Technology, Specialisation and Productivity in Manufacturing Industry: A Cross Country Analysis

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Abstract

The aim of this study is to provide evidence on the relations between manufacturing industry productivity and specialisation for thirty nine countries both developed and underdeveloped from 1981 to 2003. We first examine the degree and evolution of specialisation pattern of the manufacturing industry production and trade of the economies with respect to absolute specialisation, comparative advantages, and technological specialisation descriptively. Second, this study investigates the impact of different measures of specialisation in production and trade on productivity in manufacturing. Descriptive findings show that high/low technology intensive manufacturing industry production and trade increased/decreased from 1980s to 2000s. While developed countries and emerging economies followed this pattern, underdeveloped countries kept their low technology intensive manufacturing industry structure. More importantly, panel data estimation results show a positive association between absolute specialisation in production and labour productivity, but negative relation with specialisation in exports. Moreover, we found that while countries specialising in low technology intensive production and trade have lower labour productivity, specialising in medium and high tech industries enhances productivity.

Keywords: specialisation, productivity, comparative advantages, manufacturing industry, Turkey.

JEL Codes: O12, O14, F14.

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1. Introduction

One of the main concepts in explaining growth differentials of economies has been "productivity". The reason for this is the fact that productivity is one of the most important determinants of long term sustainable growth. The leading driver of productivity is said to be innovation capability of countries. Innovation capability of countries, on the other hand, may be explained by "specialization" dynamics. Specialisaiton dynamics of an economy, in fact, is determined by manufacturing industry simply because of the fact that realization of innovation and specialization takes place in this sector (Cornwall and Cornwall, 2002; Thirlwall, 1999 and 2002). Moreover, creation and diffusion of new technology cause productivity increase not only in manufacturing industry, but also in the other sectors of economy (Taymaz and Suiçmez, 2005: 29).

The main purpose of this study is to explore the relation between productivity and specialization in manufacturing industry. Specifically, the following questions will be answered in this study: 1) Is the nature of specialisation important in manufacturing industry production and trade? 2) Which one is more important for a better productivity performance in manufacturing industry: absolute or technological specialisation?

The rest of the paper is organized as follows: The next section discusses the relationship between productivity and specialisation in manufacturing industry theoretically. Different approaches to measurement of specialisation are examined in section three. Section four presents descriptively the evolution of production and export structure of manufacturing industry across countries for the period of 1981-2003. In section five, both econometric model used to explain the relation between specialisation and productivity is introduced and results are discussed. Finally, section six concludes.

2. Specialisation and Productivity: Theory and Literature

Specialisation in manufacturing industry can be simply stated as the distribution of the shares of sub-industries in total manufacturing production or trade. Therefore it can be said that the more share for sub-industries in total manufacturing, the more specialised for those industries in the economy.

There are two basic approaches for explaining specialisation in economics literature. First one, asserted by Adam Smith, emphasizes the importance of absolute specialisation and claims that division of labour and specialisation cause economic growth by triggering the scale economies and learning-by-doing (Laursen, 1999: 269). However, considering the international division of labour is determined by country's resources, underdeveloped countries will most probably specialize in low-technology labour and resource based industries. Such a case cannot be strategical in terms of long term economic growth.

The second approach, belongs to Ricardo, emphasizes the differences of productivity increases in different economic activities and then argues that specialisation in the sectors which have faster increase of productivity is more important for economic growth (Laursen, 1999: 269). Industries with high productivity growth are more particularly technology intensive and science-based industries. Now therefore in this study rather than solely productivity increases in industries, technological forms of specialisation of the countries will be evaluated, and it will be set forth that the countries with production based on high technology and trading exhibit a faster and sustainable growth performance.

Technological structure of manufacturing industry; and therefore specialisation structure an its direction has a crucial role for industrial development. This is because technological structure of manufacturing industry reflects both technology level and form of specialisation. In the further stages of industrialization, production structure of manufacturing industry, especially technological structure is extremely important on account of growth and competitiveness (Fagerberg, 2002; Laursen, 1999; Montobbio ve Rampa, 2005). In other

words; after a certain stage of industrialization, specialisation in which sectors has become more important rather than the degree of specialization in manufacturing industry. In this regard, to create and develop leading industry in manufacturing has a vital importance, in particular healthy and sustained growth of underdeveloped countries (Abegaz, 2000; Amsden, 2001). Form of specialisation on trade in manufacturing industry, especially in export, is as important as in the specialisation in production of manufacturing industry (Amable, 2000; Crespo-Cuaresma and Wörz, 2005; Lall, 2000). For this reason, this study analyses the specialisation dynamics in both production and trade, especially in export.

The studies examining the relations between specialisation and productivity differ in terms of their results. For example, covering for 39 countries both developed and underdeveloped for the period 1960-1990 and by using dynamic panel estimation, Weinhold ve Rauch (1999) found that high specialisation leads to high productivity increase in manufacturing industry as a statistically significant result for developing countries, but they did not found significant for developed countries. On the other hand, Archibugi and Pianta (1992) and Pianta (1997) did not found any results about the existence of technological specialisation besides Meliciani and Simonetti (1998) and Meliciani (2001) found opposite results. In addition, Pianta and Meliciani (1996) did not found a statistically significant relation between growth rate and specialisation in electronics sector. Amable (1996, 2000) found a significant relation between specialisation in trade of electronic products and comparative advantages, in other words he revealed that specialisation creates a positive impact on productivity, besides Pianta (1997) did not found any significant relation between export growth and specialisation for the same sector.

Most of the studies trying to measure the relation between specialisation and concentration by means of indices support the existence positive correlation between those two variables: Sapir (1996) measured the specialisation in manufacturing industry by using Herfindahl index and reached that specialisation did not increase in Germany, Italy and United Kingdom whereas it is increased in France in recent years. By contrast with this study, empirical results by using the mean of Finger-Kreinin statistics, which obtained in Hine (1990) and Greenaway and Hine (1991), supports specialisation increase for the same countries. In addition, Amiti (1998, 1999) estimated the specialisation by using Gini index for some countries of European Union, he reached the specialisation increase in the countries except France, Spain and United Kingdom. Yet, it was seen the specialisation increase in all countries after 1980s. Aiginger and Davies (2004) analysed the relationship between specialisation and concentration in the countries of European Union by using entropy index. One of the most important findings of this study is that specialisation increase does not mean concentration increase regionally. Other important findings of this study are as the followings: specialisation increased in almost all member countries of European Union, smaller countries concentrate in developing industries besides bigger countries strenghten in existing specialised fields.

Looking at the results of studies in which examined technological specialisation and productivitiy; Sánchez and López (1998) asserted that specialisation cannot be explained by only Ricardian model, it should be regarded Heckscher-Ohlin-Vanek model. Accordingly, the results obtained in that study supports that developed countries does not always exhibit relative labor productivity levels in high tech sectors. Fagerberg (2000) investigated the effects of specialisation and structural changes on productivity increase in manufacturing industry by using a sample that includes 39 countries and 24 manufacturing industries for the period 1973-1990. The results showed that the countries, which have more technologically developing industry (electronics), experienced more high productivity increase comparing to other countries, besides they showed structural changes does not cause, on average, to productivity increase. Huang and Miozzo (2004) computed technological specialisation with

two methods for Argentina, Brazil, Mexico, South Korea and Taiwan. They obtained that South Korea and Taiwan exhibit to relatively more specialisation in technology based products, and Argentina, Brazil, Mexico have more specialisation in trade of products in scale intensive sector. Soete (1987) Andersson and Ejermo (2006) anaylsed the relation technological specialisation and specialisation on trade, regionally and they reached that there is more exports in high specialised regions and a strong correlation between those two specialisation indices.

Harrigan (1997) obtained that the most important factors are relative technology levels and factor endowment for manufacturing industry covering for developed 10 countries by using panel data method. In a study for developed 28 countries, Harrigan and Zakrajsek (2000) added a total productivity level to the model as a factor for explaining specialisation; and they empirically raeched that only relative factor endowment has a statistically significant relation with specialisation.

