56
	(16.25)	(19.63)	(66.18)	(16.78)	(4.87)	(3.61)	(3.46)
× sector integration rate	8.19	82.54	441.53	91.87	24.87	-38.27	4.95
	(83.79)	(100.90)	(276.05)	(94.25)	(27.57)	(27.36)	(12.59)
× industry skill intensity × sector integration rate	-172.05	-325.81	-838.66	-338.11	-133.67	144.21	2.75
	(422.94)	(502.47)	(1,513.70)	(471.16)	(150.98)	(143.33)	(72.15)
Change in low-wage trade share	-4.94***	-7.74***	-36.28***	-7.02***	-0.07	-1.82***	-0.51
	(1.89)	(2.29)	(8.06)	(1.72)	(0.80)	(0.43)	(0.32)
× industry skill intensity	23.20***	35.86***	173.99***	31.37***	-0.39	9.43***	2.88*
	(8.42)	(10.24)	(39.36)	(8.33)	(4.26)	(2.21)	(1.72)
× sector integration rate	81.08**	146.43***	847.74***	140.78***	-8.13	63.90***	2.91
	(39.42)	(49.84)	(251.38)	(44.95)	(34.91)	(18.21)	(7.77)
× industry skill intensity × sector integration rate	-449.52**	-761.6***	-4256.0***	-736.94***	35.62	-361.10***	-12.42
	(200.09)	(249.38)	(1230.5)	(225.37)	(172.86)	(96.35)	(42.09)
Sector fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	516	516	502	516	502	502	502
R^2	0.26	0.23	0.21	0.20	0.23	0.25	0.22

Notes: Industry-level OLS results. The second (sixth) regressor is the average annualised changes in trade share of East European (low-wage) countries between year t-5 and t. Industry skill intensity is the share of white-collar workers in year 1997; sector integration rate is the 1997 integration rate of the sector where the industry belongs. Sector fixed effects are for two-digit NACE sectors. "*, **, ***" indicate a significance level of 10%, 5% and 1%, respectively. Robust standard errors are in parentheses.

Table A15 - Robustness test – controlling for trade with East European countries (skill upgrading)

	Skill upgrading		
	(1)	(2)	(3)
Industry integration rate 1		0.01	
		(0.01)	
Industry integration rate 2			-0.00
			(0.00)
Change in EEC trade share	0.12	0.30*	0.34
	(0.07)	(0.15)	(0.13)
× industry integration rate 1		-2.43*	
		(1.33)	
× industry integration rate 2			-4.13***
			(1.16)
Change in low-wage trade share	0.06*	0.11**	0.08**
	(0.03)	(0.05)	(0.04)
× industry integration rate 1		-1.29**	
		(0.66)	
× industry integration rate 2			-0.66
			(0.42)
Sector fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Observations	516	414	456
R^2	0.47	0.52	0.52

Notes: Industry-level OLS results. Dependent variables are average annualised change in share of white-collars between year t-5 to t. The third (sixth) regressor is the average annualised changes of trade share of East European (low-wage) countries between year t-5 and t. Industry integration rate 1 and 2 measure integration rate in 1997 at the four-digit NACE code level, with products defined at six-digit Prodcom code level for the former and eight-digit Prodcom code level for the later. Sector fixed effects are for two-digit NACE sectors. "*, **, ***" indicate a significance level of 10%, 5% and 1%, respectively. Robust standard errors are in parentheses.

Table A16 - Robustness test – alternative definition for low-wage countries 1

	Empl. growth	Output growth	TFP growth	Av. output growth	TFP change decomposition		
	(1)	(2)	(3)	(4)	(5) within	(6) between	(7) net entry
Industry skill intensity	0.01	0.02	0.31***	-0.00	0.05***	0.01	0.01
	(0.03)	(0.03)	(0.10)	(0.03)	(0.01)	(0.01)	(0.01)
Change in low-wage trade share	-7.84***	-11.86***	-53.38***	-9.22***	-0.42	-2.67***	-0.80**
	(2.40)	(2.79)	(7.83)	(1.85)	(0.99)	(0.51)	(0.35)
× industry skill Intensity	32.28***	49.85***	251.17***	38.70***	0.93	13.28***	4.75**
	(10.305)	(12.13)	(39.38)	(8.77)	(5.06)	(2.65)	(1.89)
× sector integration Rate	150.63***	232.86***	1,303***	197.89***	13.33	94.19***	8.57
	(45.59)	(57.40)	(245.8)	(51.51)	(42.02)	(19.39)	(7.49)
× industry skill intensity × sector integration rate	-710.2***	-1,101***	-6,494***	-961.9***	-60.00	-507.9***	-48.56
	(229.6)	(289.19)	(1,179)	(252.3)	(208.3)	(104.5)	(41.07)
Sector fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	516	516	502	516	502	502	502
R^2	0.27	0.25	0.21	0.20	0.21	0.28	0.21

