Derived classifications for industrial performance indicators

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1. Introduction

UNIDO maintains an international industrial statistical database which contains the most detailed business structure data covering a large number of countries. Primary data are collected through annual industrial surveys or periodic censuses by the national statistical offices and then provided to UNIDO in order to update its database and disseminate the data internationally at the 4-digit level of ISIC. There are generally two types of users of this data. Researchers from knowledge institutions want detailed data which they can use in advanced statistical analysis. It is no coincidence that the INDSTAT4 database, which presents principle indicators of industrial statistics at the most detailed level, has the largest number of users. The second type of users, especially government organizations and policymakers, are interested in more aggregated summary data reflecting different trends and patterns of industrial development. These users prefer fewer figures around which they can build a long story with some concrete recommendations for government organizations or business associations on suitable approaches to development policy or business decisions.

Such demands pose a challenge to statisticians. It requires them to synthesize large amounts of base data into a few important indicators. One of the methods that has been quite useful in this regard is to derive a classification at a more aggregated level. The standard industrial classification, such as ISIC (revision 3), comprises 151 sectors and sub-sector categories at the 4-digit level. From such a detailed classification, a new grouping of industrial activities can be derived based on predefined criteria, and can carry a meaningful taxonomy for data interpretation. This paper presents a number of such classifications currently being used in UNIDO analyses of policy-relevant topics. While classifications based on the stage of processing and technological intensity have been used for many years and are briefly described in this paper for reference purposes, a new classification has recently been developed by UNIDO Statistics based on the intensity of energy use in the manufacturing industry.

2. Economic analysis of industrial data for policy issues

Economists have placed considerable emphasis on the structural transformation of production and trade in the process of industrialization. Chenery (1975, 1986), Sherman (1986) and Syrquin (1975, 1986) focused on universal factors attributed to structural change in the process of economic growth. More recently, it has been shown that industrial sectors do not equally contribute to overall growth, especially in terms of labour productivity (Penedar, 2002). Therefore, a shift of manufacturing activity to more productive sectors has given structural change a certain degree of dynamism. This also had a huge impact on the structure of manufactured exports, which contribute to technological growth and the modernization of the industrial production of develo ping countries (Lall, 2000). UNIDO's Industrial Development Report (IDR), which has been one of the most important analytical reports for policy-relevant topics of industrialization in developing countries, has also noted the role of product sophistication and diversity in structural change (UNIDO, 2009).

Statistical indicators of structural change measure how the relative importance of one kind of industrial activity has changed with respect to others. These measures are very important for policy relevant analysis as they suggest where to shift the priority and make an appropriate reallocation of resources from one kind of manufacturing activities to another. Recent international recommendations for industrial statistics have considered structural change as one of the major indicators of industrial performance. The implementation guidance of the International Recommendation for Industrial Statistics (United Nations, 2008), Industrial Statistics: Guidelines and Methodology (UNIDO 2010) and related publications of the OECD, Eurostat and other international and supranational organizations present a range of statistical methods to measure sector shifts by various performance indicators.

On account of the availability of detailed data, researchers can choose at what level to carry out their analysis. However, policymakers may find predefined indicators more convenient, because such indicators can be easily computed and immediately used in computer applications. Secondly, they are good for measuring change over time, which serves as a monitoring tool. Below we define some methods for presenting different indicators of industrial performance by predefined taxonomies.

3. Classification and derivation process

The main purpose for developing the different classifications described here is to observe and measure the extent of structural transformation that takes place in the process of industrialization. While structural change can be analyzed using sophisticated statistical techniques, this paper dwells upon such basic measures as mean, ratio and proportion of the variable under study that can be used by policymakers to monitor the pattern of structural change within the suggested framework of derived classifications. The classifications currently being used by UNIDO are described below.

3.1 Resource-based industry

This taxonomy is based on Keith Pavitt's categorization of *supplier dominated firms* (Pavitt, 1984). He argues that such firms only make a minor contribution to thei r process or product technology as the majority of innovations come from supplie rs of equipment and materials. It includes more traditional sectors of manufacturin g such as food, textile, wood products, etc. The classification was built on survey data on innovation collected from UK firms. Later, Sanjay Lall used the term *resource-based* manufacture (Lall, 2000), which also included petroleum, rubber products and non-metallic mineral products. More recently, basic metal industry has been included in this category.

