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International Fragmentation of Production and the Labour Input into Germany's Exports – An Input-Output-Analysis

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International Fragmentation of Production and the Labour Input into Germany's Exports

– An Input-Output-Analysis –

Abstract

The import penetration of exports has become a topic of public debate, particularly in the context of Germany's position as one of the world's leading exporters. The growth in the volume of intermediate products purchased from abroad for subsequent processing into export goods in Germany seems to be undermining the importance of exports as a driver of domestic production and employment. The gains that arise from an increase in exports seem to have been offset by the losses caused by the crowding out of local production by imports. Empirical evidence on the impact of this international integration of the goods market on the German labour market is ambiguous. Short-term negative effects on employment are claimed to be offset by the long-term benefit that the jobs lost in the short run will eventually be replaced by higher-skilled jobs with better perspectives. Against this background, the following hypothesis is tested empirically: Germany is poor in natural resources, but rich in skilled labour. In line with the Heckscher-Ohlin theory, Germany should therefore specialize 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 unskilled labour.

The empirical part of the paper deals with the extent of the German export penetration by imports. At first, it analyses by what ways imports are affecting the exports directly and indirectly and shows the consequences of import penetration of exports for the national output and employment. Secondly, consequences for employment are split in different skill types of labour. These issues are discussed with the standard open static input-output-model. The data base is a time series of official input-output tables. The employment effects for Germany divided by skill types of labour are investigated using skill matrices generated by the authors.

Keywords: international trade, labour and skills market interactions, input-output-models

JEL Classification: C67, F14, F16

Internationale Fragmentierung der Produktion und der Arbeitsinput im deutschen Export

– Eine Input-Output-Analyse –

Zusammenfassung

Die Importdurchdringung der Exporte ist im Zusammenhang mit der Stellung Deutschlands als Exportweltmeister in der Öffentlichkeit diskutiert worden. Durch den wachsenden Zukauf von Vorleistungsgütern aus dem Ausland zur Weiterverarbeitung zu Exportgütern in Deutschland werde die Bedeutung des Exports als Motor von Produktion und Beschäftigung im Inland untergraben. Der Wohlfahrtsgewinn aus der Intensivierung des Exports würde durch Wohlfahrtsverluste infolge der Verdrängung einheimischer Produktion durch Importe erkaufte. Die empirische Evidenz für die Wirkungen der internationalen Integration der Gütermärkte auf den deutschen Arbeitsmarkt ist jedoch nicht eindeutig. Negativen Folgen auf Beschäftigung und Einkommen in der kurzen Frist stehen Vorteile gegenüber, wenn die wegfallenden Arbeitsplätze durch höherwertige mit besseren Einkommensperspektiven ersetzt werden. Vor diesem Hintergrund wird folgende Hypothese getestet: Deutschland ist gering ausgestattet mit Rohstoffen, aber reichlich mit qualifizierter Arbeit. Gemäß der Heckscher-Ohlin-Theorie sollte sich Deutschland deshalb im Export auf die Produktion von qualifikationsintensiven Gütern spezialisieren und solche Güter importieren, die viel unqualifizierte Arbeit enthalten.

Im empirischen Teil befasst sich der Beitrag mit dem Ausmaß der Importdurchdringung des deutschen Exports. Es wird analysiert, über welche Wege die Importe die Exporte direkt und indirekt beeinflussen, und es wird gezeigt, welche Folgen die Importdurchdringung der Exporte für die nationale Produktion und Beschäftigung haben. Dabei werden die Folgen für die Beschäftigung nach verschiedenen Qualifikationsstufen aufgespalten. Die Untersuchung erfolgt mit dem offenen statischen Input-Output-Modell. Datenbasis ist eine Zeitreihe amtlicher Input-Output-Tabellen. Die nach Qualifikationsstufen differenzierten Beschäftigungseffekte werden auf der Basis von Qualifikationsmatrizen ermittelt, die eigens durch die Autoren generiert worden sind.

Schlagwörter: Außenhandel, Arbeitsmärkte, Qualifikation, Input-Output-Modelle

JEL-Klassifikation: C67, F14, F16

International Fragmentation of Production and the Labour Input into Germany's Exports

– An Input-Output-Analysis –

1 The Problem

Production and service processes that were once provided only nationally are becoming increasingly international. They are therefore penetrated more and more by imports. This is one of the results of fragmentation,¹ which involves dividing the production process into separate sections in which parts of a product (so-called fragments) are manufactured.² The manufacturing of fragments can be moved abroad, which may be profitable if transport costs can be contained. As a result, it can be assumed that, in high-wage countries, jobs with low skill requirements are coming under pressure, whereas skilled employees are increasingly in demand. The loss of production and jobs in some areas is potentially balanced by gains in other areas, thanks to improved competitiveness. The movement away from the often labour-intensive production of individual parts or entire components towards innovation and human capital intensive sectors promises gains in efficiency for individual companies. However, at the national economy level, the balance between gains in efficiency and losses in employment is still unclear.