Considering the exports of OECD countries, Laursen (2000) found that the existence of lower specialisation levels, and trade and technological specialisation structures depend on the policy followed. Dalum et al. (1999) ascertained that whether the growth performance of a country is determined by foreign trade. Empirical results of them showed that specialisation of trade is really important for economic growth, but the effect weakened gradually in 1980s.

3. Measurement of Specialisation

To determine the degrees of specialisation levels in manufacturing industries for the economies, several measures of specialisation are in use as particularly examined in the followings. These measures are agglomerated as in two groups as *absolute specialisation indices* and *comparative advantages indices*.

3. 1. Absolute Specialisation Indices

Specialisation level in production is measured by two ways. First one is *absolute specialisation*. The second one is *comparative advantages*. Commonly used indices for absolute specialisation in production are Herfindahl and Gini-Hirschman. These indices can calculated by using a variable such as output, value added, employment, export. In this case, calculated value of index for which variable measures absolute specialisation for the same variable.

3. 1. 1. Herfindahl Index (HI)

To measure absolute specialisation in manufacturing production, Herfindhal index was used. This index is formulated as in the following (Sapir, 1996):

$$H\dot{I}\,Q_{it} = \sum_{j}\left(\frac{Q_{itj}}{\sum_{j} Q_{itj}}\right)^{2} \qquad 0{,}01 \le H\dot{I} \le 1 \qquad \textbf{(1)}$$

In equation (1) ; *i, t, j* are country, time and sector, respectively. If this index value is $H\dot{I} = 0{,}01$, it is interpreted as there is no specialisation. If $H\dot{I} = 1$, it shows complete specialisation in the sector.

3. 1. 2. Gini- Hirschman (GH) Index

One of the indices used in measuring absolute specialisation is Gini- Hirschman (GH) index. This index is formulated as in the following:

$$GHQ_{it} = 100\sqrt{\sum_{j}\left(\frac{Q_{itj}}{\sum_{j} Q_{itj}}\right)^2} \qquad \textbf{(2)}$$

In equation (2); *i, t, j* are country, time and sector, respectively. The largest value of this coefficient is 100. The larger Gini-Hirschman coefficient means the increase in specialisation, otherwise means the decrease in specialisation (Togan, 1993: 189; Kösekahyaoğlu, 2007: 19).

3. 2. Comparative Specialisation Indices

Specialisation indices for any variable based on comparative advantages, in terms of the structure of production in manufacturing industry or trade for a country, can be calculated as with respect to another country, country group and world economy. In this matter, the most commonly used indices are *Revealed Comparative Advantages and Chi-square* $\left(\chi^2\right)$. As in the absolute specialisation, these indices also can be calculated by using any variable such as output, value added, employment, export. In this case; if the value of index is calculated for any variable, it measures comparative specialisation for the same variable.

3. 2. 1. Revealed Comparative Advantages

One of the commonly used indices is Revealed Comparative Advantages $\left(CAQ\right)$ Index, proposed by Bela Balassa (1965). This index is calculated as the following:

$$CAQ_{ij} = \frac{Q_{ij} \Big/ \sum Q_{ij}}{\sum_{i} Q_{ij} \Big/ \sum_{i}\sum_{j} Q_{ij}} \qquad \textbf{(3)}$$

In equation above, Q_{ij} gives comparative advantages in production or trade of sector *j* in economy *i* for time *t*. If the benchmark is world economy, this index enables to compare the specialisation level of any economy with world economy. If this index value is 1 for a given sector in a country, this means that the sector does not differ from the world in terms of specialisation. If the index value is bigger than 1, it is inferred as the country is more specialised than world average for that sector; if it is less than 1, inferred as less specialised than world average for that sector. The dispersion degree of Revealed Comparative Advantages $\left(CAQ\right)$ is used for estimation of average level of specialisation (Frantzen, 2006).

Balassa index has been revised and improved later. One of them is the index proposed by Vollrath (1991). This index calculates revealed comparative advantages considering both the production in a certain sector of a country, and sector's production share in the country's total production for the entire world. So then, creating index is written as the following (Bender and Li, 2003: 3-4):

$$CAQM_{ij} = \frac{\left(\frac{Q_{ij}}{(\sum_{i} Q_{ij}) - Q_{ij}} \right)}{\left\{ \frac{\left((\sum_{j} Q_{ij}) - Q_{ij} \right)}{\left((\sum_{j}\sum_{i} Q_{ij}) - (\sum_{j} Q_{ij}) \right) - \left((\sum_{i} Q_{ij}) - Q_{ij} \right)} \right\}} \qquad \textbf{(4)}$$

3. 2. 2. Chi-Square (χ^2) Index

Another index that can be used in measurement for Comparative Advantages Specialisation is *Chi-square Index*. Chi-square index is formulated as the following:

$$Chi - square\ (\chi^2) = \frac{\left[\left(Q_{ij} \Big/ \sum_{i} Q_{ij} \right) - \left(\sum_{j} Q_{ij} \Big/ \sum_{i}\sum_{j} Q_{ij} \right) \right]^2}{\sum_{j} Q_{ij} \Big/ \sum_{i}\sum_{j} Q_{ij}} \qquad \textbf{(7)}$$

In equation (7) in above, Q shows the value added in sector j for country i. Chi-square index shows that the country has a strong specialisation as the value of index increases; Chi-square index means that the country has a weak specialisation degree as the value of index decreases (Laursen, 1998:8).

3.4. Structural Change Indices

In addition to the indices that measure specialisation in production and trade, actually very similar to those, indices that measure structural transformation can be used as specialisation index. Krugman's Specialisation Index and Lilien Indicator can be exemplified for these type indices.

3. 4. 1. Krugman's Specialisation Index

Another index that can be used to measure sectoral specialisation is *Krugman's Specialisation Index* (1991). This index used for economic structure comparison of a country with other countries and specialised as in the following:

$$K^{j}(t) = \sum abs\left| V_i^{j}(t) - V^{j}(t) \right| \qquad \textbf{(16)}$$

$V_i^{j}(t)$ shows the share of sector *j* in country *i*; $K^{j}(t)$ shows the share of sector *j* in other countries. If the value of Krugman's Specialisation Index approaches to 2, it shows the sectoral specialisation of the country. If the value of index approaches to zero, it shows that incapable of sectoral specialisation (Čutková, and Donoval, 2004: 5).

3. 4. 2. Lilien Indicator

"Lilien Indicator" is used to determine whether the difference in specialisation as depending upon the speed of structural change. In this indicator employment is used as variable.

$$\delta = \left[\sum_i \frac{E_{it}}{E_t} \left(\Delta \log E_{it} - \Delta \log E_t \right)^2 \right]^{1/2} \quad \textbf{(17)}$$

E_{it} shows the employment in sector i, E_t shows the total employment. This index used to measure the speed of structural change. As the value of this index increases, it will be interpreted as more rapid structural change and greater redistribution among industries. If the value of this index is low, it is interpreted that structural change has decelareted and redistribution has become smaller. In addition to this, this index value is used to measure the capability the adjustment and reaction to the changes in aggregate demand (Čutková, ve Donoval, 2004: 6).

4. Technological Structure of Production and Export in Manufacturing Industry: A Descriptive analysis

In this section, it is descriptively examined the structure of production and export in manufacturing industries of the countries. In order to do so, at first, manufacturing industries are classified as low, medium and high according to the technological intensity; and then production and exports of each are examined by comparing with the world averages.

4.1. Technologic Structure of the World Manufacturing Industry

When the production structure in manufacturing industry is treated in terms of technology intensity, whether there is a change between the periods is crucially important analysis from the point of the determination of which technolgy that intensively used in the production. Examining the periods 1981-1985, as the approximate shares of the world production; low, medium and high technologies have 55 %, 25 %, and 20 %, respectively. This picture changed in the second sub-period; and the shares of medium and high technology in production structure increased besides there was a decrease for low technology.