The main attribute of resource-based industry is that its performance is more dependent on the local availability of natural resources than on competitive advantage. Resource-based sectors account for significant shares of manufacturing output in countries with huge mineral resources such as Russia and South Africa as well as those with a sufficient amount of agricultural supplies, e.g., raw materials for processing. The share of resource-based industries in these countries has actually increased in the last decade (see Figure 1). Among the BRICS countries, only China has experienced a falling share of resource-based sectors in recent years. Production activities in these sectors are normally labour intensive with limited possibilities of technological endowment, with some exception for petroleum refineries and basic metals. There is a significant difference in the performance of industries in terms of labour productivity between resource-based and other sectors. Even an industrialized country like Republic of Korea has witnessed much lower levels of productivity in resource-based sectors compared to others. The difference for a developing economy like India is more obvious (Figure 2).

3.2 Agro-industrial sectors

The category of agro-industrial sectors is used to measure the dependence of manufacturing activity on the processing of agricultural products. As a result of the supply-based conceptual framework underlying the *International Standard Industrial Classification* (UN, 2008), the delineation of agro-industrial sectors from ISIC is fairly straightforward. Therefore, the aggregation of manufacturing activity into the category of agro-industrial sectors is done using ISIC. A compilation of statistics for this category requires the underlying data to be available at least at the 3-digit level of ISIC (rev 3). For example, at the 2-digit level of ISIC, the manufacture of rubber products, which is an agro-based (forestry) industry, is combined with the manufacture of plastic products.

The share of agro-industrial sectors in the total value of manufacturing for any major variables such as employment, production or trade indicate the extent of dependence on or departure from the traditional sectors. Most of the agro-industrial sectors, albeit not all, are also resource-based. Therefore, agro-industrial sectors contain low levels of technological innovation. As industrialization advances towards diversification and technology-intensive activities, the share of agro-industrial sectors decreases.

Manufacturing in the majority of developing countries is relatively dependent on agricultural supplies. Agro-industrial sectors account for around 15 per cent of value added in industrialized countries, however, their share in developing countries is much higher. In the least developed countries (LDCs), processing of agricultural supplies dominates the entire manufacturing sector. Agro-industrial sectors accounted for 2/3 of the manufacturing output of LDCs in 2009 (see Figure 3).

3.3 Technological intensity

The classification of manufacturing sectors by technological intensity received wide recognition in the 1990s, although initial efforts to develop such a classification in the United States date back to sometime in the 1930s. The recent classification was developed by the OECD and is based on the ratio of research and development (R&D) expenditure to industrial output. The manufacturing sectors were ranked by the coefficients of technological intensity derived from such ratios as R&D/Output and R&D/Value Added. The existing classification is based on the ISIC rev 3. Sanjay Lall used the same classification for the export performance analysis of developing countries in combination with resource-based sectors described earlier in this paper.

For a precise tabulation based on the OECD classification, the data has to be available at the 4-digit level of ISIC. For practical reasons, this classification has been slightly modified by UNIDO. The OECD classification has four taxonomies, namely high technology, medium-high technology, medium low technology and low technology. UNIDO's version combines the medium-high and high technology (MHT) sectors into one. Similarly, UNIDO includes Building and repairing of ships and boats (ISIC 351) in the medium-high technology sector group, which is included in the medium-low technology group in the OECD classification. These changes allow UNIDO to compile the relevant statistical tables from the ISIC 2-digit data, thereby expanding the analysis to many developing countries for which detailed data is not readily available.

3.4 Classification by energy intensity

This classification is relatively new and has not received wider recognition or application like other classifications. Energy intensity is measured as the relation of the quantity of energy used per unit of output. Energy intensity drops when production increases per unit of energy used, or when less energy is used for the same amount of production. In both cases, energy intensity is in inverse relation to energy efficiency. This relation serves as the basis for developing energy intensity-based classification. The main objective of this classification is to group those industrial sectors that are relatively similar (it may not be appropriate to say *homogenous*) in terms of energy intensity. Such classification would allow countries with limited data on energy consumption to monitor how industry is progressing in terms of relative energy efficiency.

First, we considered the amount of output per unit cost of energy (not energy quantity) to group the manufacturing sectors. A comparison of the energy input and value added data from a sample of developing countries indicates a convincing linear relationship between these variables. However, linearity was only revealed after a log transformation on account of the cross-country and cross-sector variation. The scatter diagram in Figure 5 depicts the change pattern of value added produced per unit of energy input.

