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# ENERGY CONTENT IN MANUFACTURING EXPORTS: A CROSS-COUNTRY ANALYSIS

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# Energy content in manufacturing exports: A cross-country analysis*

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March 2010

**Abstract**

This paper compares the energy content in manufacturing exports in a set of 30 advanced and emerging economies and examines its evolution from 1995 to 2005. The paper combines information from the OECD input-output matrices and international trade data in 18 manufacturing sectors. Energy inputs are defined as those from sectors "coke, refined petroleum products and nuclear fuel" and "electricity, gas and water supply". In addition, the value of energy inputs that is required for the production of one unit of output in a given manufacturing sector is defined as the corresponding sector's coefficient in the inverse Leontief matrix. Finally, these coefficients are weighted according to sectors' shares in countries' total manufacturing exports. The resulting indicator for the energy content of manufacturing exports is compared across countries in periods where comparable input-output matrices exist. The paper also suggests a methodology to disentangle the effects attributable to the structure of manufacturing exports and sectoral energy efficiency, presenting results according to technological categories. The paper concludes that Brazil, India and, mostly, China, present a high energy content in manufacturing exports, which has increased from 1995 to 2005. Conversely, many advanced economies, notably in Europe and North America, which showed energy contents below the world average in 1995, reinforced their position as relatively low energy intensive economies. The contribution of trade specialization and energy efficiency effects to explain differences in the energy content of exports draws attention to the situation of China. This country increased its relative energy usage in the exports of all technological categories of goods. Nevertheless, this effect was reinforced by the stronger export specialization in high-tech products and a comparatively lower specialization in medium-high-tech products.

Keywords: Energy Efficiency, Exports, Advanced and Emerging Economies

JEL Codes: F10, F14, Q40

*The opinions expressed in this paper are those of the author and do not necessarily coincide with those of Banco de Portugal or the Eurosystem. All errors and omissions are the sole responsibility of the author. Address: Banco de Portugal, Research Department, R. Francisco Ribeiro 2, 1150-165 Lisboa - Portugal. E-mail: jamador@bportugal.pt

# 1 Introduction

Energy is an input in virtually all production processes. Therefore, exported goods incorporate energy in their production and its overall energy content depends on trade patterns and underlying energy efficiency in different sectors. These two elements are very difficult to disentangle because energy efficiency is one of several elements determining comparative advantage and, consequently, affecting the share of each sector in total exports. In addition, energy efficiency is heterogeneous across firms as it is affected by technological choices, location and relative energy prices. Although very complex in terms of its structural determinants, the analysis of the aggregate energy content of countries' manufacturing exports is a relevant topic of research, especially in a context of strong international trade competition and rising international energy prices. For example, the identification of the energy content in countries manufacturing exports is important to understand policies regarding access to primary energy sources and energy security. In addition, in the short-run, for countries exporting similar products, those with higher energy content are more affected by higher energy prices. On a different front, the energy content in manufacturing exports partially signals the adjustments imposed on different countries in the context of international climate change negotiations.

This paper compares the energy content in manufacturing exports in a set of 30 industrialized and developing economies and examines its evolution from 1995 to 2005. The set of economies considered represented in 2005 about 84 per cent of world GDP, 60 per cent of total world population and three quarters of total international trade. The paper combines information from the OECD input-output matrices and international trade data in 18 manufacturing sectors. The paper evolves along three steps. Firstly, energy inputs are defined as those from sectors "coke, refined petroleum products and nuclear fuel" and "electricity, gas and water supply". In addition, the value of energy inputs that is required for the production of one unit of output in a given manufacturing sector is defined as the corresponding sector's coefficient in the inverse Leontief matrix. Secondly, these coefficients are weighted according to sectors' shares in countries' total manufacturing exports. Subsequently, the resulting indicator for the energy content of manufacturing exports is compared across countries in periods where comparable input-output matrices exist. Thirdly, given this methodological approach, the effects of sectoral energy efficiency and international trade structure are disentangled.

Although the methodological approach adopted in the paper is simple, innovative comparable results for the energy content in manufacturing exports in a large set of countries are provided. The paper, combines two broad strands of literature. Firstly, literature on energy economics discusses the concept and measures of energy efficiency. For example, Gillingham et al. (2009) review economic concepts underlying energy efficiency, providing an economic perspective of the range of market barriers and failures in this area. In addition, a review of data sources and empirical measures of energy efficiency can be found in US-DOE (1995). As for cross-country and cross-sector results in energy intensity, important contributions are, for example, those of Baksia and Green (2007) and Eichhammer and Mannsbart (1997), which focus on the role of sectoral output and inter- and intra-industrial structural effects. In general, this strand of contributions relates with projections of greenhouse gas emissions, which are key elements in climate change analysis. More recently, Martínez (2010) studies energy efficiency in selected non-energy-intensive sectors using Data Envelopment Analysis techniques. The links between energy intensity and exports and convergence are studied by Havlik (1998) and Miketaa and Mulder (2005). Secondly, in a different strand of research, international trade literature analyzes the content of specific types of inputs in total exports using coefficients of the input-output matrices, i.e., taking a methodological approach similar to the one used in this paper. In particular, Hummels et al. (2001) suggested a methodology to evaluate of the import content of total exports, contributing to the literature on *vertical specialization*. This methodology was followed by other authors such as, for example, Breda et al. (2008).

The current paper is close to Fieleke (1974), who performs an analysis of the energy content of US exports and imports, basing in input-output data and linking with the current account impact of energy price changes. The differences to this paper are that the latter issue is not covered (only manufacturing exports are considered), the technical coefficients are defined in nominal terms and not in real units of energy and these inputs are not disaggregated by type of fuel. Although facing difficulties related with the usage of nominal technical energy coefficients and data incompleteness, the current paper offers a broad cross country perspective, contrasting advanced and emerging economies and decomposing results along four technological categories.

The paper is organized as follows. Section 2 describes the methodology used in the computation of the energy content in manufacturing exports and identifies energy efficiency and trade structure effects. In addition, the databases used are presented, highlighting existing difficulties and assumptions taken regarding missing values. Furthermore, this section compares energy efficiency coefficients in the 18 considered sectors in large advanced and developing economies - US, Japan, Germany, China, Brazil and India - comparing with the world average, interpreted as the set of 30 economies considered. Section 3 presents the results obtained for the energy content in manufacturing exports in all countries included in the sample. In addition, for the subset of large advanced and developing economies, the breakdown between sector energy efficiency and international trade structure effects is presented. For the remaining countries the breakdown is reported in appendix. Section 4 offers some concluding remarks.

## 2 Methodology and database

Like virtually all goods and services produced in the economy, exported manufactured goods require energy in their production. The energy content in manufacturing exports in sector $j$ (from now on referred as $EC_j$) can be defined as the value of energy goods used in the production of one unit of output times the nominal exports of manufacturing sector $j$, that is:

$$EC_j = \sum_{i=1}^{e} \left( \frac{E_{ij} X_j}{Y_j} \right) = \sum_{i=1}^{e} c_{ij}^{E} X_j \qquad (1)$$

where $E_{ij}$ is the total value of energy intermediates $i$ absorbed by sector $j$, $Y_j$ is the gross output of sector $j$, $X_j$ is the value of exports of manufacturing sector $j$, and $c_{ij}^{E}$ is the proportion of energy input $i$ used to produce output $Y_j$, for $i = 1, 2, \ldots, e$ (sectors corresponding to energy intermediates) and $j = 1, 2, \ldots, n$ (manufacturing sectors). Therefore, $EC_j$ measures the total amount of energy intermediate goods required to produce the exports of manufacturing sector $j$, i.e., the energy content of exports of sector $j$.

For country $k$ total energy consumption in exports is simply the sum of $EC_j$ across all sectors $j$:

$$EC^k = \sum_{j=1}^{n} EC_j^k = \sum_{j=1}^{n} \sum_{i=1}^{e} c_{ij}^{E,k} X_j^k \qquad (2)$$

It is suitable to calculate the $EC_k$ as a percentage of total manufacturing exports of the country. The $EC_k$ share of total manufacturing exports in country $k$ is given by:

$$\frac{EC^k}{X_T^k} = \frac{\sum_{j=1}^{n} EC_j^k}{\sum_{j=1}^{n} X_j^k} = \sum_{j=1}^{n} \left[ \left( \frac{EC_j^k}{X_j^k} \right) \left( \frac{X_j^k}{X_T^k} \right) \right] = \sum_{j=1}^{n} \sum_{i=1}^{e} c_{ij}^{E,k} \left( \frac{X_j^k}{X_T^k} \right) \qquad (3)$$

Equation (3) measures the value of energy inputs that are used *directly* in total manufacturing exports, i.e., the direct energy content of manufacturing exports. Nevertheless, the existence of an I-O matrix makes it possible to consider also the energy inputs used *indirectly* in exports. One intermediate energy good can be initially used as input of one domestic sector and the production of this latter sector used as an intermediate in a second domestic sector and so on, until the energy product is finally embodied in a good that is exported. Therefore, the original energy good may circulate in the domestic economy across several sectors before there is an export. Citing the example presented in OECD (2005), suppose that in the production of cars to export, a manufacturer uses certain energy goods (e.g., electricity). The direct energy contribution will be the ratio of the value of electricity used to the total value of the car. However, the car manufacturer purchases other components, who in turn use energy in their production process, which are also included in the car's final value. Thus, the energy inputs required for the production of a car include not only the direct energy usage, but also the energy that is used in the production of rounds of other inputs for cars. These indirect energy consumptions must be included in a measure of the energy content of manufacturing exports. This indirect effect can only be considered if an I-O matrix is used and it is captured by:

$$\frac{EC^k}{X_T^k} = \frac{u\left[I - A^E\right]^{-1} X^k}{X_T^k} \tag{4}$$

where $I$ is the identity matrix, $A^E$ is the $n \times n$ matrix of technical coefficients and $X_T^k = \sum_{j=1}^{n} X_j^k$ are total manufacturing exports of country $k$ and $u$ is a $1 \times n$ vector of zeros, except in sectors corresponding to energy intermediates where it assumes the value 1. $X^k$ is the $n \times 1$ vector of exports in country $k$. The term $\left[I - A^E\right]^{-1}$ can be written as the sum of a converging infinite geometric series with common ratio $A^E$, that is:

$$\left[I - A^E\right]^{-1} = \left[I + A^E + A^{E^2} + A^{E^3} + \cdots + A^{E^x}\right], \text{ when } x \to \infty.$$

Thus, the numerator of equation (4) measures total energy inputs, iterated over the economy's production structure, that are needed to produce the total manufacturing exports (see Dean et al. (2007) and Xikang (2007) for a discussion). Dividing this by the amount of total manufacturing exports of a country yields the total (direct and indirect) share of manufacturing exports attributable to energy inputs. Therefore, equation (4) is the measure elected to compute the importance of energy inputs in manufacturing exports.