The import penetration of production has become a topic of public debate, particularly in the context of Germany's position as one of the world's leading exporters. The increase in the volume of intermediate products purchased from abroad for subsequent processing into export goods in Germany seems to be undermining the importance of exports as a driver of domestic production and employment. The gains that arise from an increase in exports seem to have been offset by the losses caused by the crowding out of local production by imports. In this instance, economic theory fails to offer a clear explanation.³ In addition, empirical evidence on the impact of this international integration of the goods market on the German labour market is ambiguous. Short-term negative effects on employment and income are claimed to be offset by the long-term benefit that the jobs lost in the short run will eventually be replaced by higher-skilled jobs with better income perspectives. Against this background, we start with the following hypothesis:

1 The discussion in international specialist literature was the result of case studies carried out in developing countries. Cf. *Feenstra* (1998); *Jones, Kierzkowski* (2001).

2 A survey of different interpretations can be found in *Zeddies* (2010).

3 Cf., for example, *Samuelson* (2004); *Bhagwati, Panagariya, Srinivasan* (2004).

Germany is poor in natural resources, but rich in skilled labour and capital. In line with the Heckscher-Ohlin theory, Germany should therefore specialize 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 unskilled labour.

In an earlier analysis, we could not reject this hypothesis for overall exports and imports. However, the surplus of the skilled labour content of exports over imports was marginal.⁴ In the current paper, we restrict our study to the import side of goods that are used in the production process of export goods.

The effects of Germany's international trade policy on the labour market has already been the subject of several studies by various authors. These studies include a wide range of econometric approaches and they use a variety of macro- and/or micro-economic data. Despite a number of theoretical and empirical gains from these studies, many issues have not yet been explored or have been only partly explored.⁵ Furthermore, in most cases, these approaches do not take into account interindustrial interdependence in the economy. Thus, for example, the econometric models applied to time series of GDP components cannot differentiate between the use of goods as intermediaries and as final products. An addition, this data base fails to distinguish between the foreign or domestic origin of either aggregate demand goods or intermediate products. Moreover, the direct and indirect use of foreign and domestic intermediate goods cannot be determined for either the production of consumer and investment goods demanded by the domestic market or the export goods demanded by foreign markets.

Some studies on Germany do take into account the interindustrial relationship of the production sector of the economy,⁶ showing that the rising import content of exports is not a singular phenomenon which is restricted to Germany.⁷ The question of whether this phenomenon is to be judged at only a macroeconomic level remains controversial. On the one hand, it is argued that the national value-added process in Germany is increasingly being penetrated by components manufactured abroad, with the result that the national production chains are undermined and jobs are crowded out.⁸ On the other hand, this conclusion is contested from various sides.⁹ In particular, it has been shown that the competitiveness of the German economy has been neither weakened nor destroyed by the increasing import content of the exports. The increased import content of

4 Cf. Brautzsch, Ludwig (2009), p. 486f.

5 Cf., for example, Crino (2009); Pflüger et al. (2010).

6 Cf., for example, Federal Statistical Office of Germany (2004a, b); Brautzsch, Ludwig (2004, 2005).

7 Brautzsch, Ludwig (2005).

8 Cf. Sinn (2005).

9 Cf., for example, Sachverständigenrat zur Begutachtung der gesamtwirtschaftlichen Lage (2004); Horn, Behnke (2004).

the exports has thus far contributed to a strengthening of local competitiveness in the course of globalisation.

As a rule, the studies mentioned above take into account the aspect of employment linked to export activities as a homogenous input of labour. In fact, it is heterogeneous in respect of various characteristics, such as the skills required. Therefore, in the current study, the import penetration of export production is additionally investigated from the angle of the utilisation of human capital.¹⁰

This paper studies the penetration of German exports by imports and the impact of that penetration on employment, both in general, and then broken down in terms of the low skilled, medium-skilled and highly-skilled workforce in various years. We start with the data and model used, proceed to the calculations of outputs and inputs in the export sector, and then to the employment needed directly and indirectly to run the output and input side of the export sector before we reach a conclusion.

2 Method and Database

We use the input-output technique. 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 and foreign trade. The data are arranged in the form of supply and use tables by product and industry; hence they describe the transactions and the production processes of all products of the national economy in great detail. A symmetric input-output table rearranges both supply and use into a single table, with an identical classification of products applied for the rows and columns of the table. It is in essence a product-by-product matrix.¹¹

The actual symmetric input-output tables are accompanied by at least two tables:

- a symmetric table presenting the use of imports and
- a symmetric table for domestic output.

Thus the published set of symmetric input-output tables shows the absorption of goods in the national economy produced domestically and those produced in the rest of the world. Our analysis of the import penetration in the production of export goods relies on a set of input-output tables for Germany that demonstrate separately the use of imports as intermediate inputs by industry and their use as goods and services by final demand category among them by exports.

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 macro-

¹⁰ For a similar approach applied to Austria, see *Koller, Stehrer (2010)*.