When it is looked at the traded products on account of technology in the first sub-period, high technology products has the most shares for exported goods and services in manufacturing industry with 50 %. Low and medium technology products have 33 % and 17 % shares, respectively. In the second sub-period, the share of high technology products in exports increased to approximately 58 %; the share of low technology products decreased to 23 %, it was 18 % for the medium technology products. Thus, it can be said that manufacturing products in the world trade are rather high technology intensive products. And then it can be stated that world production structure does not coincide with world trade structure. As well as the production structure in manufacturing industry is composed of low and medium technology intensive products, the picture has formed towards high technology intensive products in exports.

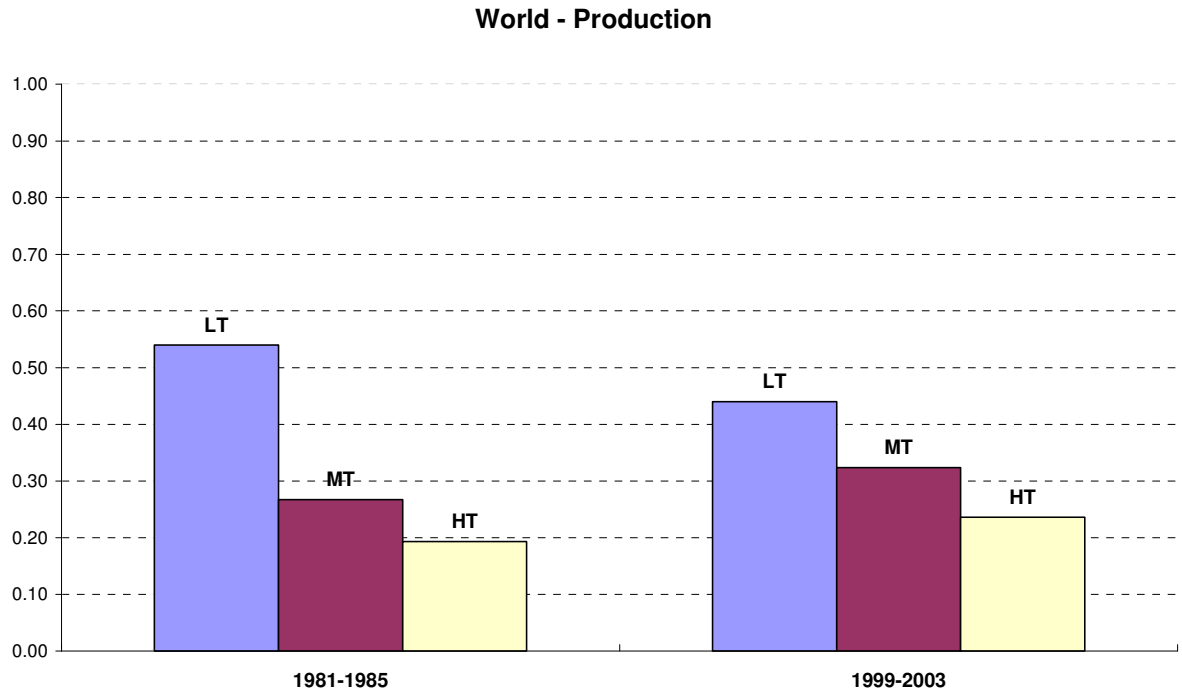
4. 2. Technologic Structure of the Economies

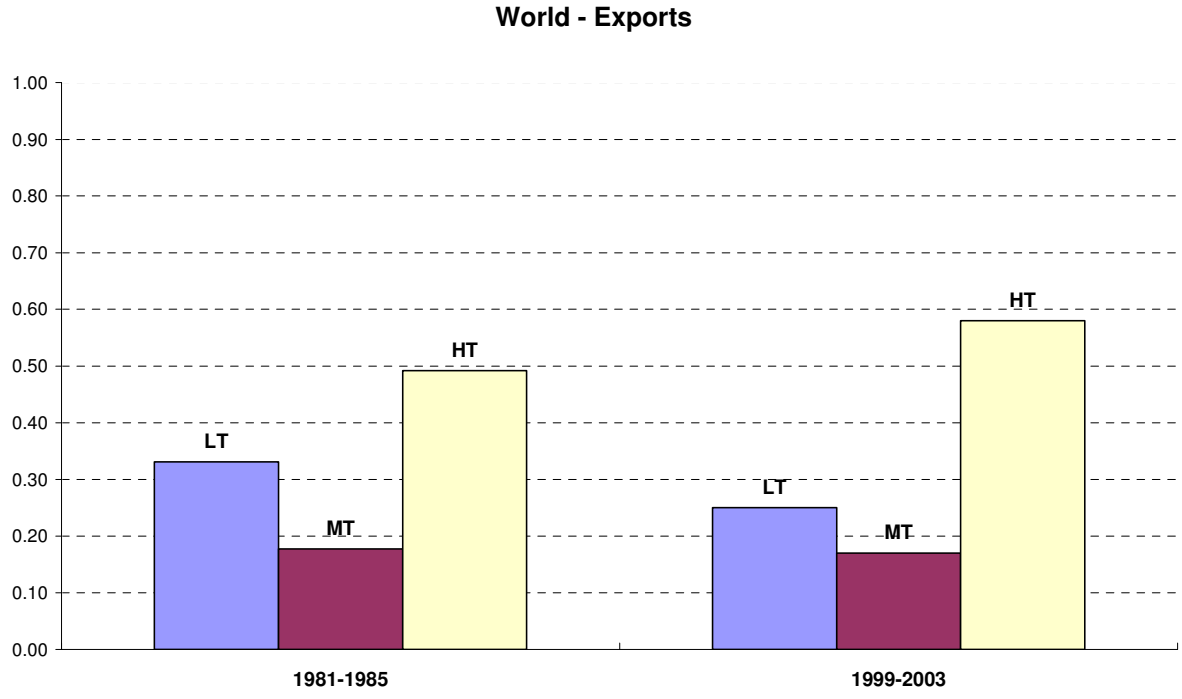
In this section, technological structure of production and trade for each country is examined by calculating comparative advantages in production and exports with respect to their technological intensity.

4. 2. 1. Comparative Advantages in Production and Exports: Low Technology Industries

The comparative advantages of manufacturing industries in production and exports for the low technology intensive industries can be seen in Figure 2. When it is looked at the intensities of low technology intensive industries in manufacturing, it can be seen that there is not differentiation for specialisation in production of the countries for the period of 1981-

Figure 1: Structure of production and export in Manufacturing Industry (world average), 1981–2003.





Source: Calculated by the authors using UNIDO Industrial Statistics (2008) and UNIDO Demand Supply Statistics (2008). Abbreviations: LT: Low Technology; MT: Medium Technology; HT: High Technology.

2003 except some countries. In the context of intensities of the countries in low technology industries in production by comparison with the world average; the countries have carried on near the world average or above it, except Germany, Hungary, Israel, Japan, Korea, Malaysia, Malta and Singapore.

In point of intensity for production in low technology industries, some countries have a great deal of amount above world average. These are Argentina, Australia, Chile, Columbia, Costa Rica, Cyprus, Ecuador, Egypt, India, Indonesia, Jordan, Morocco, Portugal, Sri Lanka, Tanzania, Tunisia and Turkey.

On the other hand, in the context of intensities of low technology manufacturing industries in the countries for exports, it can be said that the countries such as are Argentina, Austria, Australia, Ecuador, China, India, Spain, Israel, Indonesia, Morocco, Finland, Sweden, Italy, Iran, Ireland, Cyprus, Columbia, Costa Rica, Hungary, Egypt, Norway, Portugal, Sri Lanka, Chile, Tanzania, Tunisia, Turkey and Jordan. In other countries; Canada, France and Korea appear in the world average, and Germany, Japan, Malta, Mexico, Singapore, United Kingdom and United States are in below of world average[†]. In addition, in comparison with the beginning of 1980s, intensity of low technology manufacturing industries relatively increased in exports for the countries like Egypt, Morocco, Sri Lanka, Chile, Tunisia and Jordan; relatively decreased for the countries Costa Rica, Korea, Malaysia, Malta and Mexico.

