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Udo Ludwig and Hans-Ulrich Brautzsch

The Skills Balance in Germany's Import Intensity of Exports: An Input-Output Analysis

In the decade prior to the economic and financial crisis, Germany's net exports increased in absolute terms as well as relative to the growing level of import intensity of domestically produced export goods and services. This article analyses the direct and indirect employment effects induced both by exports as well as by of the import intensity of the production process of export goods and services on the skills used. It shows that Germany's export surpluses led to positive net employment effects. Although the volume of imports of intermediate goods increased and was augmented by the rise in exports, it could not undermine the overall positive employment effect.

Germany is poor in natural resources but rich in skilled labour and capital. Thus, in line with the augmented Heckscher-Ohlin theorem, Germany should specialise in the production of export goods and services that are relatively intensive in these factors and should import those goods and services that are relatively intensive in the use of low-skilled labour. Hence, Germany is expected to be a net exporter of skilled labour embodied in export-induced output. Previous studies have analysed Germany's net exports as well as the employment induced by them, assuming the input of homogeneous labour.¹ They come to the conclusion that in the decade prior to the economic and financial crisis, Germany's net exports increased in absolute terms as well as relative to the growing level of import intensity of domestically produced export goods and services. Due to this export surplus, positive employment effects offset negative employment effects.

In fact, the input of labour is heterogeneous with respect to various characteristics, such as the skills required. It concerns the input of labour in all sectors of production,

regardless of the final use of the goods and services and of whether these are used in the domestic production of export goods and services. A number of studies consider labour input at different skill levels.² Our earlier paper presented an analysis of the net effects of the import intensity of export production on skills for the total German economy,³ while Mönning et al. focussed exclusively on the gross effects of exports on qualification needs.⁴ In the present paper, the analysis is restricted to the net effects of the import intensity of the production process of export goods and services on the skills used.

Moreover, we follow a wide understanding of the effects caused by the production of export goods and services. Usually, the effects are restricted to the direct and indirect output, the value added and employment in this process. However, the circular flow of the economy consists of more than the production phase. It is followed by the use of income earned by the employers and employees through their added value contributions. The extra income is partly spent by private households on consumption goods and services. Thus, through the circular flow of income, further production is stimulated and jobs are secured.

¹ See for instance German Council of Economic Experts: External successes – internal challenges, Annual Economic Report 2004/05, Wiesbaden 2004, pp. 467 ff.; Federal Statistical Office of Germany: Importabhängigkeit der deutschen Exporte 1991, 1995, 2000 and 2002, Wiesbaden 2004.

² For an analysis of the composition of labour by occupational groups, see H.-J. Engelbrecht: The Composition of the Human Capital Stock and the Factor Content of Trade: Evidence from West(ern) Germany, in: Economic Systems Research, Vol. 8, No. 3, 1996, pp. 271-298.

³ H.-U. Brautzsch, U. Ludwig: Deutsche Exportgüterproduktion: Relativer Überschuss an Qualifikationsgehalt gering, in: Wirtschaft im Wandel, Vol. 11, No. 15, Halle 2009, pp. 481-488.

⁴ A. Mönning, G. Zika, T. Maier: Trade and qualification: Linking qualification needs to Germany's export flows, IAB-Discussion Paper 7/2013.

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We start our analysis by looking at the import content of German exports. We first present the data and the model used in the study. We then proceed to the calculation of outputs and inputs in the production phase as well as in the use-of-income phase. Finally, we derive the impact on employment of low-skilled, medium-skilled and high-skilled labour used directly and indirectly to carry out the output and input side calculations before we draw our conclusions.

Methodology and database

We use the standard input-output technique (see Box 1). The input-output system includes detailed information for a given year on production activities, the supply of and demand for goods and services, intermediate and final consumption, primary inputs, as well as foreign trade.⁵ Here, the actual sets of symmetric input-output tables show separately the absorption of goods and services in the national economy produced domestically and those produced in the rest of the world. They are accompanied by at least two tables:

- a symmetric table presenting the use of domestically produced goods and services in production activities
- a symmetric table for the input of imports.