To study the sector variation of energy intensity, we analyzed the data collected from the results of the annual industrial surveys of a sample of countries. Three variables were compared: cost of all types of energy, total intermediate input and value added. First, the manufacturing sectors were arranged based on the cost of energy required for the production of a fixed amount of value added. In Figure 6, the manufacturing sectors at the 2-digit level of ISIC are arranged according to the regression coefficient (with zero constant). Results showed that the production of electrical and electronic goods had quite a high degree of value added per unit of energy input, whereas non-metallic mineral products, basic metal and chemical industries were more energy intensive.

Further, we compared the above ranking with results obtained from the analysis of energy input ratio. This ratio indicates the share of energy cost in total input (proxy of intermediate consumption). The computation of energy input ratio was not always straightforward because reported data did not sufficiently distinguish between the purchases of energy products such as coal and oil for further processing and consumption as fuel. For some OECD countries, data were obtained from input/output tables where all forms of input were presented by product type. In such cases, it was necessary to segregate the input data by type of energy product used. After some modifications and consistency checks, the energy input ratio was calculated at the sector level (Figure 7).

A direct comparison of ratio among countries at the sector level was not possible due to the different price levels of energy products. Therefore, the manufacturing sectors were ranked within a country. Subsequently, an overall rank coefficient was calculated for each sector from the country data as follows:

$$\tau_j = \frac{\sum_i z_{ij}}{Z_{\max}}; \quad i = \overline{1, n} \quad j = \overline{1, m} \qquad (1)$$

Where; τ_j – rank coefficient of j-th industry

z_{ij} – rank score of j-th industry in i-th sample country

$z_{\max}$ – maximum value of z; i.e. (m x n)

Results obtained from the application of the above method were compared with the ranking of industrial sectors based on the mean energy ratio over sample countries calculated as

$$Mean\ Energy\_ratio = \frac{n}{\sum_i \frac{1}{x_i}} = \frac{No.\ of\ observations}{\sum_i \left(\frac{Input}{Energy\_\cos t} \right)_i} \qquad (2)$$

Both methods produced identical results on sector variation. As the final outcome of this exercise, manufacturing sectors were classified into three categories of energy intensity with the following taxonomy:

High energy intensive
Moderate energy intensive
Low energy intensive.

The classification is presented in detail in annex 1. An even distribution of the total energy consumption of the manufacturing industry over three groups resulted in a greater number of sectors in the low energy intensive category and fewer in the high energy intensive category. The classification of manufacturing sectors by energy intensity helps to assess the diversity of industrial activities in terms of energy intensity and monitor the sector shift from high to low energy intensive sectors. Policymakers may also compare the level of energy use in high intensive sectors compared to other countries and decide to acquire energy efficient technology as part of their industrial policy.

4. Use of classification for policy relevant indicators

In the present context of a globalized economy, industrial policy typically aims to create a business environment that helps countries gain the competitive advantage of their products in the world market. The task of statistics is to provide internationally comparable cross-sectional data to help policymakers understand the position of their country with respect to different types of industrial activities and to monitor growth trends.

The industrial performance of any country is broadly measured by statistical indicators related to productivity, structural change and competitiveness. Industrial policy, in contrast to the overall economic growth strategy, usually takes a strong sector specific approach. The regulatory tools and fiscal policies are directed at promoting certain products with the elements of protection or to encourage FDI for which a higher level of technology needs to be acquired from abroad. The formulation and implementation of sector-specific policy requires availability of empirical evidence in different variations of the classification categories. While the types of activity remain the fundamental element of classification, an aggregated grouping of activities by different criteria is an important tool for policy-relevant data compilation.

The classification and associated taxonomy described above are used in the system of individual as well as composite indicators of industrial performance. UNIDO has used this classification in the System of Industrial Development Indicators (SIDI) and Industrial Development Scoreboard which comprise a set of indicators including labour productivity, output and manufactured export. The technological intensity classification has been one of the major elements to construct the normalized index of Competitive Industrial Performance (CIP Index) of UNIDO. This index provides country ranks with their relative performance in world manufacturing. It is also used by the OECD to compile the STI Scoreboard. Similarly, the taxonomy of resource-based sectors has been used to assess the dependence of developing countries on the availability of local natural resources vis-à-vis technological progress. Statistics compiled by agro-based and resource-based sectors indicate the dominance of the primary stage of processing in the manufacturing industry. The energy intensity-based classification meets the increasing demand of data users regarding the energy efficiency reached by manufacturing sectors.