Finally, some countries are notably above the world averages in the context of intensities of low technology manufacturing industries. The countries such as Argentina, Columbia, Cyprus, Ecuador, Finland, Egypt, India, Indonesia, Jordan, Morocco, Portugal, Sri Lanka, Tanzania, Tunisia and Turkey come into prominence.

4.2.2. Comparative Advantages in Production and Exports: Medium Technology Industries

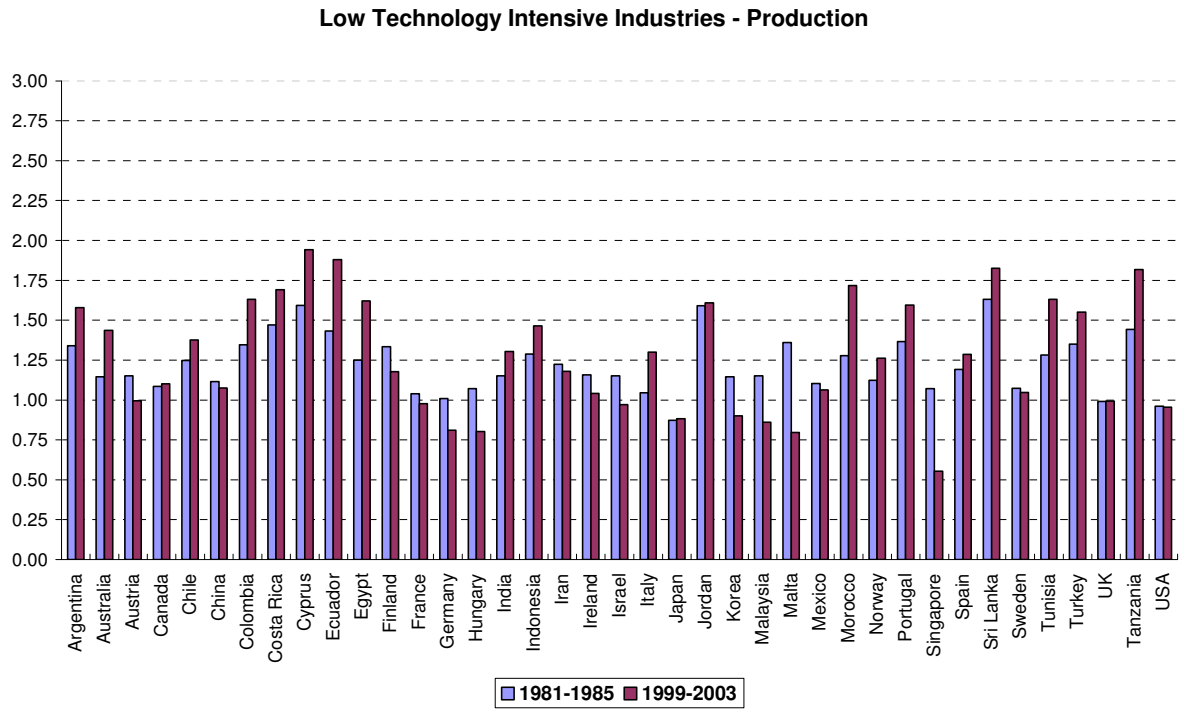
Comparative advantages of medium technology industries in production and exports are given in Figure 3. It can be seen that the comparative advantages of medium technology industries in production for the periods 1981-2003 have no great difference on specialisation except some countries. When the intensity of medium technology industries in production is compared with the world average, it can be stated that Germany, Canada, France, India, Chile, Japan, Korea, Mexico, Norway, Spain, United Kingdom and United States keep on about world average or slightly above it.

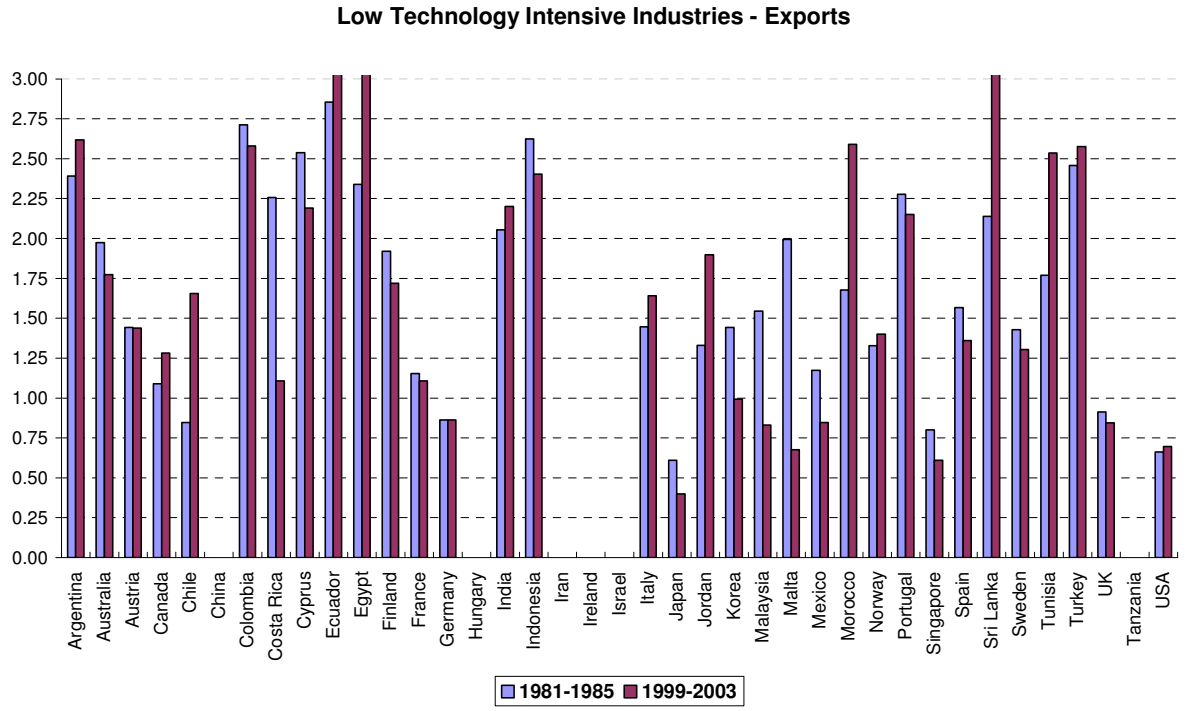
Comparing the others in recognition of the intensities of medium technology industries in production, it can be said that some countries are below the world average. These are the countries such as Cyprus, Ecuador, Malta, Sri Lanka and Tanzania. Except for those countries, although the other countries that include Turkey are below the world average, they become relatively bit much intense on medium technology industry in production.

When the intensities of medium technology industries in export is compared with the world average, it can be stated that Australia, France, Germany, Columbia, Egypt, Jordan, Morocco, Norway, Spain, Italy, Sri Lanka, Chile, United Kingdom and United States are about world average or above it. For the other countries, Argentina, Austria, Cyprus, Indonesia, Japan, Sweden are below the world average. In particular, Turkey is below the world average and it can be seen relatively smaller intensity of the country. Additionally, it can be expressed that Australia, India, Columbia, Ecuador, Indonesia intensified much more than as it was at the beginning of 1980s; on the other hand Mexico, Tunisia and Morocco intensified lesser on account of the medium technology industries in exports.

[†] It could not be interpreted for the China, Iran, Ireland, Israel, Hungary and Tanzania because of the missing data of exports UNIDO database.