Hence, the standard open static input-output model relying on this empirical database, which separates the inputs by origin, is a suitable method for uncovering, at a macroeconomic level, the functional relationship between the individual aggregate demand and the imports used. This technique allows for the calculation of the direct and indirect employment effects induced both by exports as well as by the import intensity of export production.⁶ The following features are of particular importance: firstly, the input-output model clearly differentiates between the use of goods and services as inputs and as final products. In this way, it is possible to avoid “the arbitrariness of classification schemes that divide goods into ‘intermediate’ and other categories”.⁷ Secondly, the input-output tables differentiate between aggregate demand goods and intermediate products. They identify goods by origin (foreign or domestic). This separation makes it possible to analyse

and separate the flow of goods related to the production processes. Thirdly, the direct and indirect use of foreign and domestic intermediate goods can be determined both for the production of consumer and investment goods demanded by the domestic market as well as for export goods demanded by international markets. Finally, the crucial advantage of this method is that it explicitly distinguishes between direct and indirect effects.

The calculations below are based on the official input-output tables for Germany. The economic transactions are assessed for individual years at current prices. While this could be seen as problematic, it has been shown that, at the macroeconomic level, the trends appeared to be the same for the increase of the total import content of exports from Germany between 1991 and 2000 both at current prices and at constant prices.⁸

Labour input – measured by the number of persons employed – is given for the 71 production sectors listed in the input-output tables published by the Federal Statistical Office of Germany. The data does not capture information on the employment of labour with regard to the number of hours worked or detailed structural features such as the labour force’s skills, professions or occupational fields. In reality, the labour force is heterogeneous, for example, in terms of the length of the working day or educational attainment. This lack of information can be overcome by replacing the row vector for employment in the input-output model with a matrix (hereafter referred to as the skills matrix) in which the employment in the individual sectors of production is listed row by row according to skills.

We used a broad set of statistical sources to create a primary database with which to compile these types of skills matrices. The micro-census, the largest official household survey in Germany, was of particular interest here. It covers one per cent of the population and provides year by year information for a number of employment characteristics, including gender, age, education, profession, current work and industry.⁹

Based on these data, we compiled skills matrices for the years 1996 and 2006¹⁰ in which total employment is divided into the following groups, based on formal education:

5 Eurostat Manual of Supply, Use and Input-Output Tables, Methodologies and Working Papers, Luxemburg 2008, p. 17.
6 See, for example, K. De Backer, N. Yamano: The measurement of globalization using international input-output tables, OECD, STI WP 2007/8; D. Horgos: Labor Market Effects of International Outsourcing: How Measurement Matters, in: International Review of Economics and Finance, Vol. 18, No. 4, 2009, pp. 183-204.
7 D. Hummels, J. Ishii, K.M. Yi: The nature and growth of vertical specialization on world trade, in: Journal of International Economics, Vol. 54, No. 1, 2001, pp. 75-96, here p. 80.

8 See H.-U. Brautzsch, U. Ludwig: Der Importgehalt der Exporte im Lichte von jeweiligen und konstanten Preisen, in: U. Ludwig (ed.): Neuere Anwendungsfelder der Input-Output-Analyse in Deutschland, IWH-Sonderheft, Halle 2007, pp. 140-172.

9 See T. Körner, K. Puch: Der Mikrozensus im Kontext anderer Arbeitsmarktstatistiken, in: Wirtschaft und Statistik, No. 6, Wiesbaden 2009, pp. 528-552.

10 For these years a complete set of all of the required statistical sources is available.

- preparatory education, career preparation year
- vocational training, vocational education
- master craftsmanship, technician training
- technical college, university of applied sciences
- university, PhD.

Furthermore, the persons falling into each of these skill categories are separated into three groups: full-time work, part-time work of at least 20 hours a week and part-time work of less than 20 hours a week. The skills matrices are made up of 71 sectors of production, just like the columns of the German Federal Statistical Office's input-output table, and 15 rows (five skill levels each with three working time groups).

For the sake of clarity, the following results of calculations using Germany's 71x71 symmetric input-output tables are grouped into three categories. The primary sector of the economy (agriculture, forestry, fisheries) consists of product groups 1 to 8, the secondary sector (mining, manufacturing, construction, energy) contains product groups 9 to 44, and the tertiary sector (services) includes product groups 45 to 71. Skill levels are categorised into three groups: low (preparatory education/career preparation year), medium (vocational training/vocational education and craftsmanship/technician training) and high (technical college, university of applied sciences, university and PhD).