¹¹ *Eurostat (2008, p. 17)*.

economic level, the functional relationship between the individual aggregate demands and the imports used. This technique allows a calculation of the direct and indirect employment effects induced both by exports and by the import penetration of export production. The following reasons are of particular importance: *firstly*, the input-output model clearly differentiates between the use of goods as input and as final products. This avoids an “arbitrariness of classification schemes ... (of) ... goods into ‘intermediate’ and other categories”.¹² *Secondly*, the input-output tables differentiate between aggregate demand goods and intermediate products. They identify the goods by origin, foreign or domestic. This separation makes it possible to analyse and split 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, and for export goods demanded by foreign markets. *Fourthly*, this method in general allows explicit discrimination between the direct and the non-observable indirect effects. This provides a decided advantage over econometric methods.

The calculations below are based on the officially published input-output tables for Germany. In terms of the official statistics, tables were prepared retroactively to 1995, which incorporated the conceptual changes made to the national accounting system in 2005. For previous years, tables were used that were compiled according to the concepts valid before this revision of the national accounting system.

The static input-output model was used for calculations in all the studies dealing with the development of export-induced imports. The economic transactions are assessed for the individual years *at current prices*. Hence the question arises to what extent the changes in the import content of the exports are due to an increase in the quantity of imported intermediate inputs or due to changes in the prices for intermediate inputs and exported goods. The separation of these two factors (the changes of the quantities and prices) cannot be performed with the help of the input-output model at current prices.

The statistical office in Germany does not compile input-output tables at constant prices very regularly.¹³ However, such tables at current prices and at constant prices are available for the period between 1991 and 2000.¹⁴ Based on these tables, a previous study investigated whether the development of export-induced imports should be assessed differently when using input-output tables at constant prices than when using tables at current prices.¹⁵ At a macroeconomic level, the trends appeared to be the same for the development of the total import content of exports from Germany between 1991 and 2000 at current prices and at constant prices. The basic assertions of the study on the macro-

12 Cf. *Hummels, Ishii, Yi* (2001).

13 Cf. *Stahmer, Mayer* (1985).

14 Cf. *Federal Statistical Office of Germany* (2002).

15 Cf. *Brautzsch; Ludwig* (2007).

economic development of the import content of export production in the 1990s, based solely on input-output tables at current prices, therefore remains valid.

The labour input – measured in the number of persons employed – is given for the working population and employees for the 71 industrial sectors listed in the input-output tables published by the Federal Statistical Office of Germany. Information is not provided on the employment of labour in working hours, or according to detailed structural features such as the labour force's skills, professions or activities. Broad homogeneity in the employment of labour is assumed in the analysis of labour market problems using the official input-output table.

In reality, the labour force differs with regard to many characteristics, for example, the length of the working day or education. These facts can be integrated into the study by replacing the row vector for employment of labour with a matrix (hereafter referred to as the skills matrix) in which the employment of labour in the individual branches of production is listed line by line, according to skills. A distinction is made in the matrix, in particular between the skill levels, professions, activity groups and/or duration of the employment of labour (full-time or part-time).¹⁶ The combination of two or more of these characteristics can also be presented in the form of a skills matrix.

The structure of the skills matrix depends on the question being investigated and on the primary data that are available. The database available usually limits the depth of classification of these types of skills matrix. Statistical surveys are used as a primary database for these types of skills matrix. The *micro-census*, the largest official household survey in Germany, is of particular interest here. It covers one per cent of the population every year, looking at a number of characteristics, including gender, age, education, profession, current work and industry.¹⁷ The characteristics surveyed can be combined with one another, depending on the question under review. This means that there are various possibilities for structuring the skills matrices, depending on the aim of the investigation.

Based on this micro-census, skills matrices were developed in which the work factor is divided into the following groups, based on formal education:

- preparatory education, career preparation year;
- vocational training, vocational school;
- master craftsman, technician;
- technical college, university of applied sciences; and/or
- a university degree, PhD.

Furthermore, the persons falling into each of these skills categories are separated into three groups, depending on the length of their working day: full-time, part-time work of 20 hours per week and more, and part-time work of less than 20 hours per week. The

¹⁶ Cf., for example, *ifo-Institut für Wirtschaftsforschung* (1981); *Ludwig* (1989); *Brautzsch* (1992).

¹⁷ Cf. *Körner, Puch* (2009).

skills matrix is therefore made up of 71 branches of production, like the rows of the input-output table, and 15 columns (5 skills levels with 3 working time groups).

In the interest of brevity, the results of calculations using Germany's disaggregated input-output tables are condensed into a primary sector, consisting of Product Groups 1 to 8, a secondary sector containing Product Groups 9 to 44, and a tertiary sector which includes Product Groups 45 to 71.¹⁸ A preparatory education/career preparation year is deemed to be indicative of a "low" skills level. The "medium" level includes vocational training/vocational school/master craftsman/technician degrees and the "high" level includes degrees from technical colleges, universities of applied sciences and universities as well as PhDs.

3 The Import Penetration of Exports

3.1 The Model linking the Export of Goods with the Import of Intermediary Goods

Export-induced imports are identified by means of two steps. First, the total export-induced output is calculated. This is done by multiplying the Leontief-Inverse by the vector of export goods produced domestically:

$$\mathbf{x}^{\text{ex}} = (\mathbf{I} - \mathbf{A}^{\text{d}})^{-1} * \mathbf{ex}^{\text{d}}. \quad (1)$$

The resulting overall export-induced imports are then calculated by multiplying the vector of the total export-induced output by the matrix of coefficients of the direct input of imported intermediate goods per unit of gross output:

$$\mathbf{im}^{\text{ex}} = \mathbf{A}^{\text{im}} * \mathbf{x}^{\text{ex}}. \quad (2)$$

The elements of the vector of total export-induced imports \mathbf{im}^{ex} show how many imported intermediate goods of group i are necessary to produce the total output behind the exports.