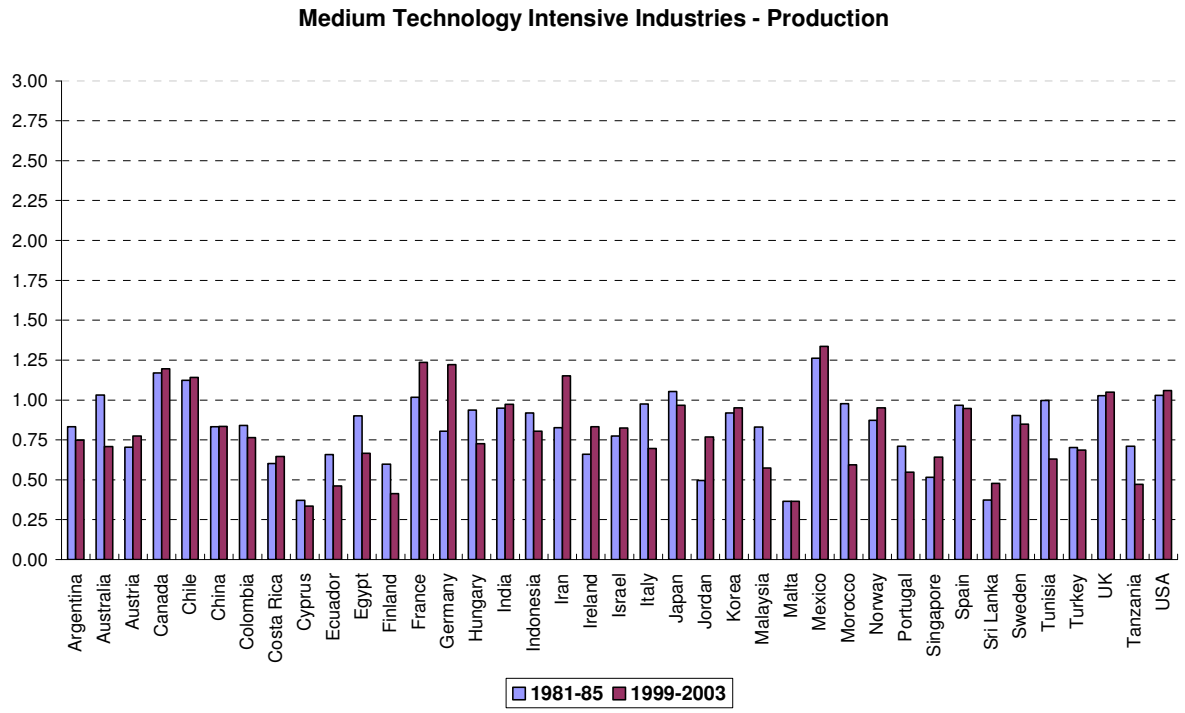
Figure 2: Comparative Advantages of Low Technology Industries in Production and Exports

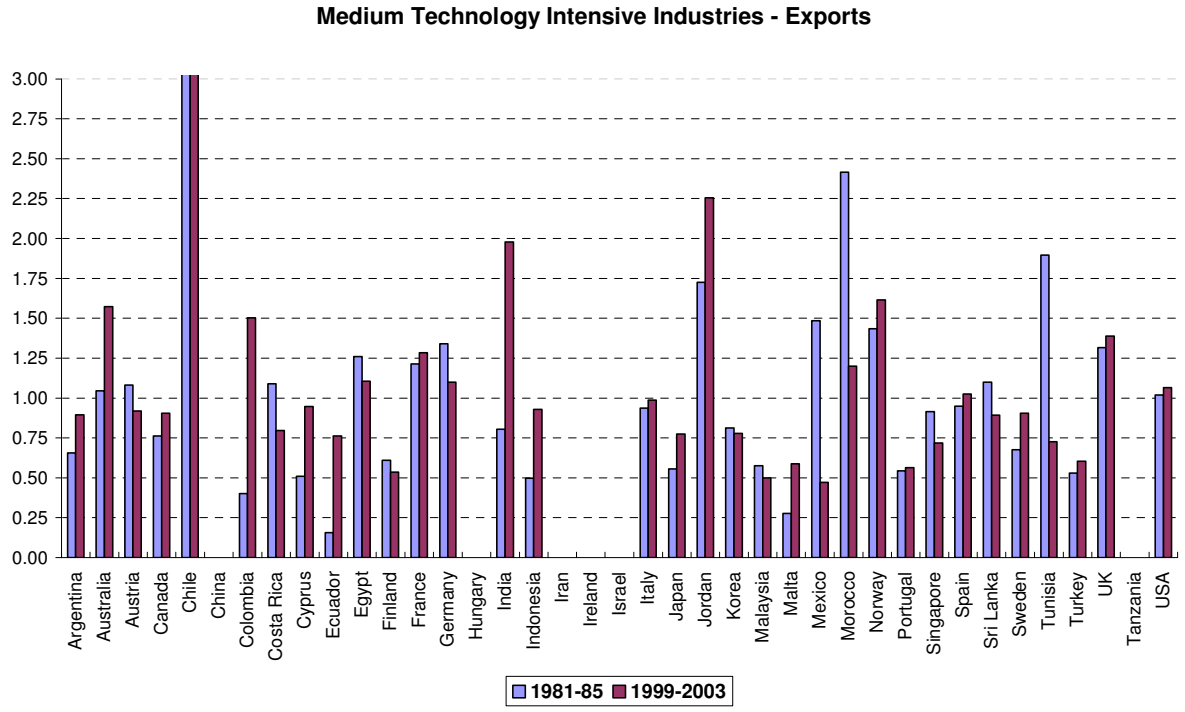




Source: Calculated by the authors using UNIDO Industrial Statistics (2008) and UNIDO Demand Supply Statistics (2008).

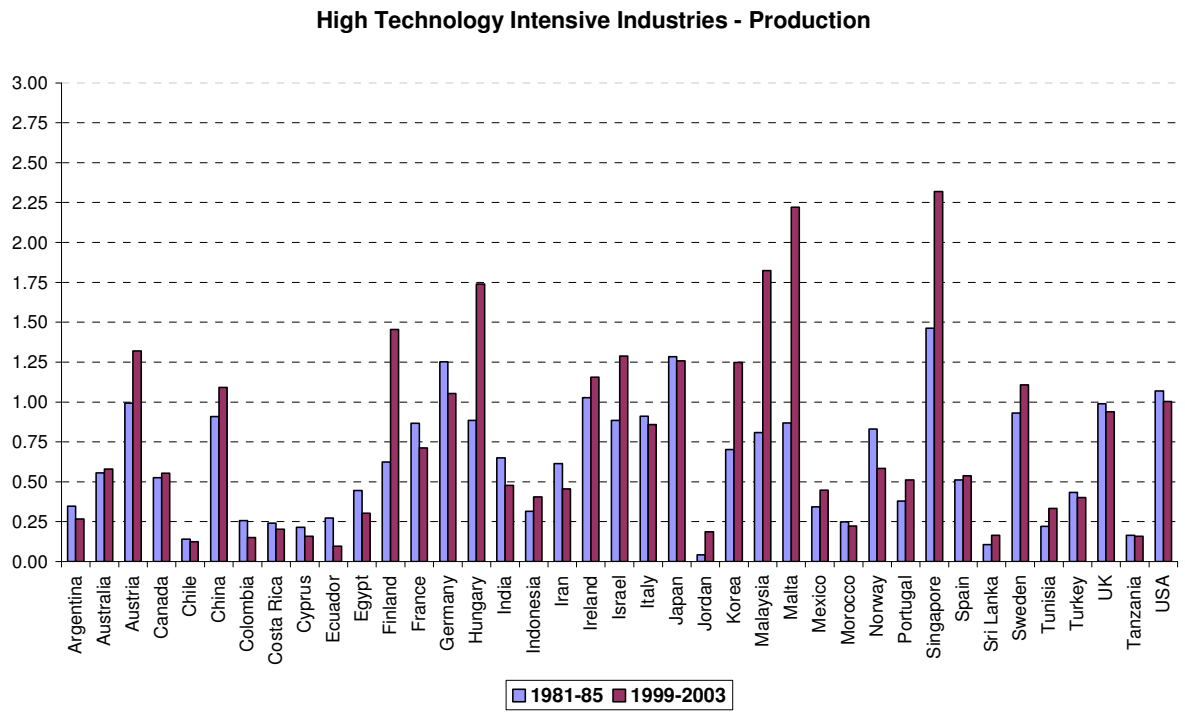
Figure 3: Comparative Advantages of Medium Technology Industries in Production and Exports