The main advantage of aggregated classification is that it provides important measures of complex industrial structural change in the form of simple and a minimal range of data. The growth achieved, in principle indicators of industrial statistics such as employment, output, capital formation and export, is reflected in structural change. Using derived classifications statisticians can advise policymakers on the pattern of the given country's industrial progress in terms of technological advancement, dependence on natural resources and efficiency of energy use. At the same time, statistics compiled by such classifications should be interpreted within the limitation of classifications in cross-country comparison. As the level of industrial development achieved varies significantly by country, the same type of activity may be a high-technological activity in one country and a low one in another. Therefore, international comparison holds with much validity if it is made within a group of homogenous economies.

Annex: Industry classification based on energy consumption intensity

	ISIC	Description of activities
High energy-intensive	17	Manufacture of textiles
	21	Paper and paper products
	23	Coke and refined petroleum products
	24	Chemical products
	26	Non-metallic mineral products
	27	Manufacture of basic metals
Moderate energy-intensive	15	Food products and beverages
	18	Wearing apparel; dressing and dyeing
	19	Manufacture of leather products
	20	Wood and wood products
	22	Printing and publishing
	24	Rubber and plastic products
	28	Fabricated metal products
Low energy-intensive	16	Tobacco products
	29	Machinery and equipment n.e.c.
	30	Office, accounting and computing machinery
	31	Electrical machinery and apparatus n.e.c.
	32	Radio, TV and communication equipment
	33	Medical, precision and optical instruments
	34	Motor vehicles, trailers and semi-trailers
	35	Other transport equipment
	36	Furniture and other manufacturing n.e.c.
	37	Recycling

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Figures

Data for all figures below are taken from the UNIDO database.

Figure 1: Percentage share of resource-based sectors in the total manufacturing output of selected countries

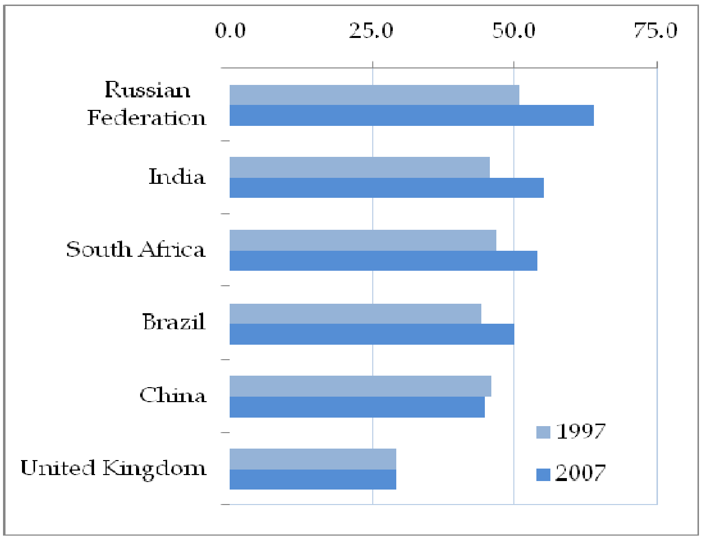

Figure 2: Ratio of sector level labour productivity to manufacturing average (Average = 100)