One basic element of the methodology proposed is the utilization of Input-Output matrices to identify the value of the different intermediates used in the production of each sector, specifically the value of energy goods. The advantages of the utilization of I-O matrices are twofold. Firstly, the value of energy intermediates is properly accounted, in the sense that the I-O approach bases the classification on the use of the good and not on its characteristics. In fact, there energy products that can be either final or intermediate, thus strong arbitrariness is introduced when the classification is based on the product characteristics. Secondly, the I-O approach allows for a sectoral breakdown of the results. The drawback is that the I-O matrix does not differentiate the energy content of a good that is domestically consumed from that of a good that is exported. Therefore, the assumption that the energy content is similar in the two cases is necessary.

A very important methodological issue is the fact that the above mentioned inverse Leontief matrix coefficients are available only in nominal terms. Therefore, changing international energy prices affect the coefficients, limiting comparisons in different moments in time. A coefficient may increase either because there is more energy usage in the production of one unit of output (lower energy efficiency) or because energy prices increased. This problem can be minimized by presenting country results for different years in relative terms, i.e., relatively to the average of the countries in the sample, designated as the world average. The difference of the energy content in manufacturing exports relatively to the world average is defined as:

$$EC^k - \overline{EC} = \sum_{j=1}^{n} \left[ \left( \sum_{i=1}^{e} a_{ij}^k \right) \left( \frac{X_j^k}{X_T^k} \right) \right] - \frac{1}{P} \sum_{k=1}^{P} \sum_{j=1}^{n} \left[ \left( \sum_{i=1}^{e} a_{ij}^k \right) \left( \frac{X_{j^k}}{X_T^k} \right) \right] \tag{5}$$

where $P$ is the total number of countries considered in the sample and $a_{ij}^k$ is the coefficient in the inverse Leontief matrix in country $k$. The energy content in manufacturing exports in one country, and consequently its difference relatively to the world average, depends on two key dimensions: energy efficiency in each manufacturing sector and structure of manufacturing exports. Departing from equation 5, it is possible to breakdown the difference of the energy content in manufacturing exports relatively to the world average along a *energy efficiency effect*, a *trade structure effect* and a residual *combined structure effect*. Simple algebra shows that:

$$EC_k - \overline{EC} =$$

$$\sum_{j=1}^{n} \left\{ \underbrace{\left[ \left( \sum_{i=1}^{n} a_{ij}^{k} \right) \left( \frac{X_j^k}{X_T^k} - \frac{1}{P} \sum_{k=1}^{P} \frac{X_j^k}{X_T^k} \right) \right]}_{\text{Trade structure effect}} + \underbrace{\left[ \left( \sum_{i=1}^{e} a_{ij}^{k} \right) - \frac{1}{P} \sum_{k=1}^{P} \left( \sum_{i=1}^{e} a_{ij}^{k} \right) \right] \left( \frac{X_j^k}{X_T^k} \right)}_{\text{Energy efficiency effect}} \right.$$

$$- \underbrace{\left[ \frac{X_j^k}{X_T^k} - \frac{1}{P} \sum_{k=1}^{P} \frac{X_j^k}{X_T^k} \right] \left[ \left( \sum_{i=1}^{e} a_{ij}^{k} \right) - \frac{1}{P} \sum_{k=1}^{P} \left( \sum_{i=1}^{e} a_{ij}^{k} \right) \right]}_{\text{Combined structure effect}}$$

$$\left. - \underbrace{\frac{1}{P} \sum_{k=1}^{P} \left[ \left( \sum_{i=1}^{e} a_{ij}^{k} \right) - \frac{1}{P} \sum_{k=1}^{P} \left( \sum_{i=1}^{e} a_{ij}^{k} \right) \right] \left[ \frac{X_j^k}{X_T^k} - \frac{1}{P} \sum_{k=1}^{P} \frac{X_j^k}{X_T^k} \right]}_{\text{Combined structure effect}} \right\} \quad (6)$$

The first term in equation 6 reflects the contribution of differences in export structure, i.e., the product of the total domestic energy usage in each sector $j$ ($\sum_{i=1}^{e} a_{ij}^{k}$) times the difference in the sector's export share ($\frac{X_j^k}{X_T^k} - \frac{1}{P} \sum_{k=1}^{P} \frac{X_j^k}{X_T^k}$). Analogously, the second term reflects the contribution of differences in energy efficiency, i.e., the product of the domestic export share ($\frac{X_j^k}{X_T^k}$) times the difference in the sector's energy efficiency ($\sum_{i=1}^{e} a_{ij}^{k} - \frac{1}{P} \sum_{k=1}^{P} \left( \sum_{i=1}^{e} a_{ij}^{k} \right)$). The remaining two terms are common in this type of decomposition and reflect combined-structure effects.

The empirical literature on energy and environmental studies has devoted substantial attention to index decomposition analysis. Many articles discuss the breaking-down of the growth rate of total energy use in the economy considering sectoral energy coefficients, changes in sectoral structure and changes in overall economic activity. The literature presents competing methodologies and discusses their appropriateness to policy-analysis, presenting strong links with the index number theory.[1] Ang and Zhang (2000) presents a detailed survey of this literature and Ang (2004), Ang (2006) and Boyd and Roop (2004) offer additional contributions. Although there are links between these methodologies and the decomposition presented above, the scope and objectives are different. Firstly, we are not decomposing the growth rate of total energy consumption in manufacturing exports, but just the energy content in one moment in time. The I-O data is only sparsely available in time, thus a static approach is preferable. Secondly, our analysis is nominal and not real, i.e., it does not focus on real

[1] Methods of index decomposition analysis are typically divided into those linked to Divisia index and those linked to Laspeyres index, in both cases dividing further into multiplicative or additive decomposition (see Ang (2004)).

energy consumption measured in units like kilowatt-hour, tonnes of oil equivalent or thermal units.

The data used in this paper comes from two sources. Sectoral energy consumption coefficients are those of the OECD I-O matrices (2011 version), included in the STAN industrial analysis database. This database covers a large range of OECD member and non-member countries, focusing on three approximate time periods: mid-1990, early-2000 and mid-2000. We select 17 manufacturing sectors, excluding "coke, refined petroleum products and nuclear fuel".

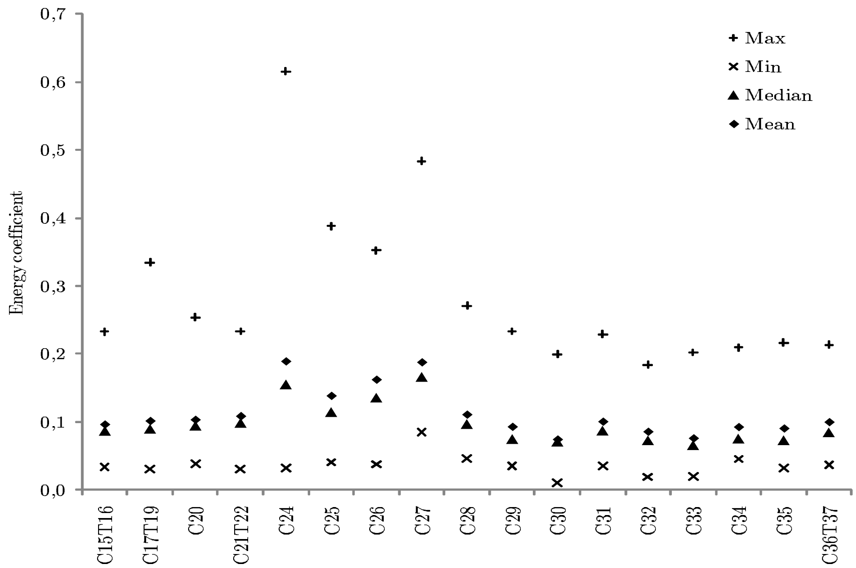
Beyond the previously referred nominal nature of I-O matrices' coefficients, other relevant limitations exist. The matrices are not available for all countries in the three approximate periods, thus we take the subset of countries where information exists in mid-1990 and mid-2000. In some cases the matrices report data at producer costs, while in the majority of cases data is referred at market prices. Nevertheless, the analysis is performed in terms of value of sectoral inputs required for one unit of output in each sector, meaning that the accounting method is neutral if the market price - producer cost margin is assumed similar in all sectors. In addition, for some countries in the sample, the inverse Leontief coefficient is not available for a small number of sectors. In this case, we take the country's sector information for any existing year and apply the change observed in the corresponding coefficient in the world average. In exceptional cases, when the sector's coefficient is not available in any year, we use the world average coefficient directly, which is a neutral hypothesis in terms of the results. Table 1 in appendix presents the list of sectors included and the four technological categories considered (high-tech, medium-high-tech, medium-low-tech and low-tech).[2] The list of countries considered and the sectors where missing data was replaced is presented in table 2.