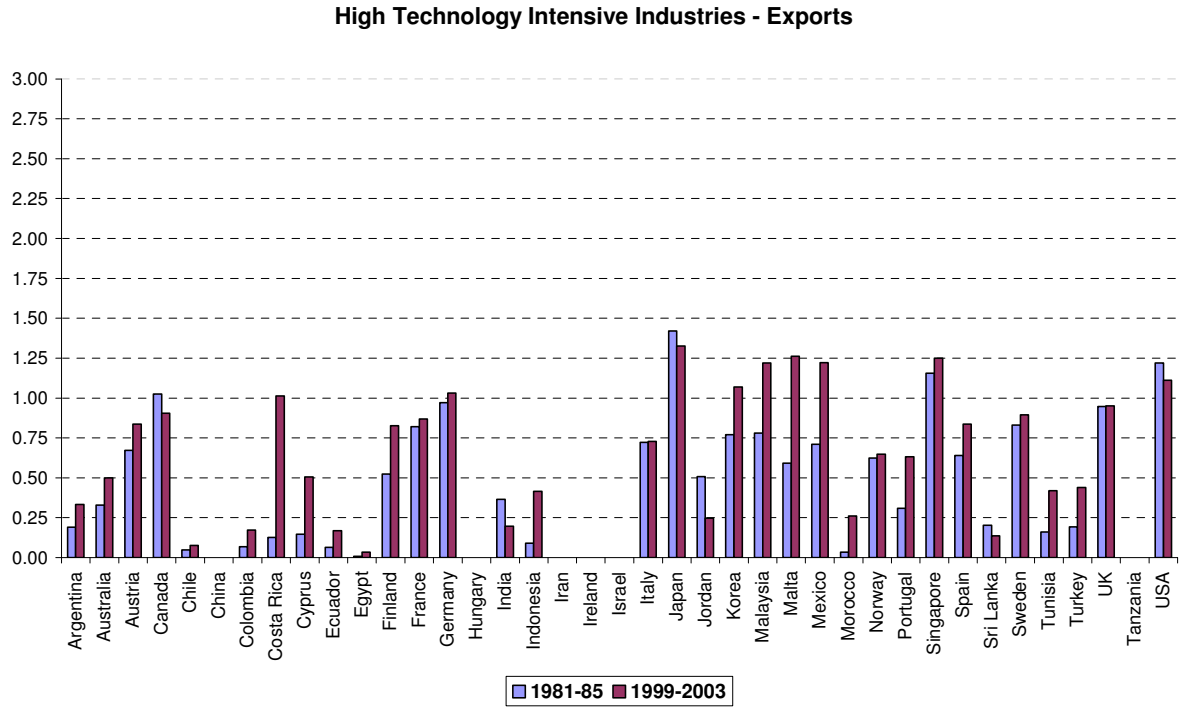




Source: Calculated by the authors using UNIDO Industrial Statistics (2008) and UNIDO Demand Supply Statistics (2008).

Figure 4: Comparative Advantages of High Technology Industries in Production and Exports





Source: Calculated by the authors using UNIDO Industrial Statistics (2008) and UNIDO Demand Supply Statistics (2008).

Finally, some countries are in much more above the world average in terms of the intensities of medium technology industries in exports. In this regard, Australia, India, Columbia, Jordan, Norway, and especially Chile come into prominence.

4.2.3. Comparative Advantages in Production and Exports: High Technology Industries

Comparative advantages of high technology industries in production and exports are given in Figure 4. Considering high technology intensive industries, it can be seen that there is not much difference for specialisation in production of the countries for the period of 1981-2003 except some countries. In comparison with the world average; Austria, Finland, Germany, China, Hungary, Israel, Ireland, Japan, Korea, Malaysia, Malta, Singapore, Sweden, United Kingdom are in above the world average; besides Italy and United States are in approximately near the world average.

Several countries carried on relatively below the world average for specialisation in high technology industries in production and exports. These are the countries as Argentina, Australia, Canada, Egypt, France, India, Indonesia, Iran, Mexico, Norway, Portugal, Spain and Turkey. Except for those, Chile, Columbia, Costa Rica, Cyprus, Ecuador, Jordan, Morocco, Sri Lanka, Tunisia, Tanzania are both carried on below the world average for specialisation in high technology industries and intensified at too few amount.

It can be said that the countries as Finland, Hungary, Malaysia, Malta and Singapore intensified more on production for high technology industries compared to the beginning of 1980s; the intensity of remaining countries did not changed much.

When the intensities of high technology industries in export is compared with the world average, it can be seen that Canada, Costa Rica, Germany, Japan, Korea, Malaysia, Malta, Mexico, Singapore, United Kingdom, United States carried near on or above the world average. For the other countries, Argentina, Austria, Cyprus, Finland, France, Italy, Norway, Portugal, Spain, Sweden, Indonesia, Tunisia, and Turkey are in below the world average. Chile, Columbia, Ecuador, Egypt, Jordan, Morocco and Sri Lanka both carried on below the world average and intensified at too few amount. In addition, it can be stated that the countries as Costa Rica, Malaysia, Korea, Malta, Mexico, Portugal intensified much more than as it was at the beginning of 1980s; India and Jordan intensified lesser on account of the high technology industries in export.

Finally, some countries are in much more above the world average in terms of the intensities of high technology industries in exports. In this regard, United States, Japan, Malaysia, Malta, Mexico and Singapore come into prominence at the least.

5. Specialisation and Productivity: An Econometric Approach

In this section, it is investigated the relationship between specialisation in production and trade and labour productivity in manufacturing by using econometric analyses. In particular with econometric approaches, the study revealed the impact of absolute specialisation, technological specialisation and technological comparative advantages on productivity in manufacturing.

5. 2. Econometric Model and Variables

In this study, it is sought whether there is a significant relation between labour productivity and specialisation in manufacturing industry. It can be answered this question with the help of a productivity model considering specialisation. In other words, we can assume that the manufacturing output (Q) is a function of labour (L), capital (K) and specialisation ($SPEC$):

$$Q_{i,t} = f(K, L, SPEC) \qquad \textbf{(18)}$$

Labour productivity that we measure as value added per labour unit can be formulated econometrically as a function of capital intensity (capital-labour ratio) and specialisation, as in the following:

$$LP_{i,t} = \alpha_i + \mu_t + \beta_1 CAPINT_{i,t} + \beta_2 SPEC + \varepsilon_{it} \quad \textbf{(19)}$$

In equation above, Li_t is the (logarithm of) value added per labour unit in fixed prices of country *i* in time *t*. μ_t is control variable for time, α_i represents the unobserved effects which are peculiar to the firm. ε_{it} is the error term.

In productivity equation *CAPINT* represents capital intensity and as measured by the logarithm of real capital stock per labor[‡].

SPEC variable represents the specialisation in the above model. Specialisation levels in manufacturing industry of the countries are calculated by three ways. The first one is absolute specialisation. *Herfindahl Index* is used as indicator for absolute specialisation. In this regard, absolute specialisation for production and trade are calculated as in the followings:

Absolute specialisation in production:

$$SPECQ_{it} = \sum_j \left(\frac{Q_{itj}}{\sum_j Q_{itj}} \right)^2 \quad \textbf{(20)}$$

Absolute specialisation in trade;

$$SPECX_{it} = \sum_j \left(\frac{X_{itj}}{\sum_j X_{itj}} \right)^2 \quad \textbf{(21)}$$

Q represents the value added and *X* does export in the two equations in above. *i, t, j*, are country, time and sector, respectively. If there is no importance about specialisation in which sector, i.e. if absolute specialisation is adequate, it should be expected a positive relation between coefficient of this variable and productivity. But, the most important defect of this index is that ignoring the across the board tendency for production and trade in the world. This is because the indices which considers specialisation in which sector (technological specialisation indices), and the evolution of production and trade in the world (comparative advantages indices) are included in the models as calculated as in the following.

Technological Specialisation Index (TSI) is used for as the second indicator for specialisation. This indicator which divides three-digit manufacturing industry into three sub-sectors as low, medium and high technology intensive, i.e. the shares of these different technological intensive sectors in total manufacturing industry. Then, *TSI-LT, TSI-MT and TSI-HT* describe the shares of low, medium and high technology production sectors in total, respectively; besides *TSIX-LT, TSIX-MT and TSIX-HT* describe the shares of low, medium and high technology export sectors in total, respectively. If there is a positive/negative relation between any of these variables and labour productivity, the estimated coefficient should be positive/negative.