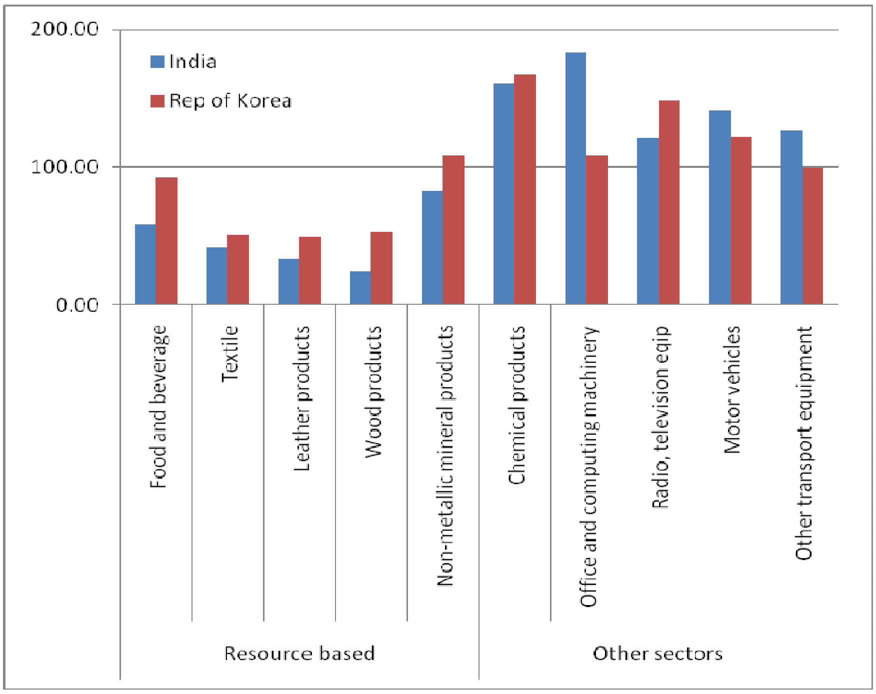

Figure 3:

Percentage share of agro-industrial sectors in total manufacturing value added by selected country groups, 2009

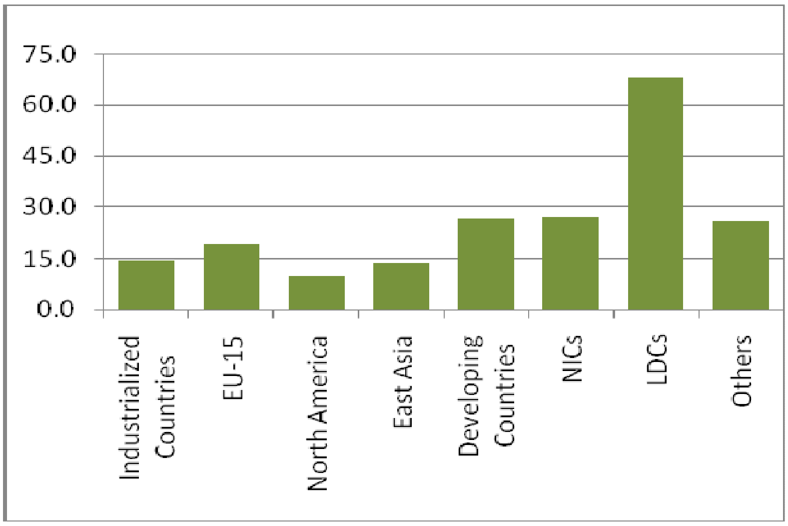

Figure 4:

Percentage share of MHT sectors in total manufacturing output and export, 2007

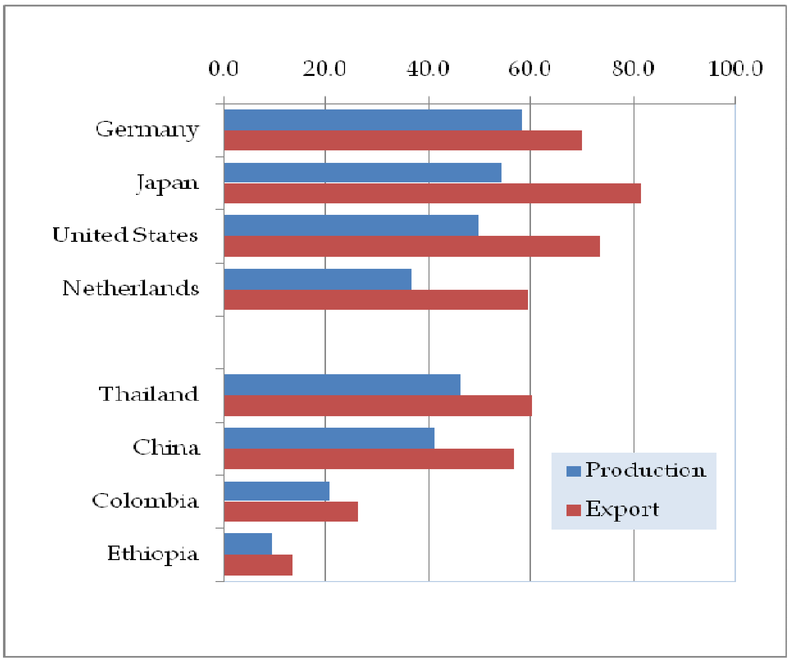

Figure 5:

Dependence of value added on energy input in selected developing countries

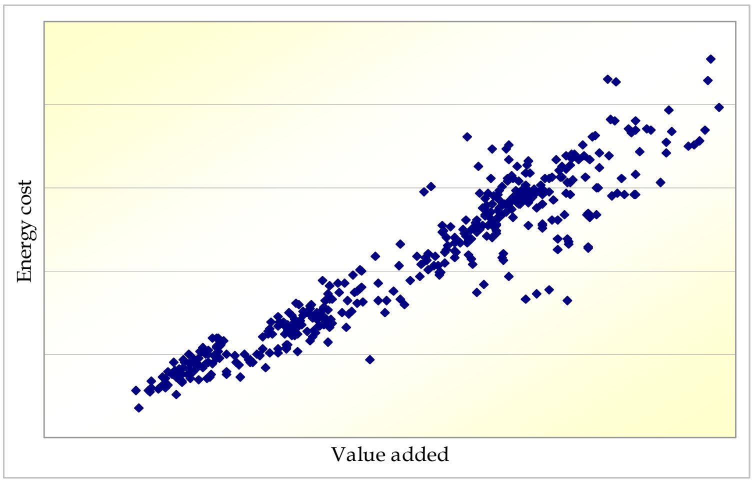

Figure 6: Value of energy input required for production of 1,000 unit of value added in developing countries by ISIC

Energy cost

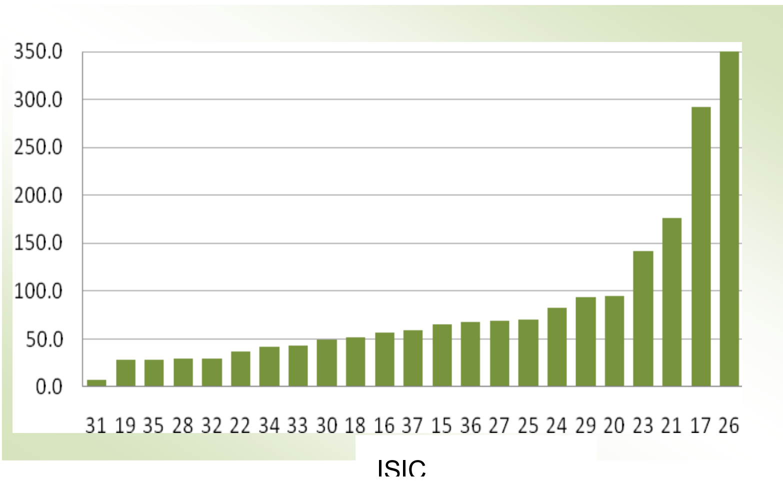

Figure 7

Energy input ratio of the manufacturing industry by ISIC division

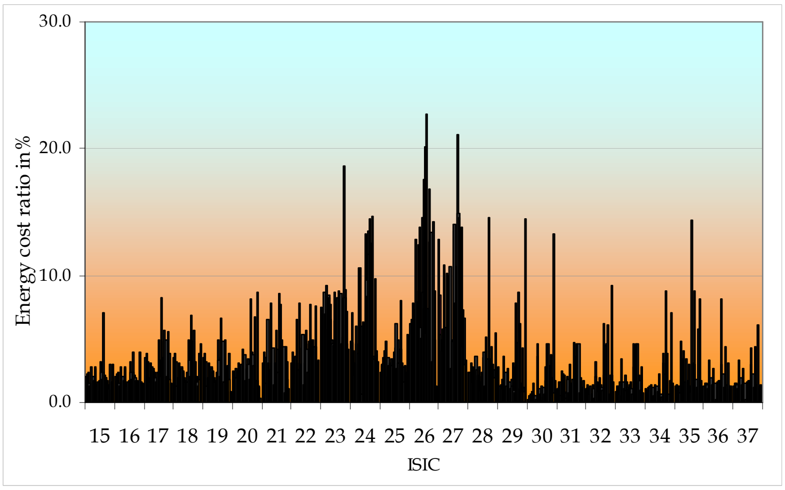

Figure 8

Share of high-energy intensive sectors in production and export of selected countries, 2007