The development of energy-efficiency indictors has always been limited by the availability of data, especially when undertaking cross-country comparisons. The configuration of technologies and sectors limits the possibility of obtaining comparable data as countries have their own surveys, timetables, definitions, etc. Even a simple indicator like energy consumption per GDP unit is difficult to use in cross-country comparisons because countries have different measurement procedures.

Another methodological issue concerns the information content of the technical inputs in I-O matrices. When compared across countries, these coefficients reflect energy efficiency but are also affected by the shares of specific types of products within each sector, especially when the sectoral classification is not very detailed. Therefore, a high

[2]This classification follows the OECD taxonomy based on manufacturing industries' technological intensity (see OECD (2007)).

Figure 1: Energy usage coefficients - inverse Leontief matrix - 2005



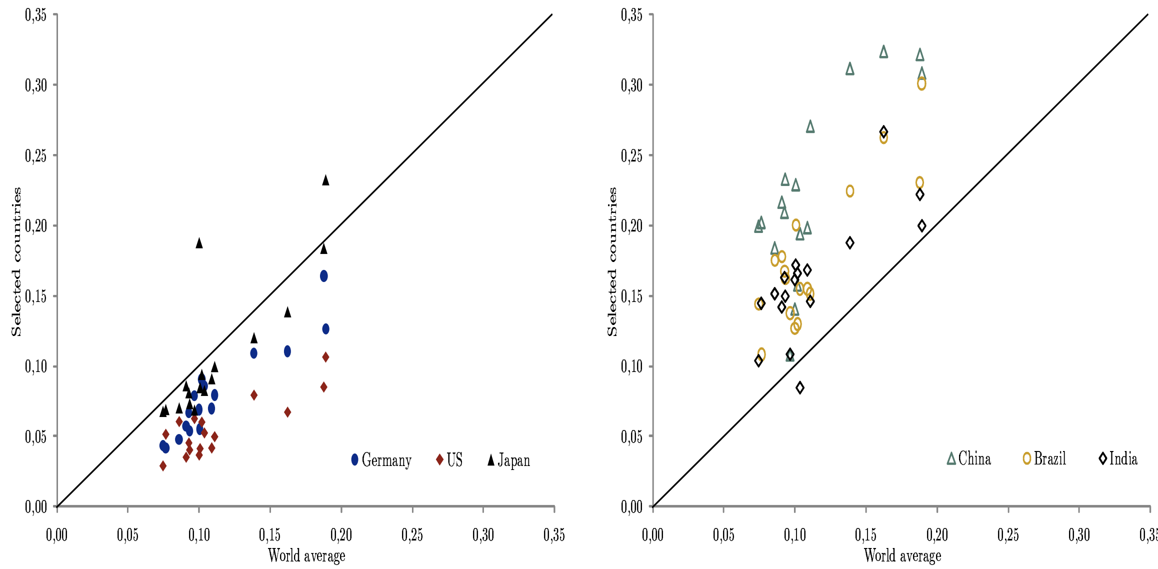

Note: Sectors are identified according to ISIC rev.3 codes (defined in Table 1 in appendix).
Sources: OECD-STAN, Input-Output databases.

energy coefficient may reflect both low efficiency and a higher share of energy-intensive products within the sector. Figure 1 presents information on the distribution of the coefficients corresponding to total energy inputs in different manufacturing sectors, i.e., the sum of technical coefficients of sectors "coke, refined petroleum products and nuclear fuel" and "electricity, gas and water supply" in the inverse Leontief matrix.

One main result emerges from this figure. The dispersion of energy coefficients amongst countries is smaller in the set of machinery and equipment sectors (C29 to C35) and higher in those sectors that are more related to the transformation of raw materials (C15, C16 and C24 to C27)). In particular the average and the maximum energy coefficients are higher in the sector "chemicals and chemical products", where some products use substantial quantities of refined petroleum products, notably in naphtha cracker plants.

Figure 2 compares the energy usage coefficients in a set of large emerging and advanced economies (Germany, Japan, US, China, Brasil and India) relatively to the world average in 2005. The difference between advanced and emerging economies is striking. The former economies present energy coefficients that are typically lower than the world average, with the US showing the highest energy efficiency, closely followed by Germany and, then, by Japan. As for the emerging economies, China presents the lowest energy efficiency in most sectors, followed by Brazil and then India. This overall picture confirms the perception that emerging economies are relatively more energy intensive.

Figure 2: Energy usage coefficients - Large advanced and emerging economies - 2005




(a) Large advanced economies

(b) Large emerging economies

Sources: OECD-STAN, Input-Output databases.

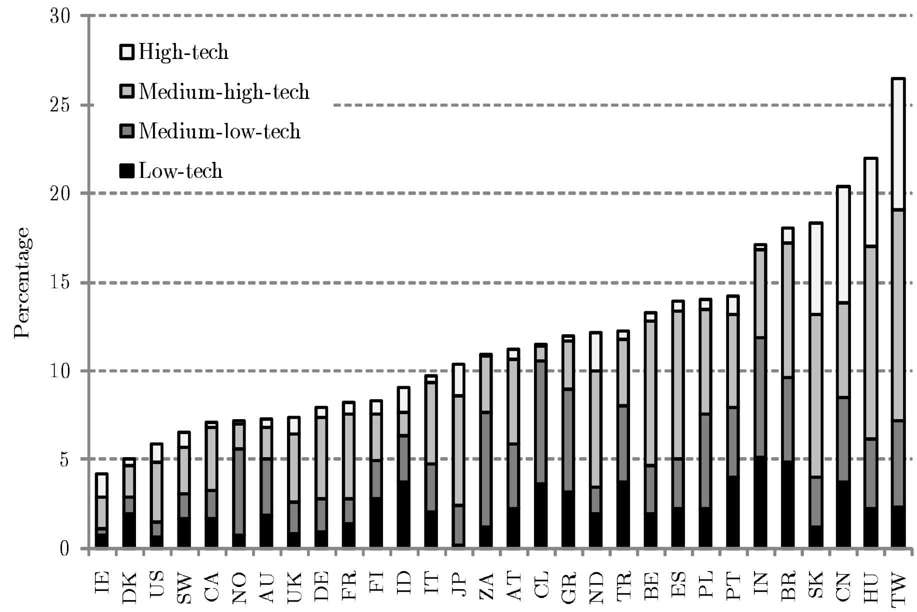
# 3 Energy content in manufacturing exports

## 3.1 Cross-country results

Following the definition of energy content in manufacturing exports presented in equation 4 we present the results obtained for 2005 in the set of 30 countries considered in the sample, breaking-down along four technological categories (figure 3). The range of values for the energy content in manufacturing exports is very large, ranging from about 4 per cent in Ireland to about 26 per cent in Taiwan. In this latter country, a large contribution is associated with the medium-low-tech category. In particular, the Taiwanese sector "chemicals and chemical products" accounted for 24 per cent of national manufacturing output in 2002 (Cheng et al. (2003)) and 14 per cent of (non-oil) manufacturing exports in 2005. In addition, Taiwan has a high share of oil-related chemical products in chemical's manufacturing, such as the referred naphtha cracker plants. Hungary, China and Slovakia also show high energy contents in manufacturing, distributed along the four technological categories. The significant role of high-tech products in these countries is driven by the high share of these products in manufacturing exports and high energy coefficients.

Brazil and India also show a high energy content in manufacturing exports and in the latter case the contribution of low-tech products is significant. Finally, in the remaining

Figure 3: Energy content in manufacturing exports - 2005



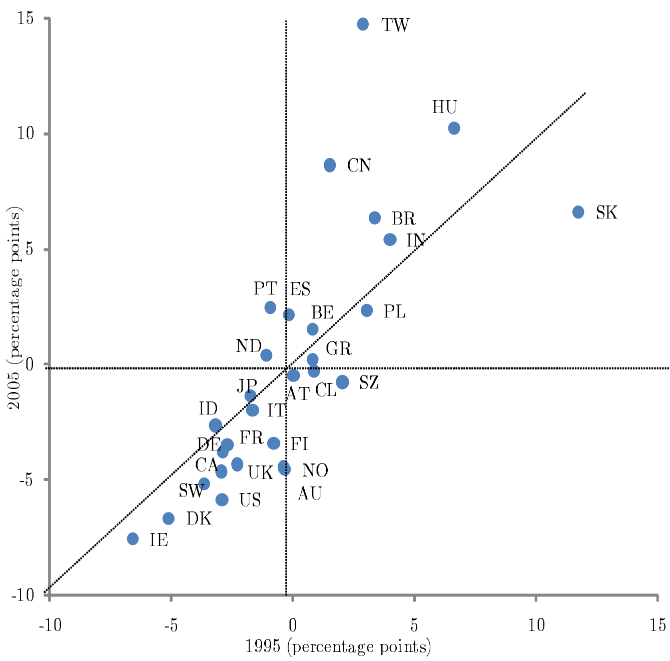

Sources: Author's calculations.

countries the contribution of medium-high-tech sectors is important, while the share of high-tech is very small.

As it was previously referred, the indicator of energy content in manufacturing exports is built in nominal terms, thus it is affected by fluctuations in energy prices and consequently cannot be compared in different years. Nevertheless, the indicator regains relevance if countries are compared with the world average in each period, i.e., assuming that changes in energy prices affect all countries simultaneously. It can be argued that some countries may intervene in energy markets distorting prices, thus affecting nominal energy usage coefficients. Although, there is certainly an impact coming from such market interventions, the final outcome in terms of energy usage is what is relevant for assessments regarding access to energy sources, energy security or short-term impacts of energy shocks on external competitiveness. Figure 4 compares the energy content in manufacturing exports, relatively to the world average, in 1995 and 2005 for the 30 countries in the sample.

The analysis of figure 4 reveals that the energy content of manufacturing exports in China, India and Brazil, as well as that of European countries like Hungary, Portugal, Spain, Belgium and the Netherlands recorded an increase from 1995 to 2005, relatively to the world average. Many advanced economies, notably in Europe and North America, which showed energy contents below the world average in 1995, reinforced their position as economies with relatively low energy content in manufacturing exports.

