Universidade de Aveiro Departamento de Economia, Gestão e Engenharia Industrial
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Gonçalo Ferreira da Silva Alves

Determinantes de Exportações de alta tecnologia

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Dissertação apresentada à Universidade de Aveiro para cumprimento dos requisitos necessários à obtenção do grau de Mestre em Economia, realizada sob a orientação científica da Doutora Celeste Maria Dias De Amorim Varum, Professora Auxiliar do Departamento de Economia, Gestão e Engenharia Industrial da Universidade de Aveiro.

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agradecimentos

Gostaria de evitar o cliché da dificuldade na realização da “minha tese de Mestrado”… contudo, não o posso evitar. Mas como toda a moeda tem duas faces, com a dificuldade da sua concepção vem o orgulho e satisfação de dever cumprido. A quem agradecer? Decerto que necessitaria de uma extensão semelhante a uma Tese de Doutoramento para agradecer a todos. Assim sendo, estão todos incluídos, mas quero vincar o contributo de certas pessoas na realização desta dissertação.

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palavras-chave

Paises em desenvolvimento, paises desenvolvidos, exportações de produtos de alta técnologia, sofisticação das exportações, *processing trade*.

resumo

Um facto que tem vindo a ser estudado na literatura é a constatação do aumento das exportações de produtos intensivos em tecnologia por parte dos países em desenvolvimento. Associado à existência de mão-de-obra barata, os países em desenvolvimento, como é o caso da China, estão a aumentar a sua quota de exportações de alta tecnologia sem uma pré-evidência de um aumento das suas capacidades endógenas. Nesta dissertação, analisamos os determinantes das exportações de alta tecnologia dos países em desenvolvimento e dos países desenvolvidos.

Especificamente, testamos se os determinantes dos países em desenvolvimento estão mais associados com o aumento das suas capacidades endógenas ou à possível ligação com o fenómeno de *processing trade*.

A análise empírica é conduzida com dados do: World Bank, World Trade Organization e as Penn World Table das quais podemos obter uma amostra de 71 países, dos quais 38 são países em desenvolvimento e 33 pertencem ao grupo dos países desenvolvidos.

Através de técnicas de dados em painel, corremos regressões para um espaço temporal de 1996-2006 de modo a identificar os principais determinantes de exportações em alta tecnologia de ambos os grupos de países.

Sumariamente, identificamos que os países desenvolvidos aproveitam mais intensamente as suas capacidades endógenas de modo a aumentar a sua competitividade nas exportações em alta tecnologia. Por outro lado, os determinantes dos países em desenvolvimento recaem mais sobre determinantes relacionado com actividades de *processing trade* como o impacto positivo do Investimento Directo Estrangeiro (IDE) e as importações de partes e componentes, e menos com um aumento das suas capacidades endógenas. A falta de capacidade por parte dos países em desenvolvimento pode ser ultrapassada com uma política forte do governo na performance de I&D. Neste caso, a economia poderá alcançar os restantes países apesar da sua desvantagem tecnológica inicial.

O assunto presente nesta dissertação tem relevância não só para os académicos e/ou investigadores da área, mas também para os governos em geral e em particular os decisores de políticas dos governos dos países em desenvolvimento.

keywords Developing countries, developed countries, high-tech exports, exports sophistication, processing trade.

abstract

A fact that has been studied in the literature is the increase of developing countries high-tech exports. The main driver of this trend is stressed to be the new technological “paradigm”. Developing countries associated with cheap-labour, like China, are increasing their share of high-tech exports without prior evidence of an upgrade of their indigenous capacity. In this dissertation we analyze the determinants of the high-tech exports of developed and developing countries and determine if the increasing share of high-tech exports from developing countries is more associated with the upgrade of their indigenous capacity or with the possible link to the processing trade phenomenon.

The databases used for the empirical analysis are the World Bank database, World Trade Organization and Penn World Tables, from which we were able to obtain a sample of 71 countries, from which 38 are developing countries and 33 belong to the developed group.

Using panel data techniques, we apply the regressions for the time span of 1996-2006 to identify the major determinants of high-tech exports for both groups of countries.