The notations mean the following:

\mathbf{x}^{ex} vector of total export-induced output;

\mathbf{I} identity matrix;

\mathbf{A}^{d} matrix of coefficients showing the direct input of intermediate goods domestically produced per unit of gross output;

¹⁸ This pertains to the input-output tables after 1991 that are arranged according to 71 product groups. In the tables for the years 1980 and 1985, which include 58 product groups, the primary sector includes Product Groups 1 to 8, the secondary sector includes Product Groups 9 to 42 and the tertiary sector contains Product Groups 43 to 58.

\mathbf{ex}^d vector of export goods domestically produced;

\mathbf{im}^{ex} vector of total export-induced imports;

\mathbf{A}^{im} matrix of coefficients of the direct input of intermediate imports per unit gross output.

This technique calculates the relationship between commodity trade and total factor intensities that implies a measure of factor abundance. It assumes free and balanced trade, factor price equalization and internationally invariant homogeneous technology. Webster has summarized results from various studies which indicate that the violation of most of these assumptions does not invalidate the model. The only critical assumption is the internationally invariant homogeneous technique of production.¹⁹ This assumption implies that all goods exported and imported by Germany are produced by the technologies available in this country. This assumption can be disputed with regard to imports, but the assumption cannot be discarded as long as imports are aggregates from the rest of the world. However, this also means that our calculations reflect an upper margin for the losses of employment by intermediate imports based on the assumption that in the majority of cases the technology used in Germany is less labour-intensive than that used in the trading partner countries.

3.2 The Import Content of Germany's Exports over the Last Decades

As expected, there is a surplus of Germany's exports over goods and services imported to produce the export goods. However, 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% (cf. Table 1). As the export surplus accelerated in the second half of the nineties, the import content per unit of exports increased in the same way. In 1996, the import content of exports already amounted to 28.5%. By 2000, it was already more than 37%, after which it rose slightly until 2005. In 2006, it again increased dramatically according to preliminary calculations (cf. Table 1).

Hidden behind the global observations of a rising import content of Germany's exports are the different developments of the two main components of exports, whose macroeconomic effects differ considerably and therefore have to be investigated and assessed separately. Exports consist of both products that are the result of the production and the value-added process in Germany and products that are imported for the purpose of being immediately re-exported and thus have very weak links to domestic production. Re-exports therefore represent a type of "item in transit". The direct export of previously

¹⁹ Cf. Webster (1993, p. 145).

imported goods is hereafter termed re-exports.²⁰ 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.

Table 1:
German exports and their import content from 1980 to 2006^a
- at current prices -

		1980	1985	1991	1996	2000	2005	2006
		in Euro						
[1]	Exports	188.7	283.3	374.1	453.3	670.6	900.5	1 031.2
[2]	Export goods produced domestically	181.1	268.0	347.5	404.4	576.6	760.0	863.9
[3]	Re-exports	7.6	15.3	26.6	48.9	94.0	140.5	167.2
[4]	Export-induced imports	47.0	76.0	99.9	129.3	251.1	358.2	435.0
[5]	Intermediate goods	39.4	60.7	73.3	80.4	157.1	217.7	267.8
[6]	Re-exports	7.6	15.3	26.6	48.9	94.0	140.5	167.2
		in %						
[7]	Import content of exports ([4]/[1])	24.9	26.8	26.7	28.5	37.4	39.8	42.2
[8]	Intermediate goods ([5]/[1])	20.9	21.4	19.6	17.7	23.4	24.2	26.0
[9]	Re-exports ([6]/[1])	4.0	5.4	7.1	10.8	14.0	15.6	16.2
[10]	<i>Memo item:</i> Import content of exports produced domestically ([5]/[2])	21.8	22.6	21.1	19.9	27.2	28.6	31.0

^a The figures for the years 1980 and 1985 refer to the Federal Republic of Germany before reunification.

Source: Federal Statistical Office of Germany: Input-Output Tables; authors' calculations.

The two components of export-induced imports – export-induced intermediate imports, on the one hand, and re-exports on the other – 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 (cf. Table 1, Row [8]) amounted to around 20% of the exports until the beginning of the 1990s. In the mid-nineties they came to just under 18%. Then they increased significantly until the end of the 1990s, to 23%, and remained at nearly the same level until 2005. The rate of re-exports (cf. Table 1, Row [9]) quadrupled from 4% in 1980 to 16% in 2006. The statistics for 2006 also signal a particularly strong rise in re-exports. They contributed significantly to the increase in the import content of all exports to 42%.