The import intensity of exports in the production phase

Export-induced imports in the production phase are identified in two steps. First, total export-induced output is calculated. This is done by multiplying the Leontief inverse by the vector of domestically produced exports (see Box 1, row 1, column 1). Subsequently, the resulting export-induced imports are calculated by multiplying the vector of total export-induced output with the matrix of coefficients reflecting the direct input of imported intermediate goods per unit of gross output (row 3, column 1). Here the elements of the vector of total export-induced imports show how many intermediate goods and services need to be imported to produce the total export output.

This technique calculates the relationship between commodity trade and total factor intensities that provides a measure of factor abundance. It assumes free and balanced trade, factor price equalisation and internationally invariant homogeneous technology. Webster has summarised

Table 1
Germany's exports and their import content, 1996 and 2006, at current prices

	1996	2006	Index
	€ bn		1996=100
[1] Exports	453.3	1 031.2	227.5
[2] Export goods produced domestically	404.4	863.9	213.5
[3] Re-exports	48.9	167.2	341.9
[4] Export-induced imports	129.3	435.0	336.4
[5] Intermediate goods	80.4	267.8	333.1
[6] Re-exports	48.9	167.2	341.9
	in %		
[7] Import content of exports ((4)/[1])	28.5	42.2	148.1
[8] Intermediate goods ((5)/[1])	17.7	26.0	146.9
[9] Re-exports ((6)/[1])	10.8	16.2	150.0
[10] Memo item: Import content of exports produced domestically ((5)/[2])	19.9	31.0	155.8

Source: Federal Statistical Office of Germany: input-output tables; authors' calculations.

risied results from various studies which indicate that the violation of either of the first two assumptions does not invalidate the model; the only critical assumption is the internationally invariant homogeneous technique of production.¹¹ This assumption implies that all goods exported and imported by Germany are produced by the technologies available in this country. It can be disputed with regard to imports, but the assumption cannot be rejected as long as imports are aggregates from the rest of the world, i.e. independent of the country of origin. However, this also means that our calculations reflect the reduction of employment in Germany by imported intermediate goods, based on the assumption that the technology used in Germany is less labour-intensive than that used in the majority of its trading partner countries.

As Table 1 shows, in line with the general condition for efficient production, there is a surplus of Germany's exports over the goods and services imported to produce them. The import content per unit of exports remained surprisingly stable from the beginning of the 1980s to the beginning of the 1990s at a rate of around 25 per cent.¹² As the

11 A. Webster: The skill and higher educational content of UK net exports, in: Oxford Bulletin of Economics and Statistics, Vol. 55, No. 2, 1993, pp. 141-159.

12 See U. Ludwig, H.-U. Brautzsch: Has the international fragmentation of German exports passed its peak?, in: Intereconomics, Vol. 43, No. 3, 2008, pp. 176-180.