Figure 4: Differences of energy content in manufacturing exports relatively to world average 2005 and 1995



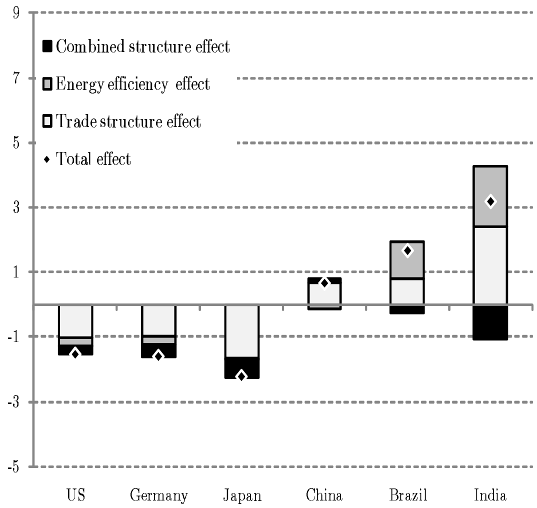

Sources: Author's calculations.

### 3.2 Trade structure and energy efficiency

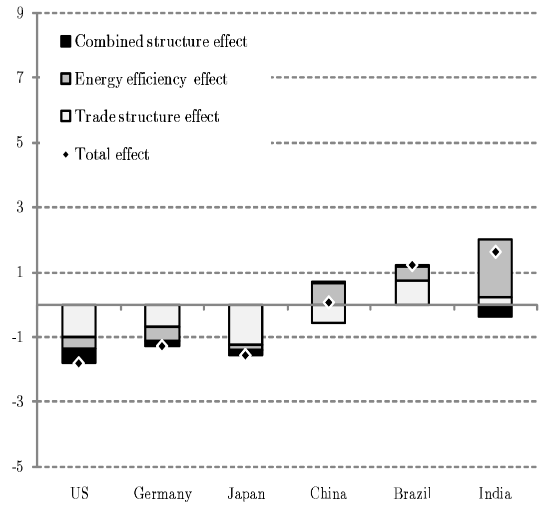
The paper refers that the energy content in manufacturing exports combines sectoral energy efficiency and international trade structure in a complex way. Nevertheless, equation 6 offers a possible breakdown of these effects, considering differences relatively to world average. Figures 5 and 6 present the results of the decomposition of energy efficiency and trade structure effects according to four technological categories in 1995 and 2005. Figures 5 and 6 refer to the set of large advanced economies (Germany, US and Japan) and large emerging economies (China Brazil and India), but the full set of decompositions is presented in table 4 in appendix.

In 1995 the set of advanced economies presents an energy content in low-tech industries that is lower than the world average. This is basically due to negative contributions from the efficiency and trade structure effects, i.e., these countries show relatively higher energy efficiency and a relatively lower share of these goods in their export pattern. The opposite situation is observed in the set of large emerging economies, especially India. As for the medium-low-tech sector, a similar pattern is observed, though differences relatively to the world average are lower in all economies considered, except the US. When the medium-high tech sector is observed, the contribution of the trade structure is positive in the advanced economies and negative in the emerging countries, while the contributions in terms of energy efficiency have the opposite signs. In other words,

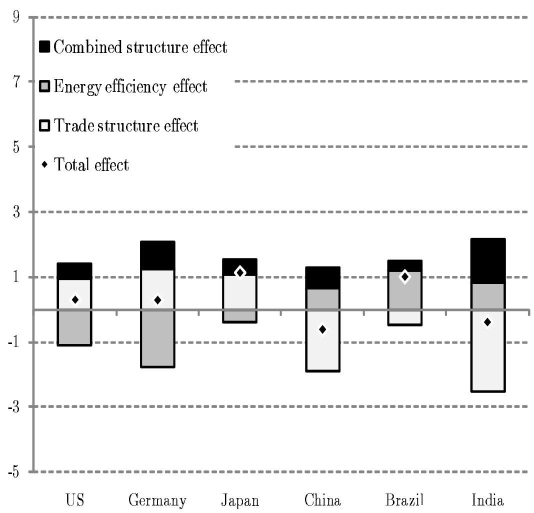
Figure 5: Contribution to difference to world average (1995)



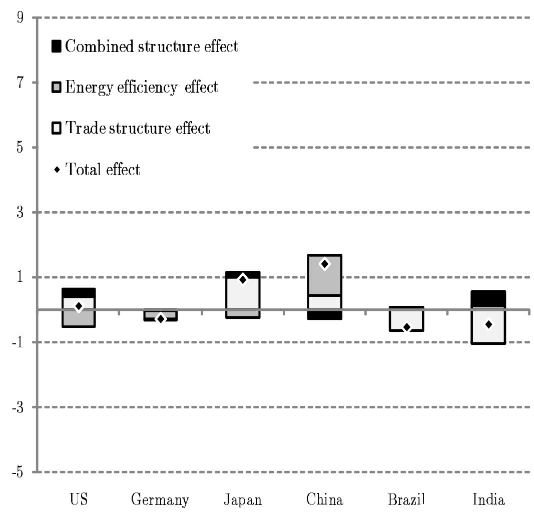

(a) Low-tech




(b) Medium-low-tech



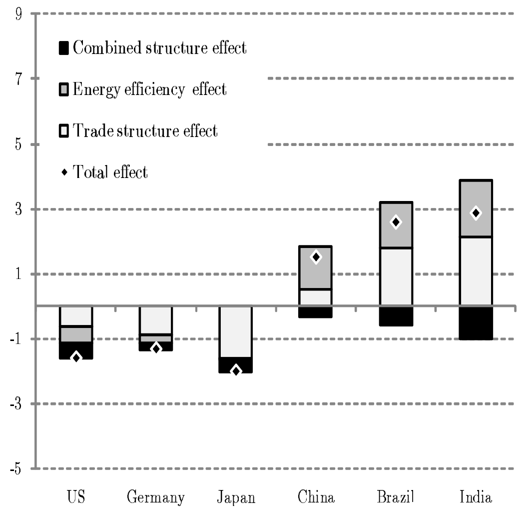

(c) Medium-high-tech



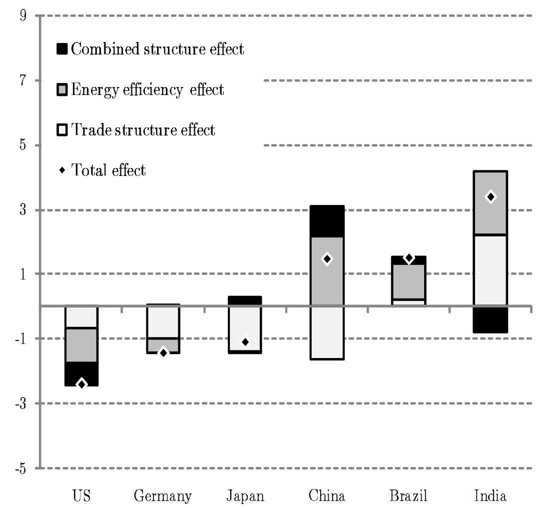

(d) High-tech

the advanced economies show higher energy efficiency in this category of exports (a negative contribution to differences against the world average) but an export pattern that is relatively more specialized in these goods. Finally, as for high-tech goods in 1995 the differences to the world average are relatively small. Nevertheless, China shows positive contributions from trade specialization and energy efficiency effects, making the energy content of its high-tech exports the highest against the world average, within

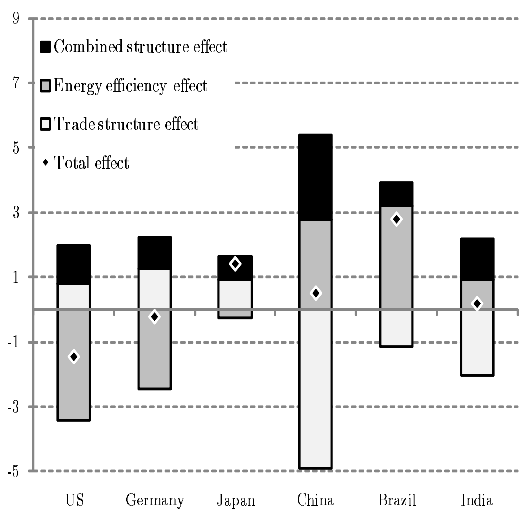
Figure 6: Contribution to difference to world average (2005)



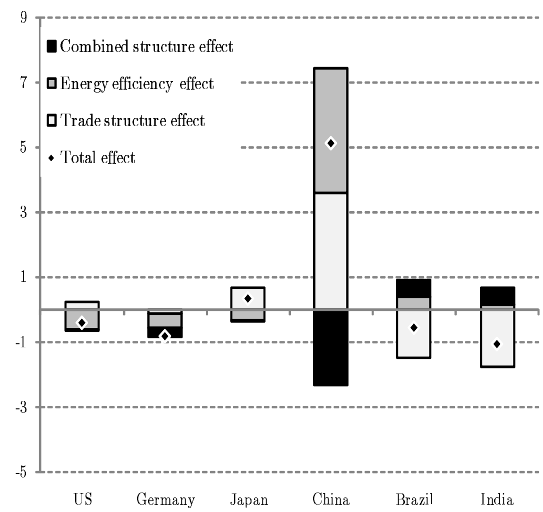

(a) Low-tech




(b) Medium-low-tech




(c) Medium-high-tech




(d) High-tech

the set of countries represented.