Germany's export sector is increasingly using imported intermediate inputs. These made up nearly 29% of the domestically produced export goods in 2005, although they

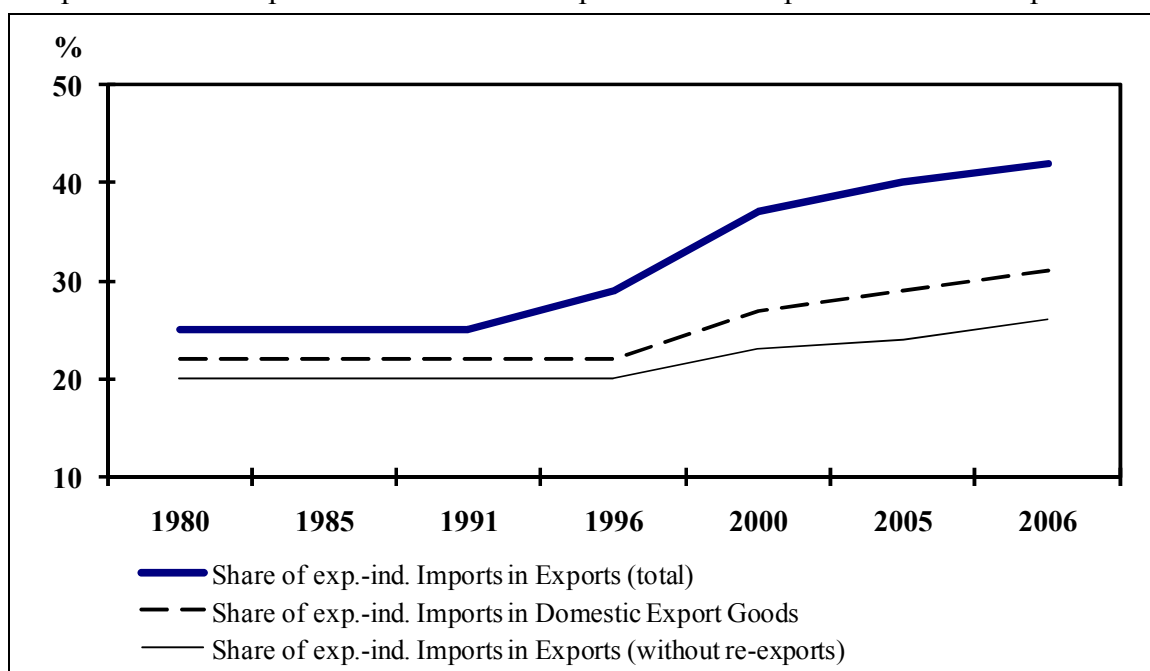
²⁰ Numerically speaking, goods in the "re-export" category correspond to the "export" column in the import table of the input-output statistics.

amounted to between 20% and 23% until the mid-1990s (cf. Table 1, Row [10]). The reference value here is only the value of the exported goods that were produced domestically. The re-exports are not taken into account, since they do not come into contact with the domestic production process. According to more recent calculations, the actual import content amounted to 31% in 2006 and lagged around 11 percentage points behind the import content of all exports.

Overall, it can be concluded that the dramatic increase in the import content of exports can be traced back to re-exports. In 2006, they amounted to one sixth of all German exports, quadrupling the share of the exports in 1980. The proportion of intermediate inputs induced by the production of export goods increased over the same period by only one fifth. In terms of the usual interpretation, re-exports are best described as an indication of a bazaar economy, because for the most part, they are only traded and not produced. The development of export-induced imports in German exports is summarized in the graph in Figure 1. The middle curve indicates the import content of domestically produced export goods. From 1980 to 2006, the import content measured in this way rose around 9 percentage points.

Figure 1:

Graph of the development of the share of export-induced imports in German exports



Sources: Federal Statistical Office of Germany: Input-Output Tables; authors' calculations.

4 The Effects of Exports and Export-induced Imports on Employment

A verdict on the growth of export-induced intermediate goods from a macroeconomic perspective cannot be given without looking at the bottom line. One cannot say that there is a negative development when, at the same time, the balance of the value-added and employment gains resulting from exports and the “losses” linked to the export-induced intermediate goods remains unchanged or even increases.²¹

The effects of exports or export-induced intermediate goods on value-added and employment appear in two phases.²² Initially, such effects are produced directly and indirectly by the production of export goods – hereafter referred to as the production phase. In addition to this, there are second round effects on the value added and employment through the circular flow of income (the use of income phase). People directly or indirectly employed in export production use part of their income to purchase goods; this further stimulates production and secures jobs. Conversely, moving production abroad or purchasing imported intermediate inputs either cuts down on jobs or makes new job creation superfluous. A curtailment in income then leads to a decline in the demand for goods and, with it, to a decline in domestic jobs.

4.1 Production Phase

4.1.1 The Model

A technique for determining the effects in the production phase is an input-output analysis, which can provide a certain orientation for the second-phase effects (the use of income phase).

The element-by-element multiplication²³ of the column vector of the exports \mathbf{x}^{ex} or the column vector of import content of exports \mathbf{im}^{ex} with a column vector \mathbf{b} , whose elements indicate the input of the labour force per one million Euros of gross production, produces the employment linked to exports or the “employment losses” induced by the export-induced imports:

$$\mathbf{l}^{\text{ex}} = \mathbf{x}^{\text{ex}} \cdot * \mathbf{b} \quad (3)$$

²¹ Because of the database available, it must be assumed with the present calculations that the individual goods are produced in Germany and by its trade partners using the same production functions (cf. *Ludwig, Brautzsch* (2008a,b)). This assumption gives the calculated employment losses resulting from export-induced imports a hypothetical nature, whereby the effects caused by the exports have *indeed* occurred and are observable.