[‡] Capital stock is calculated by using *Perpetual Inventory Method* in UNIDO Industry Statistics Database (2008). Depreciation rate is assumed as 7.5 %

Finally, *Technological Comparative Advantages Index (TCA)* is added to the model as another specialisation variable. This variable is obtained by calculating comparative advantages of the countries with respect to different technologies. This index is calculated as in the following:

$$TCAQ_{itj} = \frac{Q_{itj} \Big/ \sum_{j} Q_{itj}}{\sum_{i} Q_{itj} \Big/ \sum_{i}\sum_{j} Q_{itj}} \qquad \textbf{(22)}$$

In this equation Q_{it} represents the production of country i in time t for sector j. Therefore, TCA_{itj} is the expression of comparative advantage of country i in time t for sector j. The index was tranformed into symmetric as taking the logarithm. In this regard, *TCAQ-LT, TCAQ-MT ve TCAQ-HT* represents comparative advantages of low, medium and high technology intensive sectors, respectively.

Same index can be used for measure comparative advantages in trade by using export data:

$$TACX_{itj} = \frac{X_{itj} \Big/ \sum_{j} X_{itj}}{\sum_{i} X_{itj} \Big/ \sum_{i}\sum_{j} X_{itj}} \qquad \textbf{(23)}$$

In this equation, eşitlikte X_{itj} denotes export of sector j of country i for time t. Hence, $TCAX_{itj}$ index is the expression for comparative advantage in sector j of the country i for time t. This index was made symmetric as taking logarithm. Then, *TCAX-LT, TCAX-MT ve TCAX-HT* gives the comparative advantages in trade of low, medium and high technology intensity, respectively.

Similar to the previous variable, the sign of this coefficient will give the effects of comparative advantages in production and export activities on the productivity in respect of different technologies.

5. 3. Productivity-Specialisation Relations: Correlation Analysis

Correlations among variables used in the models are given in Table 1. Correlation analysis shows that whether there is a significant relation between absolute specialisation in both production and trade (*SPECQ* and *SPECX)* and labor productivity. The relation between capital intensity and labor productivity is significant and positive.

When it is looked at the relations between comparative technological specialisation in both production and trade and labor productivity; it is found that there is a significant and negative correlation in low technology industries; besides there is a significant and positive correlation in medium technology industries. However, correlation analysis shows that there is no significant relation between production and export of high technology industry and labor productivity.

The existence of a significant and positive relation between specialisation in production and and specialisation in export, it can cause to an interpretation that specialisation in production leads to specialisation in export. There is a significant and positive relation between absolute specialisation in export and absolute specialisation in production for the low, medium and high technology industries. A similar result is found for comparative advantages in production and comparative advantages in export for the low, medium and high technology industries.

Table 1. Pairwise Correlations

Variable	*LP*	*CAPINT*	*SPECQ*	*TSIQ-T*	*TSIQ-MT*	*TSIQ-HT*	*TCAQ-LT*	*TCAQ-MT*	*TCAQ-HT*	*SPECX*	*TSIX-LT*	*TSIX-MT*	*TSIX- MT*	*TCAX-LT*	*TCAX-MT*	*TCAX-HT*
LP	1															
CAPINT	0.964*	1														
SPECQ	-0.049	-0.082	1													
TSIQ-LT	-0.147*	-0.094	0.051	1												
TSIQ-MT	0.354*	0.307*	-0.250*	-0.661*	1											
TSIQ-HT	-0.023	-0.064	0.084	-0.892*	0.252*	1										
TCAQ-LT	-0.125*	-0.075	-0.034	0.981*	-0.602*	-0.904*	1									
TCAQ-MT	0.370*	0.333*	-0.279*	-0.663*	0.965*	0.274*	-0.587*	1								
TCAQ-HT	-0.029	-0.086	-0.122*	-0.886*	0.373*	0.919*	-0.855*	0.397*	1							
SPECX	0.099	0.113	0.549*	0.139*	-0.173*	-0.074	0.086	-0.154*	-0.261*	1						
TSIX-LT	-0.136*	-0.079	-0.020	0.785*	-0.528*	-0.688*	0.775*	-0.498*	-0.624*	0.152*	1					
TSIX-MT	0.213*	0.267*	-0.041	0.139*	0.242*	-0.325*	0.159*	0.240*	-0.381*	0.048	-0.188*	1				
TSIX-HT	0.024	-0.057	0.040	-0.825*	0.387*	0.824*	-0.825*	0.360*	0.791*	-0.171*	-0.874*	-0.312*	1			
TCAX-LT	-0.161*	-0.104	-0.065	0.776*	-0.469*	-0.711*	0.780*	-0.466*	-0.603*	0.008	0.947*	-0.098	-0.868*	1		
TCAX-MT	0.188*	0.227*	-0.095	0.057	0.294*	-0.251*	0.078	0.285*	-0.270*	-0.193*	-0.249*	0.916*	-0.211*	-0.119	1	
TCAX-HT	-0.094	-0.182*	-0.057	-0.674*	0.279*	0.695*	-0.660*	0.256*	0.714*	-0.413*	-0.750*	-0.322*	0.885*	-0.688*	-0.179*	1

Notes: Significant at the levels ** 1%, * 5%, + %10.

Abbrevitions: LP: Labour Productivity; CAPINT: Capital Intensity; SPECQ: Specialisation in Production; SPECX : Specialisation in Export; TSI: Absolute Technological Specialisation; TCA: Comparative Technological Specialisation; LT: Low Technology ; MT: Medium Technology; HT: High Technology

5. 4. Productivity-Specialisation Relations: Estimation Results

The model which used for explaining the relations between productivity and specialisation in manufacturing industries (equation 19) is estimated using by *fixed effects* model. Estimated results are given in the Tables 2 and 3. The results can be inferred as in the following:

Coefficient of capital intensity *(CAPINT)* is found statistically significant in all estimated models. Moreover, the size of this coefficient (0.41-0.47), which represents the elasticity between labour productivity and capital intensity, is very properly reasonable (see Tables 2 and 3). We can interpret the findings about the relations between specialisation and/or comparative advantages and productivity for production and trade, separately:

5. 4. 1. Specialisation and Productivity in Production: Estimation Results

The effect of absolute specialisation in production *(SPECQ)* on productivity is found statistically significant and positive. This result shows that the economies with higher specialisation are more productive, regardless of the characteristics of specialisation in which sector.

Specialisation is measured by taking into account the structure of manufacturing industry of the countries; there is a negative correlation between specialisation in low technology sectors (*TSIQ-LT*) and productivity (see Table 2). This point corresponds to the result that we also found in correlation analysis.

Similar results are encountered in considering comparative advantages in low technology industries. Findings showed that the elasticity of labour productivity on comparative advantages in low technology industries (*TCAQ-LT)* is negative (see Table 2). This result is consistent with the relation that we found in correlation analysis. We can infer that having comparative advantages in low technology sectors affect adversely labour productivity in manufacturing.

Estimation results demonstrates that a positive relation between specialisation in medium technology manufacturing industries (*TSIQ-MT*) and labour productivity (Table 2). This result is also corresponds to the relations between comparative advantages (*TCAQ-MT*) and labour productivity.

The relation between specialisation in high technology sectors *(TSIQ-HT)* or comparative advantages in high technology sectors *(TCAQ-HT)* and productivity is not statistically significant in estimation results. Although correlation analyses also produced the same result, this finding is not expected.

5. 4. 2. Specialisation and Productivity in Trade: Estimation Results

Apart from the production, the impact of absolute specialisation in export (*SPECX)* on the productivity is found statistically significant and negative. This result shows an inverse relationship between specialisation in export, or concentration of export in certain sectors, and labour productivity. One can reach an interpretation that there is an inverse relation between extensive sectoral distribution of export and productivity, or diversification in export is important for productivity.