Box 1

Basic equations of the applied input-output model

		Production phase [1]	Use-of-income phase [2]	In sum [3]
Exports				
Output	[1]	$\mathbf{x}^{\text{ex}}_{(1)} = (\mathbf{I} - \mathbf{A}^{\text{D}})^{-1} * \mathbf{ex}^{\text{D}}$	$\mathbf{x}^{\text{ex}}_{(2)} = (\mathbf{I} - \mathbf{A}^{\text{D}})^{-1} * \mathbf{y}^{\text{DC}}$	$\mathbf{x}^{\text{ex}} = \mathbf{x}^{\text{ex}}_{(1)} + \mathbf{x}^{\text{ex}}_{(2)}$
Skill content	[2]	$\mathbf{L}^{\text{ex}}_{(1)} = \mathbf{Q} * \mathbf{x}^{\text{ex}}_{(1)}$	$\mathbf{L}^{\text{ex}}_{(2)} = \mathbf{Q} * \mathbf{x}^{\text{ex}}_{(2)}$	$\mathbf{L}^{\text{ex}} = \mathbf{L}^{\text{ex}}_{(1)} + \mathbf{L}^{\text{ex}}_{(2)}$
Export-induced imports				
Output	[3]	$\mathbf{im}^{\text{ex}}_{(1)} = \mathbf{A}^{\text{IM}} * \mathbf{x}^{\text{ex}}_{(1)}$	$\mathbf{im}^{\text{ex}}_{(2)} = \mathbf{A}^{\text{IM}} * \mathbf{x}^{\text{ex}}_{(2)}$	$\mathbf{im}^{\text{ex}} = \mathbf{im}^{\text{ex}}_{(1)} + \mathbf{im}^{\text{ex}}_{(2)}$
Skill content	[4]	$\mathbf{L}^{\text{im}}_{(1)} = \mathbf{Q} * \mathbf{im}^{\text{ex}}_{(1)}$	$\mathbf{L}^{\text{im}}_{(2)} = \mathbf{Q} * \mathbf{im}^{\text{ex}}_{(2)}$	$\mathbf{L}^{\text{im}} = \mathbf{L}^{\text{im}}_{(1)} + \mathbf{L}^{\text{im}}_{(2)}$
Net effects				
Output	[5]	$\Delta \mathbf{x}_{(1)} = \mathbf{x}^{\text{ex}}_{(1)} - \mathbf{im}^{\text{ex}}_{(1)}$	$\Delta \mathbf{x}_{(2)} = \mathbf{x}^{\text{ex}}_{(2)} - \mathbf{im}^{\text{ex}}_{(2)}$	$\Delta \mathbf{x} = \mathbf{x}_{(1)} + \mathbf{x}_{(2)}$ $= \mathbf{x}^{\text{ex}} - \mathbf{im}^{\text{ex}}$
Skill content	[6]	$\Delta \mathbf{L}_{(1)} = \mathbf{L}^{\text{ex}}_{(1)} - \mathbf{L}^{\text{im}}_{(1)}$	$\Delta \mathbf{L}_{(2)} = \mathbf{L}^{\text{ex}}_{(2)} - \mathbf{L}^{\text{im}}_{(2)}$	$\Delta \mathbf{L} = \mathbf{L}_{(1)} + \mathbf{L}_{(2)}$ $= \mathbf{L}^{\text{ex}} - \mathbf{L}^{\text{im}}$

Note: The subscript (1) stands for the production phase, (2) for the use-of-income phase.

Notation:

\mathbf{I}	identity matrix
\mathbf{A}^{D}	matrix of coefficients showing the direct input of intermediate goods produced domestically per unit of gross output
\mathbf{A}^{IM}	matrix of coefficients showing the direct input of imported intermediate goods per unit of gross output
\mathbf{Q}	matrix of coefficients showing the direct labour input according to skill level per unit of gross output
\mathbf{L}^{ex}	matrix of total export-induced labour input differentiated according to skill level
\mathbf{L}^{im}	matrix of total labour input caused by export-induced imports differentiated according to skill level
\mathbf{x}^{ex}	vector of total export-induced output
\mathbf{ex}^{D}	vector of exports produced domestically
\mathbf{im}^{ex}	vector of total export-induced imports

The skills balance in net exports is calculated in two steps. The first step deals with the net effects stemming from exports and export-induced imports in the *production phase*. The total output \mathbf{x} behind the exports is measured by multiplying the Leontief inverse of the open input-output model with the vector of exports produced domestically, \mathbf{ex}^{D} . Thereafter, the labour input necessary for all production levels – differentiated according to skill level – is calculated by multiplying, element by element,¹ the \mathbf{Q} matrix with the vector of the export-induced total output. Export-induced imports \mathbf{im}^{ex} are then calculated by multiplying the vector of total export-induced output by the matrix of coefficients of the direct input of imported intermediate goods per unit of gross output \mathbf{A}^{IM} . The reduction of employment $\mathbf{L}^{\text{im}}_{(2)}$ induced by export-induced imports is calculated using the \mathbf{Q} matrix.

In the second step, the effects caused by the use of additional income (*use-of-income phase*) are included.² Here the consumption expenditure is split between the purchase of domestic and imported goods. The share of imports in the total expenditure on consumable goods is excluded. The “gains” to output $\mathbf{x}^{\text{ex}}_{(2)}$ are calculated by multiplying the Leontief inverse with the vector \mathbf{y}^{DC} .³

The output and the skills balances resulting from net exports in both phases are given by $\Delta \mathbf{x}$ and $\Delta \mathbf{L}$ respectively.