Overall, we identify that developed countries rely more heavily on their indigenous capabilities in order to gain high-tech exports competitiveness. On the other hand, developing countries rely on determinants related to their involvement on processing trade activity, like the positive impact of Foreign Direct Investment (FDI) and the imports of parts and components, and less on upgrade of their indigenous capabilities.

The subject discussed along this dissertation has importance, not just for academic and researcher purposes, but also for governments in general and particularly for policymakers of developing countries.

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CHAPTER 1

INTRODUCTION AND RELEVANCE OF RESEARCH QUESTION

A fact that has been studied in the literature is the increase of developing countries high-tech exports. The main driver of this trend is stressed to be the new technological “paradigm”. This paradigm can be defined by the emergence of new technologies and skills in the traditional sense but also the new work methods and management techniques (Lall, 1998). As stated by The Economist (2010), the emerging world is redesigning not just products but the entire production processes to satisfy the needs of some of the world’s poorest people. Even so this intrusion of developing countries in developed countries premier products is not new, with Japan replacing many American car makers in 1980, the paradigm seems to be happening again. Developing countries associated with cheap-labour, like China, are increasing their share of high-tech exports without prior evidence of an upgrade of their indigenous capacity. In this dissertation we will attend to analyze the determinants of the high-tech exports of both group of countries and determine if the increasing share of high-tech exports from developing countries is more associated with the upgrade of their indigenous capacity or with the possible link to the processing trade phenomenon.

The process of globalization and the free to move labour and capital across the globe should be reducing the disparities across countries rather than increment them. The increase of high-tech exports performed by developing countries is not a homogenous trend across the developing world. This trend is highly concentrated in few developing countries from South-East Asia like China, Malaysia, Thailand and Indonesia. Even so, the referred trend for developing countries was firstly found for the South-East Asian countries like Singapore, Korea and Hong Kong, although these countries are not considered developing countries anymore[1].

It is denoted by the review on high-tech products classifications made by Peneder (2003) the differentiation of high-tech and low-tech products in the technological-intensive

[1] According to World Bank criteria, developed countries are considered to be those which belong to the high-income group – countries whose GNI per capita was superior to $11,909.

content contained in each group of products. Since developed countries are more endowed with technology and skill capabilities and developing countries are endowed with cheap and unskilled labour abundance, the increment of the high-tech products exports made by developing countries seems a contradiction with prior expectations and theoretic models like the Heckscher-Ohlin (H-O) theory (Keesing, 1966).

The current literature on this thematic often defends that the increment of high-tech exports of developing countries is due to the phenomenon of "processing trade", where developing countries import parts and components with technological-intensive content, from developed countries, to then process and assembly in labour-intensive processes, and lastly export again to the world (Cui and Syed, 2007). The growth of this phenomenon is possible as a result of the slicing up of the global chain and the intra-trade between firms in intermediate goods (Krugman, 1995).

Considering the reviewed literature, the high-tech exports made by developed countries rely deeply on their indigenous capabilities contrary to developing countries that rely more on their abundant cheap labour to focus on the final stages of production of some high-tech products, which are labour-intensive segments. It is also argued that the foreign presence in developing countries boosts the processing-trade activities in this type of countries (Porter et al., 2001). Archibugi and Pietrobilli (2003) denote the scarce of technology and innovation activities from developing countries, which increases the expectation that these countries are mainly specialized in less technology intensive segments of production of high-tech products.

The present study intends to contribute to the existing literature by applying an econometric analysis of this problematic using a large panel of countries, comprising developed and developing countries to infer about the differences in determinants of high-tech exports between these two groups of countries. To the best of our knowledge there is no other econometric study on this problematic using such a large sample of countries to study this problematic. The main empirical approaches available in the literature are concentrated in the Chinese case (e.g. Rodrik, 2006; Cui and Syed, 2007; Huang et al., 2008; Xu and Lu, 2009). The classification of this problematic is still important The Economist (2010) notices the clear effort of emerging economies on innovation and management skills but states that these countries continue to rely on cheap labour rather than innovation to drive their growth.

The data used in this work were obtained from three databases that will be covered along the chapter 3 and chapter 4: World Bank Database, World Trade Organization and Penn World Tables. The use of these three databases is explained by the restrictions that every database contains, namely the fact that each database does not contain all the variables needed to carry on this econometric study. Our final sample is composed by 71, which are divided into 33 developed countries and 38 developing countries.