When the 2005 situation is observed in figure 6, significant differences emerge in some technological categories. In the low-tech sectors the contributions to differences in energy content relatively to the world average are relatively similar to the ones reported for 1995. When the medium-low-tech sector is studied the positive contributions coming from the efficiency effect are substantial in the emerging economies. This positive contribution is reinforced by the trade structure effect in India but counteracted in the case of China. That is, although China shows higher energy intensity in these sectors, its exports are relatively less important in medium-low-tech. In the medium-high-tech sector, from 1995 to 2005, the contribution of the trade structure effect became much more negative in China. Conversely, the relatively lower energy efficiency in China reflected into a larger positive contribution to the energy content of medium-high-tech exports. A similar result is obtained for Brazil, though with a smaller magnitude. China also stands out when the change in the contribution of the high-tech sector to the energy content of exports is analyzed. From 1995 to 2005 China increased its export specialization in high-tech goods relatively to the world average, though the energy requirements in the production of these goods also became relatively larger. The two effects led to an increase in the contribution of high-tech goods to total energy content of Chinese manufacturing exports.

## 4 Concluding remarks

This paper compares the energy content in manufacturing exports in a set of 30 advanced and emerging economies and examines its evolution from 1995 to 2005. In addition, a methodology to disentangle the effects attributable to the structure of manufacturing exports and sectoral energy efficiency is suggested.

The paper concludes that there are very important differences in energy content in manufacturing exports across countries. Brazil, India and, mostly, China, present energy efficiency coefficients that lie above the world average in most sectors, while in Japan, Germany and US the opposite situation is observed. Not surprisingly, the three developing countries mentioned show a high energy content in manufacturing exports. The analysis reveals that the energy content of manufacturing exports of China, India and Brazil, as well as that of European countries like Hungary, Portugal, Spain, Belgium and the Netherlands increased from 1995 to 2005, when compared with the world average. Many advanced economies, notably in Europe and North America, which showed energy contents below the world average in 1995, reinforced their position as relatively low energy intensive economies.

It is possible to decompose the difference between the energy content of manufacturing exports in countries and the world average along trade specialization and energy efficiency effects. In this context, from 1995 to 2005, emerging economies show larger deviations relatively to the world average, notably China. This country increased its relative energy usage in the exports of all technological categories of goods. Nevertheless, this effect was reinforced by the stronger export specialization in high-tech products and a comparatively lower specialization in medium-high-tech products.

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# 5 Appendices

Table 1: **Sector codes and technological categories**

| ISIC rev. 3 | Sector | Technological category |
|---|---|---|
| C15 and 16 | Food products, beverages and tobacco | Low-tech |
| C17 to 19 | Textiles, textile products, leather and footwear | Low-tech |
| C20 | Wood and products of wood and cork | Low-tech |
| C21 to 22 | Pulp, paper, paper products, printing and publishing | Low-tech |
| C23 | Coke, refined petroleum products and nuclear fuel | Not considered in article |
| C24 | Chemicals and chemical products | Medium-high-tech |
| C25 | Rubber and plastics products | Medium-low-tech |
| C26 | Other non-metallic mineral products | Medium-low-tech |
| C27 | Basic metals | Medium-low-tech |
| C28 | Fabricated metal products except machinery and equipment | Medium-low-tech |
| C29 | Machinery and equipment n.e.c | Medium-high-tech |
| C30 | Office, accounting and computing machinery | High-tech |
| C31 | Electrical machinery and apparatus n.e.c | Medium-high-tech |
| C32 | Radio, television and communication equipment | High-tech |
| C33 | Medical, precision and optical instruments | High-tech |
| C34 | Motor vehicles, trailers and semi-trailers | Medium-high-tech |
| C35 | Other transport equipment | Medium-high-tech |
| C36 and 37 | Manufacturing n.e.c; recycling | Medium-low-tech |

Note: Technological categories according to OECD(2007).

Table 2: **Country list and data availability**

| Country | Sector | Food and beverages | Textiles and footwear | Wood | Pulp and paper | Chemicals | Rubber and plastics | Non-metallic min. prod. | Basic metals | Fab. metal prod. | Mach. and equip. | Office and computing | Elect. mach. | Radio, tv and comm. | Medical and optical | Motor vehicles | Other transport equip. | Manuf. n.e.c |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ISIC rev.3 | C15-16 | C17to19 | C20 | C21-22 | C24 | C25 | C26 | C27 | C28 | C29 | C30 | C31 | C32 | C33 | C34 | C35 | C36-37 |
| US | 1995 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | 2000 | + | + | + | + | + | + | + | + | + | + | + | + | a | a | + | + | + |
| | 2005 | + | + | + | + | + | + | + | + | + | + | + | + | a | a | + | + | + |
| Canada | 1995 | + | + | + | + | + | + | + | + | + | + | + | + | a | a | + | + | + |
| | 2000 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | 2005 | + | + | + | + | + | + | + | + | + | + | + | + | + | a | + | + | + |
| France | 1995 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | 2000 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | 2005 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| Belgium | 1995 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | 2000 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | 2005 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| Germany | 1995 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | 2000 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | 2005 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| Italy | 1995 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | 2000 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | 2005 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| Netherlands | 1995 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | 2000 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | 2005 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| UK | 1995 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | 2000 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | 2005 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| Ireland | 1995 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | 2000 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | 2005 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| Denmark | 1995 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | 2000 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | 2005 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |

Note: + - Available data a - Updated with change observed in world average b - world average included

Table 2: **Country list and data availability (cont.)**

| Country | Sector | Food and bever-ages | Textiles and footwear | Wood | Pulp and paper | Chemicals | Rubber and plas-tics | Non-metallic min. prod. | Basic metals | Fab. metal prod. | Mach. and equip. | Office and com-puting | Elect. mach. | Radio, tv and comm. | Medical and opti-cal | Motor vehi-cles | Other trans-port equip. | Manuf. n.e.c |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ISIC rev.3 | C15-16 | C17to19 | C20 | C21-22 | C24 | C25 | C26 | C27 | C28 | C29 | C30 | C31 | C32 | C33 | C34 | C35 | C36-37 |
| Finland | 1995 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | 2000 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | 2005 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| Norway | 1995 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | 2000 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | 2005 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| Sweden | 1995 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | 2000 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | 2005 | + | + | + | + | + | + | + | + | + | + | + | + | a | + | + | + | + |
| Austria | 1995 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | 2000 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | 2005 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| Spain | 1995 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | 2000 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | 2005 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| Greece | 1995 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | 2000 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | 2005 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| Portugal | 1995 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | 2000 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | 2005 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| Turkey | 1995 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | 2000 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | 2005 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| Australia | 1995 | + | + | + | + | + | + | + | + | + | + | + | + | b | + | + | + | + |
| | 2000 | + | + | + | + | + | + | + | + | + | + | + | + | b | + | + | + | + |
| | 2005 | + | + | + | + | + | + | + | + | + | + | + | + | b | + | + | + | + |
| Japan | 1995 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | 2000 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | 2005 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |

Note: + - Available data  a - Updated with change observed in world average  b - world average included

Table 2: **Country list and data availability (cont.)**

| Country | Sector | Food and beverages | Textiles and footwear | Wood | Pulp and paper | Chemicals | Rubber and plastics | Non-metallic min. prod. | Basic metals | Fab. metal prod. | Mach. and equip. | Office and computing | Elect. mach. | Radio, tv and comm. | Medical and optical | Motor vehicles | Other transport equip. | Manuf. n.e.c |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ISIC rev.3 | C15-16 | C17to19 | C20 | C21-22 | C24 | C25 | C26 | C27 | C28 | C29 | C30 | C31 | C32 | C33 | C34 | C35 | C36-37 |
| South Africa | 1995 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | 2000 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | 2005 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| Brazil | 1995 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | 2000 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | 2005 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| Chile | 1995 | + | + | + | + | + | + | + | + | + | + | b | + | b | b | + | b | + |
| | 2000 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | 2005 | + | + | + | + | + | + | + | + | + | + | b | + | b | b | + | **b** | + |
| Indonesia | 1995 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | 2000 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | 2005 | + | + | + | + | + | + | + | + | + | + | a | + | + | + | + | + | + |
| India | 1995 | + | + | + | + | + | + | + | + | + | + | + | + | + | a | + | + | + |
| | 2000 | + | + | + | + | + | + | + | + | + | + | + | + | + | a | + | + | + |
| | 2005 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | a |
| Slovakia | 1995 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | 2000 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | 2005 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| Taiwan | 1995 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | 2000 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | 2005 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| Hungary | 1995 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | 2000 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | 2005 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| Poland | 1995 | + | + | + | + | + | + | + | + | + | + | + | a | a | a | + | a | + |
| | 2000 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | 2005 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| China | 1995 | + | + | + | + | + | + | + | + | + | + | a | + | a | + | + | + | + |
| | 2000 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | 2005 | + | + | + | + | + | + | a | + | + | + | + | + | a | + | + | a | + |

Note: + - Available data   a - Updated with change observed in world average   b - world average included