1 The symbol * used in the equation stands for element-by-element multiplication, the so-called Hadamard product.

2 The methodological approach is described in more detail in H.-U. Brautzsch, U. Ludwig: Gesamtwirtschaftliche Beschäftigungswirkungen von Großinvestitionen, in: U. Ludwig (ed.): Neuere Anwendungsfelder der Input-Output-Analyse in Deutschland, IWH-Sonderheft, Halle 2003, pp. 151-180.

3 The calculations were carried out through the second round.

export surplus increased in the second half of the 1990s due to the growing internationalisation of national production processes, the import content per unit of exports also increased. In 1996 the import content of exports already amounted to 28.5 per cent. By 2006 it had again increased dramatically, to 42.2 per cent (see Table 1, row 7).

Hidden behind the overall rising import content of German exports, there are several trends regarding the two main components of exports, the macroeconomic effects of which differ considerably and therefore have to be investigated and assessed separately. Exports consist of two types of products: those that are the result of the production and the value-adding process in Germany and those that are imported for the purpose of being immediately re-exported and thus have very weak links to domestic production. The latter, therefore, represent an “item in transit”. The direct export of previously imported goods is hereafter termed re-export.¹³ In line with this classification, export-induced imports have to be divided into those that enter the national production process as intermediate inputs and are then subsequently processed into export goods and those that are imported for re-export. The latter are identical in content and size with the above-mentioned re-exports.

The two components of export-induced imports – export-induced intermediate imports and re-exports – contributed to differing degrees to the rise in the import content of German exports in the second half of the 1990s. The export-induced intermediate imports (see Table 1, row 8) amounted to 18 per cent of the exports in the mid-1990s. They increased significantly by the end of the 1990s and reached 26 per cent in 2006. At the same time, the share of re-exports (see Table 1, row 9) increased to 16 per cent in 2006, and they contributed significantly to the overall increase in the import content of all exports to 42 per cent by 2006.

Germany’s export sector is increasingly using both domestically produced as well as imported intermediate inputs. Nevertheless, export-induced output significantly exceeds the input of intermediate goods from abroad. These imports made up 31 per cent of the domestically produced exports in 2006, whereas they amounted to 20 per cent in the mid-1990s (see Table 1, row 10). Here the re-exports are not taken into account, since they do not come into contact with the domestic production process.

¹³ Goods in the “re-export” category numerically correspond to the “export” column in the import table of the input-output statistics.

Output effects in the use-of-income phase

As described above, the effects of exports or export-induced intermediate goods and services on employment appear in two phases of the circular flow of the economy. Such effects are caused directly and indirectly by the production of export goods and services – here referred to as the production phase. In addition to this, there are effects on output and employment caused by the circular flow of extra income earned by workers in the export sector (the use-of-income phase). People directly or indirectly employed in export production use part of their income to purchase goods; this further stimulates output and secures (additional) jobs. These effects can only be estimated approximately using the standard open input-output model.

The starting point for calculating these effects is the consumption expenditure of private households. The gross income that is induced domestically through the production of export goods and services can be derived from the wages earned by the additional labour force. To calculate disposable income, it has to be adjusted by taxes and social contributions. Savings also have to be taken into account. We assume that the additional private consumption expenditure prompted by the extra income created from export-related increases in employment corresponds to the average composition of household goods consumption on the whole. Moreover, the consumption expenditure is split between the purchase of domestic and imported goods. As imports do not stimulate additional production in the country of destination, their share in total expenditure on consumable goods is excluded.

Methodologically, the calculation of the net effects in the use-of-income phase is similar to that of the production phase. The induced output is calculated by multiplying the Leontief inverse by the assumed vector of private consumption expenditure (see rows 1 and 3 in column 2 of Box 1).

The total net effect of exports on output is calculated as shown in column 3 of Box 1.