²² The methodical approach is described in more detail in *Brautzsch, Ludwig* (2003).

²³ The symbol $\cdot *$ used in the equation stands for element-by-element multiplication, the so-called Hadamard product. Along the same lines, the symbol $\cdot /$ is used for element-by-element division.

$$\mathbf{l}^{\text{im}} = \mathbf{im}^{\text{ex}} \cdot \mathbf{b}. \quad (4)$$

Vector \mathbf{l}^{ex} indicates the macroeconomic employment effect initiated by the export of domestic products. Vector \mathbf{l}^{im} contains the (hypothetical) “employment losses” that are directly and indirectly induced by the intermediate inputs.

4.1.2 Findings

The effects of Germany’s export production on employment, the job “losses” caused by imported intermediate goods and the balance of both are shown in Table 2. Due to the growth of productivity, the employment “net gains” increased only by 68%, less than the export-induced output. Despite increased import penetration in production, the expansion of export production contributed significantly to the rise in macroeconomic employment.

Table 2:

Net effects induced by Germany’s exports on employment^a from 1980 to 2006: *Production stage*
- 1000 persons -

		1980	1985	1991	1996	2000	2006
[1]	Exports	5 251	5 729	7 006	6 310	7 650	9 139
[2]	Export-induced imports of intermediate goods	461	547	736	535	852	1 081
[3]	Balance ([1]-[2])	4 790	5 182	6 270	5 775	6 798	8 058

^a The figures for the years 1980 and 1985 refer to the Federal Republic of Germany before reunification.

Source: Federal Statistical Office of Germany: Input-Output Tables; authors’ calculations.

4.2 Use of Income Phase

4.2.1 The Model

Employment gains induced by the exports²⁴ lead to multiplying effects via the circular flow of income. The effects on production and employment resulting from the circular flow of income are very complex and can only be approximated using the open static input-output model. First, the income that is induced domestically through exports \mathbf{in}^{ex} is calculated:

$$\mathbf{in}^{\text{ex}} = \mathbf{w} \cdot \mathbf{l}^{\text{ex}}, \quad (5)$$

where \mathbf{w} is a vector whose elements indicate the *average* wage of the labour force.

²⁴ We here show only the procedure for calculating the income gains as a result of export activities. Employment losses as a result of export-induced imports are calculated along the same lines.

The proportion of “leakage” caused by taxes, savings, etc. in the expenditure of private households is described by means of the scalar k , which is exogenously calculated. The effect of private consumption y^{pc} is calculated as follows:

$$y^{pc} = (1 - k) * \mathbf{in}^{ex}. \quad (6)$$

It is presumed that the structure of additional private consumption y^{pc} corresponds to the average structure of household goods consumption on the whole. The total production growth x^{in} from the circular flow of income is calculated as follows:

$$\mathbf{x}^{in} = (\mathbf{I} - \mathbf{A}^d)^{-1} * \mathbf{y}^{pc}. \quad (7)$$

The “gains” to employment \mathbf{l}^{in} corresponding to \mathbf{x}^{in} arises from the element-by-element multiplication with the vector \mathbf{b} , whose elements indicate the labour input per one million Euros of gross production for each employment group:

$$\mathbf{l}^{in} = \mathbf{x}^{in} * \mathbf{b}. \quad (8)$$

4.2.2 Findings

The effects on employment that are additionally created via the circular flow of income are indicated in Table 3. Despite of productivity growth in the period from 1980 to 2006, the employment gains increased by 76%.

Table 3:

Net effects induced by Germany’s exports on employment^a from 1980 to 2006: *Use of Income*

- 1000 persons -

		1980	1985	1991	1996	2000	2006
[1]	Exports	1 263	1 405	2 044	1 798	2 184	2 376
[2]	Export-induced imports of intermediate goods	105	128	239	173	291	342
[3]	Balance ([1]-[2])	1 158	1 277	1 805	1 625	1 893	2 034

^a The figures for the years 1980 and 1985 refer to the Federal Republic of Germany before reunification.

Source: Federal Statistical Office of Germany : Input-Output Tables; authors’ calculations.

4.3 The Overall Effect

The effects stemming from both the production phase and the use of income phase result in the overall effect induced by export production (cf. Table 4). Employment induced by export production increased over the same period by around 70%. On the whole, bottom line employment gains from exports constitute around one fourth of macroeconomic employment.

Table 4:

Total net effects induced by Germany's exports on employment^a from 1980 to 2006
- 1000 persons -

		1980	1985	1991	1996	2000	2006
[1]	Production stage	4 790	5 182	6 270	5 775	6 798	8 058
[2]	Use of income	1 158	1 277	1 805	1 625	1 893	2 034
[3]	Total([1]+[2])	5 948	6 459	8 075	7 400	8 691	10 092
	<i>Memo item:</i> Share of the total as a percentage	22.6%	25.4%	21.0%	19.9%	22.2%	25.8%

^a The figures for the years 1980 and 1985 refer to the Federal Republic of Germany before reunification.