Table 3: **Detailed country results - energy content of manuf. exports**

| **Country** | **Year** | **Low-tech** | **Medium-low-tech** | **Medium-high-tech** | **High-tech** | **Total** | **Difference to average** |
|---|---|---|---|---|---|---|---|
| US | 1995 | 0.87 | 1.04 | 3.22 | 0.80 | 5.93 | -2.93 |
| | 2000 | 0.55 | 0.60 | 2.03 | 1.18 | 4.35 | -5.15 |
| | 2005 | 0.62 | 0.92 | 3.34 | 0.99 | 5.87 | -5.87 |
| Canada | 1995 | 1.70 | 1.60 | 2.39 | 0.24 | 5.92 | -2.94 |
| | 2000 | 1.44 | 1.11 | 2.10 | 0.32 | 4.98 | -4.53 |
| | 2005 | 1.71 | 1.53 | 3.58 | 0.27 | 7.09 | -4.64 |
| France | 1995 | 1.24 | 1.52 | 3.02 | 0.38 | 6.16 | -2.70 |
| | 2000 | 1.16 | 1.30 | 3.60 | 0.64 | 6.70 | -2.81 |
| | 2005 | 1.39 | 1.42 | 4.79 | 0.63 | 8.24 | -3.50 |
| Belgium | 1995 | 1.83 | 3.25 | 4.33 | 0.28 | 9.69 | 0.82 |
| | 2000 | 2.40 | 3.32 | 6.59 | 0.62 | 12.92 | 3.42 |
| | 2005 | 1.94 | 2.77 | 8.10 | 0.44 | 13.26 | 1.52 |
| Germany | 1995 | 0.80 | 1.57 | 3.20 | 0.40 | 5.98 | -2.89 |
| | 2000 | 0.73 | 1.36 | 3.68 | 0.50 | 6.26 | -3.25 |
| | 2005 | 0.90 | 1.89 | 4.57 | 0.58 | 7.93 | -3.80 |
| Italy | 1995 | 1.72 | 2.02 | 3.08 | 0.37 | 7.19 | -1.68 |
| | 2000 | 1.94 | 2.22 | 3.75 | 0.41 | 8.32 | -1.19 |
| | 2005 | 2.05 | 2.73 | 4.59 | 0.39 | 9.75 | -1.98 |
| Netherlands | 1995 | 1.97 | 1.16 | 3.85 | 0.78 | 7.76 | -1.11 |
| | 2000 | 1.67 | 1.03 | 4.31 | 1.49 | 8.49 | -1.01 |
| | 2005 | 1.99 | 1.48 | 6.55 | 2.10 | 12.12 | 0.38 |
| UK | 1995 | 0.95 | 1.42 | 3.22 | 0.98 | 6.56 | -2.30 |
| | 2000 | 0.78 | 1.21 | 3.50 | 1.25 | 6.74 | -2.76 |
| | 2005 | 0.80 | 1.81 | 3.86 | 0.95 | 7.41 | -4.33 |
| Ireland | 1995 | 0.79 | 0.29 | 0.67 | 0.51 | 2.26 | -6.60 |
| | 2000 | 0.37 | 0.16 | 0.76 | 0.73 | 2.02 | -7.49 |
| | 2005 | 0.71 | 0.36 | 1.85 | 1.23 | 4.16 | -7.58 |
| Denmark | 1995 | 1.62 | 0.72 | 1.17 | 0.22 | 3.73 | -5.14 |
| | 2000 | 1.73 | 0.76 | 1.39 | 0.35 | 4.23 | -5.28 |
| | 2005 | 1.99 | 0.93 | 1.74 | 0.40 | 5.07 | -6.67 |
| Finland | 1995 | 3.90 | 1.60 | 1.90 | 0.65 | 8.06 | -0.81 |
| | 2000 | 2.83 | 1.39 | 2.06 | 1.00 | 7.28 | -2.23 |
| | 2005 | 2.76 | 2.16 | 2.61 | 0.77 | 8.31 | -3.42 |
| Norway | 1995 | 1.53 | 4.07 | 2.56 | 0.37 | 8.53 | -0.34 |
| | 2000 | 1.61 | 4.32 | 3.02 | 0.42 | 9.38 | -0.13 |
| | 2005 | 0.78 | 4.83 | 1.39 | 0.16 | 7.16 | -4.57 |
| Sweden | 1995 | 1.47 | 1.24 | 1.99 | 0.51 | 5.23 | -3.64 |
| | 2000 | 1.05 | 1.15 | 1.97 | 0.82 | 4.99 | -4.52 |
| | 2005 | 1.64 | 1.48 | 2.61 | 0.82 | 6.55 | -5.18 |
| Austria | 1995 | 1.75 | 3.07 | 3.71 | 0.36 | 8.88 | 0.02 |
| | 2000 | 1.53 | 2.21 | 2.77 | 0.43 | 6.94 | -2.57 |
| | 2005 | 2.24 | 3.66 | 4.78 | 0.57 | 11.25 | -0.48 |
| Spain | 1995 | 1.55 | 2.17 | 4.61 | 0.36 | 8.70 | -0.16 |
| | 2000 | 1.86 | 2.37 | 6.66 | 0.52 | 11.41 | 1.90 |
| | 2005 | 2.23 | 2.84 | 8.29 | 0.54 | 13.90 | 2.17 |
| Greece | 1995 | 3.84 | 4.32 | 1.40 | 0.12 | 9.68 | 0.81 |
| | 2000 | 3.53 | 3.39 | 2.00 | 0.42 | 9.33 | -0.18 |
| | 2005 | 3.14 | 5.85 | 2.68 | 0.25 | 11.93 | 0.19 |

Table 3: **Detailed country results - energy content of manuf. exports (cont.)**

| Country | Year | Low-tech | Medium-low-tech | Medium-high-tech | High-tech | Total | Difference to average |
|---|---|---|---|---|---|---|---|
| Portugal | 1995 | 4.04 | 1.32 | 2.20 | 0.37 | 7.92 | -0.94 |
| | 2000 | 3.01 | 1.67 | 2.65 | 0.46 | 7.79 | -1.71 |
| | 2005 | 4.02 | 3.90 | 5.26 | 1.02 | 14.20 | 2.47 |
| Turkey | 1995 | 5.48 | 3.49 | 1.63 | 0.05 | 10.65 | 1.79 |
| | 2000 | 4.30 | 3.30 | 2.17 | 0.16 | 9.92 | 0.42 |
| | 2005 | 3.72 | 4.33 | 3.70 | 0.46 | 12.22 | 0.48 |
| Japan | 1995 | 0.18 | 1.29 | 4.05 | 1.61 | 7.13 | -1.74 |
| | 2000 | 0.15 | 1.12 | 3.87 | 1.63 | 6.77 | -2.74 |
| | 2005 | 0.21 | 2.23 | 6.18 | 1.74 | 10.37 | -1.37 |
| Australia | 1995 | 2.05 | 4.86 | 1.24 | 0.34 | 8.48 | -0.38 |
| | 2000 | 1.89 | 4.59 | 1.44 | 0.49 | 8.41 | -1.10 |
| | 2005 | 1.84 | 3.18 | 1.81 | 0.44 | 7.27 | -4.47 |
| South Africa | 1995 | 1.39 | 7.46 | 1.96 | 0.09 | 10.90 | 2.03 |
| | 2000 | 1.31 | 7.06 | 2.84 | 0.16 | 11.37 | 1.86 |
| | 2005 | 1.23 | 6.43 | 3.17 | 0.14 | 10.97 | -0.77 |
| Brazil | 1995 | 4.08 | 4.07 | 3.92 | 0.15 | 12.23 | 3.36 |
| | 2000 | 4.89 | 4.28 | 6.09 | 0.53 | 15.80 | 6.29 |
| | 2005 | 4.83 | 4.84 | 7.55 | 0.84 | 18.07 | 6.34 |
| Chile | 1995 | 3.44 | 5.69 | 0.59 | 0.02 | 9.74 | 0.87 |
| | 2000 | | | | | | |
| | 2005 | 3.60 | 6.98 | 0.86 | 0.02 | 11.46 | -0.28 |
| Indonesia | 1995 | 3.10 | 1.43 | 0.62 | 0.51 | 5.66 | -3.20 |
| | 2000 | 3.81 | 1.69 | 0.89 | 1.46 | 7.84 | -1.67 |
| | 2005 | 3.70 | 2.68 | 1.26 | 1.46 | 9.10 | -2.63 |
| India | 1995 | 5.60 | 4.48 | 2.52 | 0.24 | 12.85 | 3.98 |
| | 2000 | 7.10 | 5.36 | 3.40 | 0.33 | 16.19 | 6.69 |
| | 2005 | 5.11 | 6.73 | 4.96 | 0.34 | 17.14 | 5.41 |
| Slovakia | 1995 | 3.45 | 4.90 | 8.04 | 4.24 | 20.62 | 11.76 |
| | 2000 | 2.02 | 2.96 | 7.12 | 4.42 | 16.52 | 7.01 |
| | 2005 | 1.17 | 2.85 | 9.18 | 5.13 | 18.33 | 6.60 |
| Taiwan | 1995 | 2.47 | 2.70 | 3.68 | 2.89 | 11.73 | 2.87 |
| | 2000 | 2.30 | 2.75 | 4.84 | 4.98 | 14.87 | 5.37 |
| | 2005 | 2.33 | 4.84 | 11.93 | 7.39 | 26.48 | 14.75 |
| Hungary | 1995 | 3.36 | 4.88 | 6.66 | 0.61 | 15.51 | 6.64 |
| | 2000 | 1.77 | 2.43 | 7.03 | 3.22 | 14.45 | 4.94 |
| | 2005 | 2.22 | 3.93 | 10.91 | 4.94 | 22.00 | 10.26 |
| Poland | 1995 | 3.19 | 4.55 | 3.71 | 0.44 | 11.90 | 3.04 |
| | 2000 | 2.56 | 4.33 | 4.31 | 0.67 | 11.87 | 2.36 |
| | 2005 | 2.27 | 5.26 | 5.91 | 0.62 | 14.06 | 2.33 |
| China | 1995 | 3.07 | 2.92 | 2.29 | 2.10 | 10.39 | 1.52 |
| | 2000 | 4.32 | 5.69 | 5.40 | 4.16 | 19.57 | 10.06 |
| | 2005 | 3.75 | 4.80 | 5.29 | 6.53 | 20.37 | 8.63 |
| **World Average** | 1995 | 2.41 | 2.84 | 2.91 | 0.70 | 8.87 | 0.00 |
| | 2000 | 2.23 | 2.59 | 3.52 | 1.16 | 9.51 | 0.00 |
| | 2005 | 2.23 | 3.32 | 4.78 | 1.41 | 11.73 | 0.00 |