The skills content of exports and export-induced imports

The employment effects generated in the production phase as well as in the use-of-income phase are derived via labour coefficients classified by skill level. The transformation of the basic equations of the open static input-output model to include labour input by skill level involves the element-by-element multiplication of the column vec-

Table 2
Net employment effects of export-induced output and imports of intermediate goods and services by sector and skill level in Germany, 1996 and 2006

in 1000 persons

	Skill level	1996			2006			Growth in absolute terms		
		Export-induced		Net effect	Export-induced		Net effect	Export-induced		Net effect
		output	imports		output	imports		output	imports	
		[1]	[2]	[3]=[1]-[2]	[4]	[5]	[6]=[4]-[5]	[7]=[4]-[1]	[8]=[5]-[2]	[9]=[7]-[8]
Primary sector										
[1]	Low	107	22	85	74	27	47	-33	5	-38
[2]	Medium	219	46	173	236	96	140	17	50	-33
[3]	High	24	5	19	26	21	5	2	16	-14
[4]	Total ([1]+[2]+[3])	350	73	277	336	144	192	-14	71	-85
Secondary sector										
[5]	Low	959	101	858	939	141	798	-20	40	-60
[6]	Medium	2 492	246	2 246	3 089	446	2 643	597	200	397
[7]	High	418	42	376	545	84	461	127	42	85
[8]	Total ([5]+[6]+[7])	3 869	389	3 480	4 573	671	3 902	704	282	422
Tertiary sector										
[9]	Low	945	61	884	1 505	152	1 353	560	91	469
[10]	Medium	2 377	151	2 226	4 132	390	3 742	1 755	239	1 516
[11]	High	583	34	549	1 274	110	1 164	691	76	615
[12]	Total ([9]+[10]+[11])	3 905	246	3 659	6 911	652	6 259	3 006	406	2 600
Total										
[13]	Low	2 011	184	1 827	2 518	320	2 198	507	136	371
[14]	Medium	5 088	443	4 645	7 457	932	6 525	2 369	489	1 880
[15]	High	1 025	81	944	1 845	215	1 630	820	134	686
[16]	Total ([4]+[8]+[12])	8 124	708	7 416	11 820	1 467	10 353	3 696	759	2 937

Note: Total employment effects (production phase and use-of-income phase).

Source: Federal Statistical Office of Germany: input-output tables; authors' calculations.

tor of the exports or the column vector of the import content of exports with the skills matrix (see Box 1, rows 2 and 4 in columns 1 and 2). The rows of the skill matrix Q contain the coefficients of labour input according to skill levels per unit of output. The row totals indicate the overall labour input per output unit.

Table 2 shows that the balance of goods in the export sector also had a net positive effect on employment in Germany. In 2006 export-induced production employed 11.8 million members of the workforce. Compared to 1996, this is an increase of 3.7 million workers. At the same time, export-induced imports displaced a growing share of the workforce. Due to the rising import content of domesti-

cally produced exports, the number of people affected more than doubled. Nevertheless, in the final analysis the net effect of the export penetration by imports was an increase of almost 3 million workers (see Table 2, row 16).

In total, the positive net effects hold for all skill levels. They are determined by the rising employment in export-induced production processes as well as in the imports linked with them. However, in line with the augmented Heckscher-Ohlin theorem, only an increase in medium- and high-skilled labour could be expected in the export-induced production processes, whereas in export-induced imports, only the input of low-skilled labour should rise. An analysis by sector helps to clarify the situation.

The net effects are mainly determined by the medium-skilled category of the workforce in the tertiary sector of the economy. Although in 2006 more medium-skilled workers were needed for the export-induced production of goods and services in all three sectors of the economy than ten years earlier, the tertiary sector saw the most substantial rise (Table 2, row 10). Due to the generally higher labour intensity in the service sector in 2006, it overtook the secondary sector, formerly the leading sector in terms of export-induced employment. Moreover, the share of the high-skilled labour input almost doubled due to the strong increase in the service sector. On the other hand, the input of low-skilled labour caused by export-induced production fell only in the primary and secondary sectors of the economy. It increased in the tertiary sector as well as in total. This means that in terms of export production, the service sector contradicts expectations.

The amount of low-skilled labour embodied in export-induced imports rose in total but decreased with regard to the products stemming from the primary and secondary sectors of the economy. However, a considerably higher amount of low-skilled labour was embodied in direct and indirect imports of services (tertiary sector). Thus, export-induced imports in all three sectors signal an increase – albeit modest – in low-skilled labour. Here it is exclusively the service sector that may help to confirm expectations regarding the import side.

The results presented in Table 2 cannot reveal the true relationship between the skills directly and indirectly embodied in exports (and the output induced by them), and those embodied in their export-induced imports. One reason for this is the difference in the scale of production of export-induced output and export-induced intermediate imports.¹⁴ Another reason could be found in the different levels of skill intensity. As shown in Table 3, Germany's labour input per output value varies strongly by skill level and by sector of the economy, and it has changed dramatically in the period under consideration.