Notes: Industry-level OLS results. The second regressor is the average annualised changes in trade share of low-wage countries between year t-5 and t. Here, low-wage countries are defined as countries with with average per capita GDP less than 5% of Belgium's over 1994-2009. Industry skill intensity is the share of white-collar workers in year 1997; sector integration rate is the 1997 integration rate of the sector where the industry belongs. Sector fixed effects are for two-digit NACE sectors. "*, **, ***" indicate a significance level of 10%, 5% and 1%, respectively. Robust standard errors are in parentheses.

Table A17 - Robustness test – alternative definition for low-wage countries 1 (skill upgrading)

	Skill upgrading		
	(1)	(2)	(3)
Industry integration rate 1		-0.00	
		(0.005)	
Industry integration rate 2			-0.01
			(0.005)
Change in low-wage trade share	0.06	0.18**	0.14**
	(0.04)	(0.07)	(0.06)
× industry integration rate 1		-2.03**	
		(0.89)	
× industry integration rate 2			-1.09**
			(0.49)
Sector fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Observations	516	414	456
R^2	0.47	0.52	0.51

Notes: Industry-level OLS results. Dependent variables are average annualised change of share of white-collars between year t-5 to t. The third regressor is the average annualised changes in trade share of low-wage countries between year t-5 and t. Here, low-wage countries are defined as countries with with average per capita GDP less than 5% of Belgium's over 1994-2009. Industry integration rate 1 and 2 measure integration rate in 1997 at the four-digit NACE industry level, with products defined at six-digit Prodcom code level for rate 1 and eight-digit Prodcom code level for rate 2. Sector fixed effects are for two-digit NACE sectors. *, **, *** indicate a significance level of 10%, 5% and 1%, respectively. Robust standard errors are in parentheses.

Table A18 - Robustness test – alternative definition for low-wage countries 2

	Empl. growth	Output growth	TFP growth	Av. output growth	TFP change decomposition		
	(1)	(2)	(3)	(4)	(5) within	(6) between	(7) net entry
Industry skill intensity	0.02	0.02	0.36***	-0.01	0.05***	0.01	0.01*
	(0.03)	(0.03)	(0.11)	(0.03)	(0.011)	(0.01)	(0.01)
Change in low-wage trade Share	-1.24	-2.70	-16.99**	-3.44***	-0.28	-1.21***	-0.08
	(1.21)	(1.69)	(7.12)	(1.31)	(0.36)	(0.33)	(0.23)
× industry skill intensity	6.59	13.20*	68.94**	15.21***	0.93	5.91***	0.19
	(5.05)	(6.74)	(30.787)	(5.75)	(1.84)	(1.61)	(1.15)
× sector integration rate	47.07*	99.95***	473.55***	107.25***	22.17*	35.46***	-1.68
	(24.01)	(33.22)	(162.36)	(28.67)	(12.25)	(10.62)	(5.17)
× industry skill intensity × sector integration rate	-240.2**	-434.3***	-1,867**	-478.2***	-84.4	-194.2***	19.7
	(116.0)	(152.6)	(751)	(138.7)	(60.1)	(55.6)	(27.6)
Sector fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	516	516	502	516	502	502	502
R^2	0.23	0.18	0.16	0.15	0.22	0.21	0.18

Notes: Industry-level OLS results. The second regressor is the average annualised changes of trade share of low-wage countries between year t-5 and t. Here, low-wage countries are defined as countries with with average per capita GDP less than 20% of Belgium's over 1994-2009. Industry skill intensity is the share of white-collar workers in year 1997; sector integration rate is the 1997 integration rate of the sector where the industry belongs. Sector fixed effects are for two-digit NACE sectors. "*, **, ***" indicate a significance level of 10%, 5% and 1%, respectively. Robust standard errors are in parentheses.