Table 4: **Contributions to difference to world average**

| Country | Year | Low-tech Trade structure effect | Low-tech Energy efficiency effect | Low-tech Comb. structure effect | Medium-low-tech Trade structure effect | Medium-low-tech Energy efficiency effect | Medium-low-tech Comb. structure effect | Medium-high-tech Trade structure effect | Medium-high-tech Energy efficiency effect | Medium-high-tech Comb. structure effect | High-tech Trade structure effect | High-tech Energy efficiency effect | High-tech Comb. structure effect | Sum |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| US | 1995 | -1.02 | -0.27 | -0.25 | -1.01 | -0.37 | -0.42 | 0.93 | -1.10 | 0.47 | 0.39 | -0.54 | 0.25 | -2.93 |
| | 2000 | -0.61 | -0.46 | -0.61 | -0.44 | -0.82 | -0.74 | 0.40 | -2.86 | 0.97 | 0.44 | -0.59 | 0.17 | -5.15 |
| | 2005 | -0.63 | -0.53 | -0.45 | -0.68 | -1.05 | -0.68 | 0.78 | -3.43 | 1.21 | 0.23 | -0.58 | -0.05 | -5.87 |
| Canada | 1995 | 0.10 | -0.32 | -0.50 | -0.41 | -0.62 | -0.21 | 0.49 | -1.50 | 0.48 | -0.02 | -0.28 | -0.15 | -2.94 |
| | 2000 | 0.13 | -0.43 | -0.49 | -0.27 | -0.94 | -0.27 | 0.23 | -2.30 | 0.65 | -0.16 | -0.47 | -0.21 | -4.53 |
| | 2005 | 0.23 | -0.57 | -0.17 | -0.18 | -1.57 | -0.05 | 0.21 | -2.01 | 0.61 | -0.30 | -0.32 | -0.52 | -4.64 |
| France | 1995 | -0.49 | -0.36 | -0.32 | -0.62 | -0.52 | -0.18 | 0.94 | -1.38 | 0.55 | -0.02 | -0.27 | -0.03 | -2.70 |
| | 2000 | -0.39 | -0.32 | -0.36 | -0.51 | -0.54 | -0.25 | 1.01 | -1.75 | 0.82 | -0.13 | -0.34 | -0.06 | -2.81 |
| | 2005 | -0.29 | -0.37 | -0.17 | -0.69 | -0.91 | -0.30 | 1.30 | -2.15 | 0.86 | -0.32 | -0.22 | -0.23 | -3.50 |
| Belgium | 1995 | -0.80 | 0.22 | -0.01 | 0.20 | 0.26 | -0.05 | 1.40 | -0.10 | 0.12 | -0.22 | -0.08 | -0.12 | 0.82 |
| | 2000 | -0.64 | 0.75 | 0.06 | 0.38 | 0.53 | -0.18 | 2.22 | 1.03 | -0.18 | -0.61 | 0.05 | 0.02 | 3.42 |
| | 2005 | -0.52 | 0.20 | 0.02 | -0.34 | -0.32 | 0.10 | 3.35 | -0.12 | 0.11 | -0.58 | -0.09 | -0.30 | 1.52 |
| Germany | 1995 | -1.00 | -0.25 | -0.36 | -0.68 | -0.46 | -0.13 | 1.24 | -1.79 | 0.84 | -0.04 | -0.25 | 0.00 | -2.89 |
| | 2000 | -0.85 | -0.27 | -0.39 | -0.47 | -0.57 | -0.19 | 1.20 | -2.05 | 1.01 | -0.14 | -0.42 | -0.11 | -3.25 |
| | 2005 | -0.89 | -0.25 | -0.20 | -0.96 | -0.48 | 0.01 | 1.26 | -2.44 | 0.97 | -0.11 | -0.46 | -0.26 | -3.80 |
| Italy | 1995 | -0.34 | -0.20 | -0.16 | -0.12 | -0.48 | -0.21 | 0.45 | -0.47 | 0.18 | -0.26 | -0.04 | -0.03 | -1.68 |
| | 2000 | -0.06 | -0.11 | -0.12 | 0.05 | -0.32 | -0.10 | 0.45 | -0.59 | 0.37 | -0.63 | -0.06 | -0.06 | -1.19 |
| | 2005 | 0.02 | -0.24 | 0.04 | -0.16 | -0.56 | 0.12 | 0.40 | -0.92 | 0.33 | -0.63 | -0.09 | -0.29 | -1.98 |
| Netherlands | 1995 | -0.01 | -0.13 | -0.31 | -0.66 | -0.58 | -0.44 | 1.21 | 0.01 | -0.28 | 0.26 | -0.24 | 0.06 | -1.11 |
| | 2000 | -0.09 | -0.17 | -0.30 | -0.76 | -0.39 | -0.42 | 0.70 | 0.19 | -0.11 | 0.65 | -0.57 | 0.24 | -1.01 |
| | 2005 | -0.01 | -0.08 | -0.15 | -1.14 | -0.45 | -0.26 | 1.16 | 0.97 | -0.36 | 1.01 | -0.17 | -0.15 | 0.38 |
| UK | 1995 | -0.85 | -0.27 | -0.35 | -0.84 | -0.35 | -0.22 | 0.88 | -0.92 | 0.34 | 0.45 | -0.30 | 0.13 | -2.30 |
| | 2000 | -0.76 | -0.27 | -0.41 | -0.86 | -0.28 | -0.23 | 0.83 | -1.56 | 0.71 | 0.41 | -0.46 | 0.13 | -2.76 |
| | 2005 | -0.57 | -0.51 | -0.35 | -1.05 | -0.46 | 0.00 | 0.77 | -2.61 | 0.92 | 0.27 | -0.80 | 0.07 | -4.33 |
| Ireland | 1995 | -0.06 | -1.48 | -0.09 | -1.26 | -0.33 | -0.95 | -0.17 | -2.56 | 0.49 | 0.32 | -1.35 | 0.85 | -6.60 |
| | 2000 | -0.29 | -0.86 | -0.69 | -1.08 | -0.21 | -1.14 | -0.30 | -5.33 | 2.87 | 0.39 | -1.89 | 1.06 | -7.49 |
| | 2005 | -0.54 | -0.51 | -0.47 | -3.16 | -0.03 | 0.23 | -0.39 | -7.72 | 5.19 | 0.55 | -1.24 | 0.51 | -7.58 |
| Denmark | 1995 | 0.43 | -0.99 | -0.24 | -0.44 | -0.97 | -0.70 | 0.04 | -2.07 | 0.29 | -0.05 | -0.36 | -0.07 | -5.14 |
| | 2000 | 0.60 | -0.94 | -0.16 | -0.33 | -0.94 | -0.56 | -0.03 | -2.61 | 0.50 | -0.10 | -0.58 | -0.14 | -5.28 |
| | 2005 | 0.67 | -0.91 | 0.00 | -0.66 | -1.12 | -0.62 | 0.00 | -3.75 | 0.72 | -0.07 | -0.68 | -0.26 | -6.67 |
| Finland | 1995 | 1.78 | 0.68 | -0.97 | -0.70 | -0.34 | -0.19 | -0.40 | -0.60 | -0.01 | 0.13 | -0.21 | 0.03 | -0.81 |
| | 2000 | 1.02 | 0.10 | -0.52 | -0.59 | -0.35 | -0.26 | -1.02 | -0.64 | 0.19 | 0.13 | -0.84 | 0.54 | -2.23 |
| | 2005 | 0.91 | 0.10 | -0.47 | -0.34 | -0.82 | 0.00 | -1.11 | -1.14 | 0.09 | 0.36 | -1.31 | 0.32 | -3.42 |
| Norway | 1995 | -0.26 | -0.46 | -0.17 | 1.52 | -0.33 | 0.04 | -0.33 | -0.24 | 0.21 | -0.19 | -0.09 | -0.04 | -0.34 |
| | 2000 | 0.08 | -0.45 | -0.25 | 2.03 | -0.14 | -0.16 | -0.63 | -0.33 | 0.45 | -0.36 | -0.21 | -0.17 | -0.13 |
| | 2005 | 0.00 | -1.27 | -0.18 | 2.42 | -1.08 | 0.16 | -0.34 | -2.99 | -0.06 | -0.12 | -0.51 | -0.61 | -4.57 |
| Sweden | 1995 | -0.21 | -0.41 | -0.32 | -0.37 | -0.94 | -0.28 | 0.25 | -1.55 | 0.38 | 0.13 | -0.41 | 0.10 | -3.64 |
| | 2000 | -0.26 | -0.40 | -0.52 | -0.21 | -1.01 | -0.22 | 0.16 | -2.24 | 0.53 | 0.25 | -0.75 | 0.16 | -4.52 |
| | 2005 | 0.11 | -0.38 | -0.31 | -0.43 | -1.27 | -0.15 | 0.25 | -2.91 | 0.50 | 0.10 | -0.52 | -0.16 | -5.18 |
| Austria | 1995 | -0.45 | -0.08 | -0.14 | 0.14 | 0.03 | 0.06 | 0.16 | 0.17 | 0.46 | -0.21 | -0.08 | -0.05 | 0.02 |
| | 2000 | -0.13 | -0.37 | -0.19 | 0.18 | -0.59 | 0.04 | 0.09 | -1.37 | 0.52 | -0.31 | -0.23 | -0.19 | -2.57 |
| | 2005 | 0.04 | 0.10 | -0.13 | -0.31 | 0.27 | 0.38 | -0.08 | -0.48 | 0.57 | -0.44 | -0.13 | -0.26 | -0.48 |
| Spain | 1995 | -0.71 | -0.01 | -0.14 | -0.31 | -0.19 | -0.17 | 1.54 | 0.21 | -0.05 | -0.33 | 0.00 | -0.01 | -0.16 |
| | 2000 | -0.42 | 0.16 | -0.11 | -0.09 | 0.06 | -0.19 | 1.61 | 1.54 | -0.02 | -0.84 | 0.08 | 0.12 | 1.90 |
| | 2005 | -0.21 | 0.21 | -0.01 | -0.51 | 0.01 | 0.02 | 1.88 | 1.78 | -0.15 | -0.93 | 0.09 | -0.02 | 2.17 |