In the less labour-intensive and, at the same time, most export-intensive sectors of the economy – including mining, manufacturing, construction and energy – the labour input per unit of output fell most sharply (see Table 3, row 14). This sector achieved the highest increase in productivity, which affected all skill levels. In absolute terms per unit of output, only the decline in input of low-skilled work in the primary sector was stronger. By contrast, in the

¹⁴ This includes the total cost of export production or export-induced intermediate imports in the production phase and – through the circular flow of income – in the use-of-income phase.

Table 3
Germany's labour input per million euros of output value by sector and skill level, 1996 and 2006

	Sector	1996	2006	Productivity effects per unit of output	
		in number of people		in %	
Low skill					
[1]	Primary	5.16	3.05	-2.11	-40.8
[2]	Secondary	1.89	0.97	-0.92	-48.8
[3]	Tertiary	3.12	2.44	-0.68	-21.8
[4]	Total	2.63	1.81	-0.82	-31.2
Medium skill					
[5]	Primary	10.36	9.69	-0.67	-6.5
[6]	Secondary	5.12	3.31	-1.82	-35.5
[7]	Tertiary	7.74	6.88	-0.86	-11.1
[8]	Total	6.67	5.37	-1.29	-19.4
High skill					
[9]	Primary	1.12	1.04	-0.07	-6.5
[10]	Secondary	0.76	0.52	-0.24	-31.7
[11]	Tertiary	2.66	2.45	-0.21	-7.9
[12]	Total	1.81	1.59	-0.22	-12.0
Total					
[13]	Primary [1]+[5]+[9]	16.64	13.79	-2.85	-17.1
[14]	Secondary [2]+[6]+[10]	7.77	4.79	-2.98	-38.3
[15]	Tertiary [3]+[7]+[11]	13.51	11.76	-1.75	-13.0
[16]	Total	11.10	8.77	-2.33	-21.0

Source: Federal Statistical Office of Germany: input-output tables; authors' calculations.

service sector, these declines were small. Above all, the employment of highly qualified workers per unit of output declined relatively little.

Table 4 shows the impact of the increasing productivity of labour on the balance of skills embodied in the export-induced production and imports per unit of output in 1996 and 2006. In both years, the composition of the labour input per unit of output was dominated by the medium-skilled category in export-induced output as well as in imports. Highly skilled labour lagged behind. The export-induced output proved to be more labour-intensive than the export-induced imports (see Table 4, row 13, columns 3 and 6). The high level of labour intensity in export-induced output compared to imports is determined by the positive net effect of medium- and high-skilled labour per unit of output. However, there is also a surplus of low-skilled labour that is not in line with the expectations of the aug-

Table 4
Germany's net employment effects from export-induced output and imports of intermediate goods by sector and skill level, 1996 and 2006

in people per million euros of output value

Skill level	1996			2006			Productivity effects			
	Export-induced		Net effect	Export-induced		Net effect	Export-induced		Net effect	
	output	imports		output	imports		output	imports		
	[1]	[2]	[3]=[1]-[2]	[4]	[5]	[6]=[4]-[5]	[7]=[4]-[1]	[8]=[5]-[2]	[9]=[7]-[8]	
Primary sector										
[1]	Low	0.11	0.23	-0.12	0.04	0.09	-0.05	-0.07	-0.14	0.07
[2]	Medium	0.23	0.48	-0.25	0.13	0.31	-0.18	-0.10	-0.17	0.07
[3]	High	0.02	0.05	-0.03	0.01	0.07	-0.06	-0.01	0.02	-0.03
[4]	Total ([1]+[2]+[3])	0.36	0.76	-0.40	0.18	0.47	-0.29	-0.18	-0.29	0.11
Secondary sector										
[5]	Low	0.99	1.05	-0.06	0.50	0.46	0.04	-0.49	-0.59	0.10
[6]	Medium	2.58	2.56	0.02	1.64	1.44	0.20	-0.94	-1.12	0.18
[7]	High	0.43	0.44	-0.01	0.29	0.27	0.02	-0.14	-0.17	0.03
[8]	Total ([5]+[6]+[7])	4.00	4.05	-0.05	2.43	2.17	0.26	-1.57	-1.88	0.31
Tertiary sector										
[9]	Low	0.98	0.64	0.34	0.80	0.49	0.31	-0.18	-0.15	-0.03
[10]	Medium	2.46	1.58	0.88	2.20	1.26	0.94	-0.26	-0.32	0.06
[11]	High	0.60	0.35	0.25	0.68	0.36	0.32	0.08	0.01	0.07
[12]	Total ([9]+[10]+[11])	4.04	2.57	1.47	3.68	2.11	1.57	-0.36	-0.46	0.10
Total										
[13]	Low	2.08	1.92	0.16	1.34	1.04	0.30	-0.74	-0.88	0.14
[14]	Medium	5.27	4.62	0.65	3.97	3.01	0.96	-1.30	-1.61	0.31
[15]	High	1.05	0.84	0.21	0.98	0.70	0.28	-0.07	-0.14	0.07
[16]	Total ([4]+[8]+[12])	8.40	7.38	1.02	6.29	4.75	1.54	-2.11	-2.63	0.52