Table A19 - Robustness test – alternative definition for low-wage countries 2 (skill upgrading)

	Skill upgrading		
	(1)	(2)	(3)
Industry integration rate 1		-0.00	
		(0.005)	
Industry integration rate 2			-0.01
			(0.005)
Change in low-wage trade share	0.01	0.06	0.03
	(0.03)	(0.04)	(0.04)
× industry integration rate 1		-1.10*	
		(0.57)	
× industry integration rate 2			-0.37
			(0.33)
Sector fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Observations	516	414	456
R^2	0.47	0.51	0.51

Notes: Industry-level OLS results. Dependent variables are average annualised change of share of white-collars between year t-5 to t. The third regressor is the average annualised changes of trade share of low-wage countries between year t-5 and t. Here, low-wage countries are defined as countries with with average per capita GDP less than 20% of Belgium's over 1994-2009. Industry integration rate 1 and 2 measure integration rate in 1997 at the four-digit NACE industry level, with products defined at six-digit Prodcom code level for rate 1 and eight-digit Prodcom code level for rate 2. Sector fixed effects are for two-digit NACE sectors. *, **, *** indicate a significance level of 10%, 5% and 1%, respectively. Robust standard errors are in parentheses.

Table A20 - Robustness test – trade with China

	Emp. growth	Output growth	TFP growth	Avg. output growth	TFP change decomposition		
	(1)	(2)	(3)	(4)	(5) within	(6) between	(7) net entry
Industry skill intensity	0.01	0.02	0.31***	-0.00	0.05***	0.01*	0.01
	(0.03)	(0.04)	(0.10)	(0.03)	(0.01)	(0.01)	(0.01)
Change in Chinese trade share	-8.49***	-12.15***	-59.67***	-8.59***	0.44	-3.13***	-1.37***
	(2.98)	(3.44)	(10.10)	(2.32)	(1.37)	(0.56)	(0.51)
× industry skill Intensity	35.73***	52.73***	293.1***	36.87***	-3.22	16.95***	8.19***
	(13.02)	(15.27)	(51.6)	(11.23)	(7.34)	(3.00)	(2.71)
× sector integration Rate	176.3***	248.2***	1,441***	198.8***	1.22	113.5***	21.49**
	(59.9)	(75.0)	(356)	(67.8)	(57.56)	(17.8)	(8.62)
× industry skill intensity × sector integration rate	-808.2***	-1,194***	-7,230***	-974.9***	45.53	-660.6***	-121.7***
	(302.6)	(375)	(1,602)	(333.2)	(290.81)	(94.0)	(46.6)
Sector fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	516	516	502	516	502	502	502
R^2	0.25	0.21	0.19	0.17	0.21	0.30	0.22

Notes: Industry-level OLS results. The second regressor is the average annualised changes of trade share of China between year t-5 and t. Industry skill intensity is the share of white-collar workers in year 1997; sector integration rate is the 1997 integration rate of the sector where the industry belongs. Sector fixed effects are for two-digit NACE sectors. "*, **, ***" indicate a significance level of 10%, 5% and 1%, respectively. Robust standard errors are in parentheses.

Table A21 - Robustness test – trade with China (skill upgrading)

	Skill upgrading		
	(1)	(2)	(3)
Industry integration rate 1		0.00	
		(0.005)	
Industry integration rate 2			-0.01
			(0.005)
Change in Chinese trade share	0.06	0.21**	0.15*
	(0.07)	(0.09)	(0.09)
× industry integration rate 1		-3.18**	
		(1.25)	
× industry integration rate 2			-1.12*
			(0.67)
Sector fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Observations	516	414	456
R^2	0.47	0.52	0.51

Notes: Industry-level OLS results. Dependent variables are average annualised change of share of white-collars between year t-5 to t. The third regressor is the average annualised changes in trade share of China between year t-5 and t. Industry integration rate 1 and 2 measure integration rate in 1997 at the four-digit NACE industry level, with products defined at six-digit Prodcom code level for rate 1 and eight-digit Prodcom code level for rate 2. Sector fixed effects are for two-digit NACE sectors. *, **, *** indicate a significance level of 10%, 5% and 1%, respectively. Robust standard errors are in parentheses.

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