Estimation results of fixed effects model demonstrates that there is a positive relation between the concentration of export in medium and high technology *sectors (TSIX-MT and TSIX-HT) and productivity; besides it shows that concentration of export in low* technology sectors effects productivity negatively (see Table 3). Similar findings are also obtained when specialisation in export is measured by using comparative advantages index. It is observed

Table 2. Specialisation and Productivity in Production, dependent variable: labour productivity, *fixed-effects* model

Variable	*Model-1*	*Model-2*	*Model-3*	*Model-4*	*Model-5*	*Model-6*	*Model-7*
CAPINT	0.414** [0.036]	0.430** [0.036]	0.452** [0.033]	0.456** [0.037]	0.422** [0.036]	0.472** [0.035]	0.468** [0.035]
SPECQ	2.719** [0.692]						
TSIQ-LT		-0.896** [0.257]					
TSIQ-MT			1.813** [0.395]				
TSIQ-HT				0.295 [0.363]			
TCAQ-LT					-0.459** [0.121]		
TCAQ-MT						0.211* [0.097]	
TCAQ-HT							-0.014 [0.046]
Intercept	6.578** [0.426]	7.187** [0.505]	5.952** [0.415]	6.278** [0.439]	6.825** [0.448]	6.177** [0.427]	6.181** [0.441]
Observations	247	247	247	247	247	247	247
Countries	36	36	36	36	36	36	36
R^2	0.497	0.489	0.509	0.461	0.494	0.471	0.459
F-statistics $H_0 : \beta_i = 0$	103.05**	99.94**	108.21**	89.36**	101.99**	93.08**	88.84**
F-statistics $H_0 : u_i = 0$	105.70**	101.33**	103.38**	98.39**	103.11**	96.97**	95.97**

Notes: Significant at the levels ** 1%, * 5%, + %10 (standard errors are in brackets).
Abbreviations: CAPINT: Capital Intensity; SPECQ: Specialisation in Production; TSIQ: Technological Specialisation in Production; TCAQ: Comparative Technological Specialisation in Production; LT: Low Technology; MT: Medium Technology; HT: High Technology

Table 3. Specialisation and Productivity on Trade, dependent variable: labour productivity, *fixed-effects* model

Variable	*Model-1*	*Model-2*	*Model-3*	*Model-4*	*Model-5*	*Model-6*	*Model-7*
CAPINT	0.454** [0.035]	0.384** [0.036]	0.429** [0.036]	0.409** [0.036]	0.423** [0.037]	0.419** [0.035]	0.439** [0.035]
SPECX	-0.715** [0.240]						
TSIX-LT		-0.715** [0.163]					
TSIX-MT			0.612+ [0.310]				
TSIX-HT				0.521** [0.166]			
TCAX-LT					-0.136 [0.084]		
TCAX-MT						0.150** [0.052]	
TCAX-HT							0.096** [0.031]
Intercept	6.385** [0.422]	7.473** [0.474]	6.458** [0.427]	6.655** [0.426]	6.699** [0.458]	6.705** [0.432]	6.546** [0.422]
Observations	219	219	219	219	219	219	219
Countries	32	32	32	32	32	32	32
R^2	0.479	0.505	0.465	0.481	0.461	0.478	0.48
F-statistics $H_0 : \beta_i = 0$	84.88**	94.30**	80.35**	85.85**	79.19**	84.53**	85.27**
F-statistics $H_0 : u_i = 0$	17.24**	19.84**	10.35**	10.07**	09.37**	15.03**	08.27**

Notes: Significant at the levels ** 1%, * 5%, + %10 (standard errors are in brackets).
Abbreviations: CAPINT: Capital Intensity; SPECQ: Specialisation in Production; SPECX: Absolute Specialisation in Export; TSIX: Technological Specialisation in Export; TCAX: Comparative Technological Specialisation in Export; LT: Low Technology; MT: Medium Technology; HT: High Technology

that productivity increase for the countries which increased the exports of medium and high technology sector at an above the world average, i.e. the economies that rise the comparative advantages. On the other hand, the effect of having comparative advantage in export for the low technology industries on the productivity is negative, but not statistically significant.

6. Conclusion

In this study the relationship between productivity of manufacturing industry, which is one of the most important determinants of economic growth performances of countries, and specialisation in production and trade and/or comparative advantages is analysed. In particular, in the study shows either "*absolute specialisation*" or "*technological specialisation*" in both production and is more important for clarifying productivity differences in manufacturing industry among countries;

For the period 1981-1985, descriptive analyses of the world production and export demonstrates that about 55%, 25%, 20% of the world production are produced by low, medium and high technology intensive industries, respectively. Our findings show that this structure changed in the 2000s; and the shares of medium and high technology in production structure increased besides there was a decrease for low technology. Similar developments also occurred in trade. At the beginning of 1980s, 50% of exports in manufacturing industry is made by high technology intensive industries, while low and medium technology industries had the share 33 % and 17 %, respectively. In 2000s, however, we observed that export of goods produced by high technology intensive industries increased to about 58 %, while the share of low technology intensive products decreased to about 23 %. In this period, the share of the exports of medium technology intensive industries did not changed considerably. These results showed that trade structure of the countries transformed in favour of high technology intensive industries from 1980s to 2000s.

Our results show that Morocco, Egypt, Argentina, Jordan, Portugal and Turkey, Ecuador, Sri Lanka and Tanzania are the countries specialising in low technology intensive production in manufacturing. During this period, Korea, Malaysia, Malta and Singapore are the countries despecializating in low technology intensive production. The descriptive analysis shows that the exports Ecuador, Egypt, Sri Lanka, Argentina, Columbia, Morocco, Tunisia and Turkey are low technology intensive.

The most specialized countries in medium technology intensive industries in manufacturing are Mexico, Germany, France and Canada. The least specialized countries are Malta, Finland, Cyprus, Ecuador, Sri Lanka and Tanzania. Between two periods, the share of medium technology sectors in manufacturing industries increased in France, Germany, Mexico; and the shares decreased for Australia, Egypt, Hungary and Morocco.

It is observed that the share of high technology production in manufacturing industry is high for Singapore, Malta, Malaysia, and Hungary. The share of these industries, on the other hand, are very low in Columbia, Costa Rica, Cyprus, Ecuador, Jordan, Morocco, Sri Lanka, Tanzania, Argentina, Mexico, Indonesia, Iran, Egypt, Tunisia and Turkey.

Technological structure of export is not different from the production. The exports of Japan, Malta, Singapore, Malaysia and Mexico are composed mainly of high technology intensive goods. The shares of export of high technology intensive industries in manufacturing are very low for the countries Chile, Columbia, Ecuador, Egypt, Jordan, Morocco, Sri Lanka, Argentina, Tunisia, Indonesia, Turkey, and India. From 1980s to 2000s, it is seen that the countries Korea, Malaysia, Malta, Mexico, and Finland increased the high technology intensive exports.

Correlation analysis demonstrates that there is a positive relation between labour productivity and absolute specialization in both production and export. However, correlation analysis also shows that there is a negative relation between productivity and specialization in

low technology industries, while there is a positive relation between productivity and specialization in medium technology industries. This result is very important and it points out that the economies having higher labour productivity in manufacturing industries have comparative advantages in medium technology intensive production and export. Finding a significant and positive correlation between specialization in production and specialization in export can mean that specialization in production leads to specialisation in export.

The results of estimated *fixed effects* model demonstrate that absolute specialization in production is a labour productivity enhancing factor. This means that the countries with higher specialization are more productive, without considering the characteristics of specialization. More importantly estimation results revealed that there is a negative relation between specialization in low technology sectors and productivity, but a positive relation between specialization in medium technology industries and labour productivity. This result is also true for comparative advantages.

Contrary to the production, the impact of absolute specialization in export on the productivity is found as negative. This result demonstrates that there is a reverse relation between specialization in export and labour productivity. This finding shows the importance of export diversification in productivity increase.

Finally; estimation results demonstrates that there is a positive relation between productivity and export concentration in medium and high technology industries, besides that intensity of export in low technology sectors negatively affects the productivity. These findings are consistent with the results when it is measured for comparative advantages specialization index.

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