Note: Total employment effects (production phase and use-of-income phase). Unit of output induced by export or "hypothetical" import production.

Source: Federal Statistical Office of Germany: input-output tables; authors' calculations.

mented Heckscher-Ohlin theorem. Despite the expected relationship between the input of low-skilled labour in the export-induced output and imports of products of the primary and secondary sector, the opposite can be observed for the tertiary sector. Here the content of low-skilled labour embodied in export-induced imports is lower than in export-induced output (see Table 4, row 9).

The ambiguity of these results disappears, however, if the analysis is conducted in relative terms. Indeed, in 1996 as well as in 2006, the percentage shares of low-skilled labour embodied in export-induced imports exceeded their shares in the export-induced output. At the same time, in both years the share of high-skilled labour in exports exceeded its share in imports, whereas the share of me-

dium-skilled labour was more or less similar in export-induced output and imports. Although these balances vary between the three sectors of the economy, in total they are determined by the service sector.

In the final analysis, the results for 1996 as well as for 2006 reveal a positive net effect of both labour input and the skill content per unit of output in export-induced production compared to that of intermediate inputs from abroad. In both years, the positive balance was determined by the medium-skilled labour input in the tertiary sector of the economy. In 2006, the secondary sector caught up with positive net effects in all skill categories. By contrast, the primary sector of the economy did not contribute to this tendency. The net effects were negative in all categories.

Furthermore, the total net effect of export-induced production through intermediate imports on the skills input increased in the decade under consideration.

Conclusions

In the decade prior to the economic and financial crisis, Germany's export surpluses led to positive net employment effects. Although the volume of imports of intermediate goods increased and was augmented by the rise in exports, it could not undermine the overall positive employment effect.

Our empirical analysis also reveals that in this period Germany was a net exporter of skilled labour that was directly and indirectly embodied in the country's exports. The balance might marginally change if the skilled labour embodied in imports were accounted for by national inputs in the countries of origin, but any change would not be significant enough to effect our core findings. In this analysis, we assumed the technology used abroad is the same as in Germany. While this probably holds for its highly developed trading partners, it is not the case for all of them.

However, the analysis also signals that there are some relative shortages. Skilled labour is scarce in the secondary sector of the economy where manufacturing forms the backbone of German exports. The net skills effect per unit of export-induced output was negligible in 1996, and in 2006 it was still very small. This finding matters for medium- and high-skilled labour. When looking at the overall picture, this critical point is hidden, as the high net exports prevail. In contrast to the secondary sector, the relative surplus in the service sector was high, although its direct share in Germany's exports was very low. However, to a large extent this is due to a growing interdependence between services and manufacturing industries (e.g. backward linkages). In the context of the business services outsourced from the manufacturing sector, the surplus once more underlines the crucial role of the secondary sector of the economy in export activities.

Selective policies targeting different skill groups are required. If Germany's leading position in the export of goods is to be maintained in the future, the focus should be on policies that expand training for medium-skilled workers in manufacturing and highly-skilled engineers. Skilled labour remains the only resource Germany can use to reinforce its strong position in international markets. In light of ongoing demographic changes, our results also imply that it is in Germany's inherent interest to strengthen its efforts to recruit, train and integrate immigrants, as the number of young people born here and entering the educational and training systems is decreasing.