Source: Federal Statistical Office of Germany : Input-Output Tables; authors' calculations.

Table 5:

Net effects induced by Germany's exports on employment^a: annual rate of growth from 1980 to 2006
- in % -

	1985/ 1980	1991/ 1985	1996/ 1991	2000/ 1996	2006/ 2000	2006/ 1980	2006/ 1991
Net effects on employment	1.7	3.8	-1.7	4.1	2.5	2.1	1.5
<i>Memo item:</i> Total employment growth in the economy	-0.6	7.1	-0.6	1.2	0.0	1.5	0.1

^a The figures for the years 1980 and 1985 refer to the Federal Republic of Germany before reunification.

Source: Federal Statistical Office of Germany: Input-Output Tables; authors' calculations.

Seen over the entire time period, the balance of the effects of exports on employment rose considerably faster than the corresponding macroeconomic figures (cf. Table 5). However, this development was not uniform over all the time segments. The expansion of the market in the course of the German Unification resulted in a boom economy in 1991, as reflected in an above-average increase in production and employment in the time segment from 1985 to 1991. In the initial years after the German Reunification, the export-induced effects on employment also grew faster than the macroeconomic figures. This was caused by a redirection of part of the previous flow of foreign trade to the domestic market for the restructuring of the East German economy.

4.4 Structural Shifts

Between the years 1980 and 2006, there was a substantial shift within the sectors participating in export production (cf. Table 6). Starting from the Three-Sector-Hypothesis, the secondary and tertiary sectors of the economy profited on the whole from the employment growth induced by exports. Nevertheless, the secondary sector lost 20 points in the overall share of export-induced employment. Conversely, the tertiary sector's percentage of employment increased dramatically. The percentage gains were stronger

than the percentage losses for the secondary sector, since, on balance, the export production in the primary sector shrank considerably.

Table 6:

Net effects induced by Germany's exports on employment^a by three economic sectors^b in Germany^c from 1980 to 2006

	1980	1985	1991	1996	2000	2006
	Persons in employment					
Primary	340	438	478	277	241	186
Secondary	3 451	3 632	4 240	3 475	3 625	3 853
Tertiary	2 157	2 389	3 357	3 647	4 825	6 053
Total	5 948	6 459	8 075	7 399	8 691	10 092
	in %					
Primary	5.7	6.8	5.9	3.7	2.8	1.8
Secondary	58.0	56.2	52.5	47.0	41.7	38.2
Tertiary	36.3	37.0	41.6	49.3	55.5	60.0
Total	100.0	100.0	100.0	100.0	100.0	100.0

^a Effects on gross value added and employment caused by production stage, as well as by use of income.

^b The classification of goods into a primary, secondary and tertiary sector is explained in Section 2.

^c The figures for the years 1980 and 1985 refer to the Federal Republic of Germany before reunification.

^d At current prices.

Source: Federal Statistical Office of Germany : Input-Output Tables; authors' calculations.

5 The Skills Content of Exports and Export-induced Imports

5.1 The Model

The labour input necessary over all the production levels – differentiated according to skills level – is calculated by multiplying, element-by-element, the left side of the **Q** matrix with the matrix of the total domestic production:

$$\mathbf{E}^{\text{ex}} = \mathbf{Q} \cdot \mathbf{x}^{\text{ex}}. \quad (9)$$

The rows of the **Q** matrix contain the coefficients of the labour input according to skills level per output unit of a product group. The row totals indicate the overall labour input per output unit. The \mathbf{E}^{ex} matrix reveals the total labour input linked to exports according to skills level.

The output and employment abroad which are materialised in Germany's imports, are – as assumed – at the level of all domestic intermediate goods necessary for the production of these imported goods.

5.2 Findings

Table 7 (below) shows the total effects of exports and export-induced imports on employment, broken down by the three skills levels and by economic sector. There is a clear difference between the employment effects shown in Tables 7 and 5. Hence, income differentials earned by employees with different skills levels were taken into account. In Section 4.3, homogeneous compensation of labour is assumed.

Table 7:

Net employment effects of export induced output and imported intermediate goods^a by main economic sector and skills level^b in Germany in 1996 and 2006
- in 1000 persons -

	Skill level	1996			2006			Changes		
		Export-induced		Net effect	Export-induced		Net effect	Export-induced		Net effect
		out-put	im-ports		out-put	im-ports		out-put	im-ports	
		[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

^a Effects on employment caused by production stage as well as by use of income.

^b The classification of skills into a low, medium and high level as well as the classification of goods into primary, secondary and tertiary sectors is explained in Section 2.

Source: Federal Statistical Office of Germany Input-Output Tables; authors' calculations.

The data show that the production of export goods in 2006 absorbed less low-skilled labour in the primary and secondary sectors than in 1996. However, a considerably higher amount of low-skilled work was in demand in the tertiary sector. Conversely, the (hypothetical) domestic production of export-induced imports in all three sectors would necessitate an increase – however slight – of low-skilled workers. Considerably more medium-skilled workers were needed in 2006 for the production of export goods in all three production areas than ten years earlier, with overall growth in the tertiary sector being the highest. The same was true for highly-qualified work.