Table 4: **Contributions to difference to world average (cont.)**

| | **Tech.** | **Low-tech** | | | **Medium-low-tech** | | | **Medium-high-tech** | | | **High-tech** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Country** | **Year** | **Trade structure effect** | **Energy efficiency effect** | **Comb. structure effect** | **Trade structure effect** | **Energy efficiency effect** | **Comb. structure effect** | **Trade structure effect** | **Energy efficiency effect** | **Comb. structure effect** | **Trade structure effect** | **Energy efficiency effect** | **Comb. structure effect** | **Sum** |
| Greece | 1995 | 1.63 | -0.34 | 0.14 | 0.60 | 1.19 | -0.30 | -1.56 | -0.09 | 0.13 | -0.56 | 0.01 | -0.03 | 0.81 |
| | 2000 | 1.69 | -0.34 | -0.05 | 0.72 | 0.16 | -0.08 | -2.07 | -0.63 | 1.17 | -0.73 | -0.01 | 0.00 | -0.18 |
| | 2005 | 1.29 | -0.70 | 0.32 | 1.21 | 1.52 | -0.20 | -0.78 | -1.79 | 0.48 | -0.62 | -0.11 | -0.43 | 0.19 |
| Portugal | 1995 | 1.57 | 0.18 | -0.13 | -1.10 | -0.03 | -0.38 | -0.69 | -0.17 | 0.14 | -0.16 | -0.06 | -0.10 | -0.94 |
| | 2000 | 1.27 | -0.57 | 0.09 | -0.56 | -0.05 | -0.31 | -0.65 | -0.55 | 0.32 | -0.41 | -0.11 | -0.19 | -1.71 |
| | 2005 | 1.49 | 0.51 | -0.21 | -0.34 | 0.98 | -0.06 | -1.39 | 1.22 | 0.65 | -0.48 | 0.19 | -0.09 | 2.47 |
| Turkey | 1995 | 2.79 | 1.12 | -0.84 | 0.02 | 0.67 | -0.04 | -1.45 | 0.04 | 0.13 | -0.36 | -0.04 | -0.24 | 1.79 |
| | 2000 | 2.24 | 0.12 | -0.29 | 0.34 | 0.47 | -0.10 | -1.46 | -0.10 | 0.20 | -0.51 | -0.14 | -0.36 | 0.42 |
| | 2005 | 1.56 | -0.03 | -0.04 | 0.47 | 0.37 | 0.17 | -0.87 | 0.38 | -0.59 | -0.77 | 0.02 | -0.20 | 0.48 |
| Japan | 1995 | -1.67 | -0.04 | -0.53 | -1.25 | -0.14 | -0.16 | 1.07 | -0.39 | 0.45 | 1.01 | -0.23 | 0.13 | -1.74 |
| | 2000 | -1.21 | -0.07 | -0.80 | -0.90 | -0.30 | -0.28 | 0.70 | -1.15 | 0.80 | 0.74 | -0.49 | 0.21 | -2.74 |
| | 2005 | -1.59 | -0.03 | -0.40 | -1.39 | 0.00 | 0.30 | 0.93 | -0.25 | 0.73 | 0.69 | -0.30 | -0.05 | -1.37 |
| Australia | 1995 | 0.30 | -0.36 | -0.30 | 2.69 | -1.33 | 0.66 | -0.97 | -0.45 | -0.25 | -0.38 | 0.03 | -0.01 | -0.38 |
| | 2000 | 0.48 | -0.60 | -0.21 | 2.70 | -1.03 | 0.33 | -0.92 | -0.97 | -0.19 | -0.71 | -0.06 | 0.09 | -1.10 |
| | 2005 | 0.59 | -1.18 | 0.20 | 1.42 | -3.45 | 1.89 | -1.05 | -1.40 | -0.51 | -0.69 | -0.09 | -0.19 | -4.47 |
| South Africa | 1995 | -0.66 | -0.16 | -0.20 | 4.93 | -0.61 | 0.30 | -0.93 | -0.08 | 0.06 | -0.46 | -0.02 | -0.13 | 2.03 |
| | 2000 | -0.56 | -0.13 | -0.23 | 4.78 | -0.99 | 0.69 | -1.08 | 0.09 | 0.30 | -1.07 | 0.01 | 0.06 | 1.86 |
| | 2005 | -0.55 | -0.29 | -0.16 | 3.95 | -3.01 | 2.17 | -1.23 | -0.49 | 0.11 | -0.82 | -0.04 | -0.40 | -0.77 |
| Brazil | 1995 | 0.81 | 1.13 | -0.27 | 0.75 | 0.42 | 0.07 | -0.49 | 1.21 | 0.29 | -0.63 | 0.02 | 0.06 | 3.36 |
| | 2000 | 1.39 | 2.04 | -0.77 | 0.48 | 1.28 | -0.07 | -0.40 | 2.46 | 0.51 | -0.91 | 0.10 | 0.18 | 6.29 |
| | 2005 | 1.79 | 1.39 | -0.59 | 0.22 | 1.13 | 0.17 | -1.15 | 3.22 | 0.70 | -1.48 | 0.42 | 0.51 | 6.34 |
| Chile | 1995 | 1.06 | 0.36 | -0.39 | 3.35 | -1.75 | 1.25 | -1.91 | -0.33 | -0.08 | -0.62 | 0.00 | -0.06 | 0.87 |
| | 2000 | | | | | | | | | | | | | |
| | 2005 | 1.56 | 0.01 | -0.20 | 4.43 | -2.79 | 2.02 | -2.06 | -0.95 | -0.91 | -1.20 | 0.00 | -0.18 | -0.28 |
| Indonesia | 1995 | 1.42 | -1.11 | 0.38 | -0.56 | -0.75 | -0.10 | -0.97 | -0.61 | -0.71 | -0.18 | -0.08 | 0.07 | -3.20 |
| | 2000 | 1.85 | 0.05 | -0.31 | -0.32 | -0.47 | -0.11 | -0.76 | -1.15 | -0.73 | 0.14 | 0.16 | -0.01 | -1.67 |
| | 2005 | 1.75 | -0.26 | -0.02 | -0.03 | -0.77 | 0.16 | -1.24 | -1.46 | -0.81 | 0.16 | -0.01 | -0.09 | -2.63 |
| India | 1995 | 2.39 | 1.87 | -1.07 | 0.21 | 1.80 | -0.37 | -2.55 | 0.82 | 1.34 | -1.04 | 0.11 | 0.47 | 3.98 |
| | 2000 | 3.69 | 3.37 | -2.19 | 1.71 | 2.20 | -1.13 | -2.97 | 0.76 | 2.08 | -1.91 | 0.16 | 0.92 | 6.69 |
| | 2005 | 2.13 | 1.75 | -1.01 | 2.21 | 1.98 | -0.79 | -2.01 | 0.92 | 1.27 | -1.75 | 0.15 | 0.54 | 5.41 |
| Slovakia | 1995 | -1.98 | 1.98 | 1.03 | -2.49 | 3.02 | 1.54 | 0.20 | 4.99 | -0.06 | 2.58 | 2.48 | -1.52 | 11.76 |
| | 2000 | -1.79 | 0.80 | 0.79 | -1.57 | 1.30 | 0.64 | -0.73 | 3.64 | 0.68 | 2.39 | 1.85 | -0.99 | 7.01 |
| | 2005 | -2.86 | 0.47 | 1.33 | -1.97 | 0.77 | 0.73 | -0.08 | 4.01 | 0.49 | 3.08 | 2.15 | -1.50 | 6.60 |
| Taiwan | 1995 | -1.13 | 1.04 | 0.15 | -0.81 | 0.73 | -0.06 | -0.63 | 1.20 | 0.20 | 1.83 | 1.00 | -0.65 | 2.87 |
| | 2000 | -1.47 | 1.23 | 0.31 | -0.67 | 0.83 | 0.00 | -1.97 | 2.23 | 1.06 | 3.06 | 1.96 | -1.21 | 5.37 |
| | 2005 | -2.69 | 1.53 | 1.27 | -1.36 | 2.25 | 0.62 | -0.90 | 7.54 | 0.50 | 4.76 | 3.93 | -2.71 | 14.75 |
| Hungary | 1995 | -0.27 | 1.25 | -0.02 | -0.96 | 2.49 | 0.52 | 1.27 | 2.80 | -0.32 | -0.37 | 0.17 | 0.10 | 6.64 |
| | 2000 | -1.34 | 0.60 | 0.28 | -2.09 | 1.05 | 0.88 | 0.14 | 2.79 | 0.57 | 1.41 | 1.22 | -0.58 | 4.94 |
| | 2005 | -2.40 | 1.16 | 1.23 | -4.49 | 2.24 | 2.86 | -1.82 | 6.11 | 1.84 | 2.76 | 2.07 | -1.30 | 10.26 |
| Poland | 1995 | 0.20 | 0.80 | -0.22 | 1.42 | 0.51 | -0.21 | -0.44 | 0.99 | 0.24 | -1.08 | 0.26 | 0.56 | 3.04 |
| | 2000 | 0.11 | 0.42 | -0.19 | 1.21 | 0.83 | -0.31 | -0.10 | 0.62 | 0.27 | -1.22 | 0.33 | 0.39 | 2.36 |
| | 2005 | -0.10 | 0.17 | -0.04 | 0.28 | 1.25 | 0.41 | 0.05 | 1.00 | 0.08 | -0.95 | 0.15 | 0.02 | 2.33 |
| China | 1995 | 0.69 | -0.15 | 0.13 | -0.57 | 0.64 | 0.01 | -1.89 | 0.64 | 0.63 | 0.44 | 1.23 | -0.27 | 1.52 |
| | 2000 | 0.75 | 1.54 | -0.20 | -0.71 | 3.42 | 0.39 | -4.11 | 3.35 | 2.63 | 1.06 | 2.61 | -0.67 | 10.06 |
| | 2005 | 0.52 | 1.31 | -0.32 | -1.61 | 2.17 | 0.92 | -4.87 | 2.80 | 2.59 | 3.61 | 3.82 | -2.31 | 8.63 |

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