The structural changes in labour input according to skills levels, as seen in Table 7, are caused by two factors. One is the change in the scale of production for exports or the export-induced intermediate imports.²⁵ The other is due to the differences in the skill-intensity of the labour force by sector. The general changes in labour input per 1 million Euros output broken down by economic sector and skills level can be seen in Table 8.

Table 8:

Germany's labour input per 1 million Euro of output by main economic sector and skill level^a in 1996 and 2006

Sector	1996	2006	Changes	
			Persons	%
Low				
Primary	5.16	3.05	-2.11	-40.8
Secondary	1.89	0.97	-0.92	-48.8
Tertiary	3.12	2.44	-0.68	-21.8
Total	2.63	1.81	-0.82	-31.2
Medium				
Primary	10.36	9.69	-0.67	-6.5
Secondary	5.12	3.31	-1.82	-35.5
Tertiary	7.74	6.88	-0.86	-11.1
Total	6.67	5.37	-1.29	-19.4
High				
Primary	1.12	1.04	-0.07	-6.5
Secondary	0.76	0.52	-0.24	-31.7
Tertiary	2.66	2.45	-0.21	-7.9
Total	1.81	1.59	-0.22	-12.0
Total				
Primary	16.64	13.79	-2.85	-17.1
Secondary	7.77	4.79	-2.98	-38.3
Tertiary	13.51	11.76	-1.75	-13.0
Total	11.10	8.77	-2.33	-21.0

^a The classification of skills by low, medium and high level as well as the classification of goods by primary, secondary and tertiary sector is explained in Section 2.

Source: Federal Statistical Office of Germany : Input-Output Tables; authors' calculations.

²⁵ This includes the total production cost for the export production or export-induced immediate imports in the production phase and – via the circular flow of income – in the use of income phase.

The reduction in labour input necessary to produce one unit of output was strongest in the sector that achieved the highest increase in productivity, namely the secondary sector, and affected the labour input of all skills levels. In absolute terms, only the decline in input of low-skilled work in the primary sector was stronger. By contrast, in the service sector, these declines were limited. Above all, the employment of highly-qualified workers per unit of output sank relatively little.

Table 9:

Germany's net employment effects^a of export-induced production and imported intermediate goods per 1 million Euros of output^b, by three economic sectors and skill level^c in 1996 and 2006

– in number of persons –

	Skill level	1996			2006			Changes		
		Export-induced		Net-effect	Export-induced		Net-effect	Export-induced		Net-effect
		output	im-ports		output	im-ports		out-put	im-ports	
		[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]	Total ([4]+[8]+[12])	8.40	7.38	1.02	6.29	4.75	1.54	-2.11	-2.63	0.52
[14]	Low	2.08	1.92	0.16	1.34	1.04	0.30	-0.74	-0.88	0.14
[15]	Medium	5.27	4.62	0.65	3.97	3.01	0.96	-1.30	-1.61	0.31
[16]	High	1.05	0.84	0.21	0.98	0.70	0.28	-0.07	-0.14	0.07

^a Effects on employment caused by production stage as well as by use of income.

^b Unit of output for export-induced production vs. "hypothetical" import production.

^c The classification of skills into a low, medium and high level as well as the classification goods into primary, secondary and tertiary sector is explained in Section 2.

Source: Federal Statistical Office of Germany: Input-Output Tables; authors' calculations.

The balance of skills content in export production and export-induced intermediate imports per unit of output can be seen in Table 9. For the year 1996, as well as for 2006, it shows a positive net effect of both labour input and skills content in export production compared to that of induced intermediate inputs from abroad. In 1996, 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 skills categories. By contrast, the primary sector of the economy did not contribute to the overall tendency. The net effects were negative in all categories. Furthermore, the total net effect of export-induced production over intermediate imports on the skills input increased in the decade.

6 Conclusion

In the decade prior to the economic and financial crisis, Germany's export surpluses increased in total, as well as with regard to the growing import penetration of domestically produced export goods. The surplus in goods also caused a surplus of positive employment effects over negative employment effects. In sum, the growth of imported intermediate goods used in the production processes and strengthened by the rise in exports could not undermine the overall positive employment balance. This finding holds for all three groups of skilled labour. However, the net effect on employment increased only outside the primary sector, but covered all three categories of skills input. The reduction of medium and highly qualified labour in the primary sector was offset by an increase in the secondary and tertiary sectors. The decrease of low-skilled labour in the primary and secondary sector was outweighed by the rise in the tertiary sector. Per unit of output, Germany was found to be a net exporter of skilled labour, embodied in exported goods. This result is mainly caused by the direct and indirect inputs of medium- and highly-skilled labour in the tertiary sector of the economy and the improving balance in the secondary sector. Overall, the analysis of the production chain for Germany's export goods and its growing penetration by imported intermediaries shows that in total Germany is a net exporter of skilled labour too. Hence, this segment of the German economy is in line with the Heckscher-Ohlin world – thus the hypotheses stated at the start of this paper cannot be rejected.

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