The Table 1.1 presents the outline of this dissertation. After this introduction, in Chapter 2 we will present a survey of some theoretical models that would contradict the urge of developing countries in high-tech exports. The taxonomies of high-tech products will be briefly reviewed, highlighting some limitations of these classifications. The phenomenon of fragmentation and processing trade is also discussed. Then a review of the findings from descriptive studies and empirical studies is wielded in order to cover the variables that could explain the patterns of exports from developed and developing countries in what concerns high-tech exports.

Table 1.1 Outline of the content of the dissertation

Chapter 1	Introduction
Chapter 2	Introductory background (**2.2**) Fragmentation and Processing Trade (**2.3)** Low Developed Countries in Developed Countries World (**2.4**)
Chapter 3	Databases and Countries (**3.2)** Descriptive Analysis (**3.3)** Computation of export's Sophistication through EXPY index (**3.4)**
Chapter 4	Methodological Issues (**4.2)** Determinants of high-tech exports: all countries (**4.3)** Determinants of high-tech exports: Developed vs. Developing countries (**4.4)**
Chapter 5	Conclusions and Policy Implications

The Chapter 3 introduces the databases used in this dissertation and the classification of high-tech products, as well as the countries included in this study. In addition, some descriptive statistics are presented, in order to capture the facts and trends. More precisely, we look at the evolution of high-tech exports from developed and developing countries, first through the analysis of the shares of high-tech products in total exports of both countries, secondly through the Balassa index and finally, through a more sophisticated index: the EXPY index.

After the descriptive analysis presented in Chapter 3, an econometric study is conducted in Chapter 4. The methodological issues are presented and then the regressions are applied, first to the whole sample, and second separately to the samples of developed and developing countries, in order to capture the differences in the determinants of high-tech exports of these two groups. The Chapter 5 concludes and presents the policy implications.

CHAPTER 2

LITERATURE REVIEW AND DEFINITION OF THE RESEARCH QUESTIONS

2.1 INITIAL CONSIDERATIONS

Can developing countries catch-up developed countries in the exports of high-tech products? Are there theoretical models that predict the exports of high-tech products from developing countries, or are these countries confined to export low-tech products? Which products can be considered high-tech products? Which are the determinants that developing countries are using to increment high-tech exports? Are they any different from the developed countries?

In this chapter, we overview these questions and explain them throughout the literature review presented in the next sections. The H-O theory is static in time and assumes that every country has the same production function, which allows export specialization to be different, is the capital-labour ratio endowments between countries (Keesing, 1966). However, Fagerberg (1996) states that the innovation and indigenous Research and Development (R&D) may influence the trade performance of a country and enhance its economic performance. Hence, the ability of a country to overcome its scarce endowments in skill and technology is a trade-off between the investments in R&D or continue to rely on cheap and unskilled labour.

The principal taxonomies used to classify products into high-tech and low-tech products are based on R&D content of the products. As a result, high-tech products are those ones with higher R&D content (Peneder, 2003). Hence, a reason for a country to produce high-tech products is advanced by the empirical study of Kaplinsky and Paulino (2005) with the analysis of unit price trends, where they conclude that the probability of prices falling are more reduced as higher is the innovation content on them.

In this chapter we also present the phenomenon of processing trade and its role in the increase of high-tech exports from developing countries. With the increment of processing trade, developing countries can focus their competitive advantages in the segments of production where those capabilities are more intensive. The high-tech products, especially the electronics and electrical goods, are labour-intensive products in the final stages of production, through the functions of process and assembly of parts and components. The developing countries can use their vast cheap-labour, in addition to their processing and assembling of parts and components into the final products and export them as their own high-tech products.

Based on the facts here presented, we review the main implications of the current problematic in order to perform an econometric study to infer about the possible determinants of high-tech exports of both groups of countries. Next sections are organized as follows: in section 2.2 we introduce this problematic by evoking the main theoretical contributes from International Economics, namely the H-O theory and the North-South models. In section 2.3 we present the problems raised by taxonomies of high-tech products. Section 2.4 introduces the debate on fragmentation and processing trade phenomenon. In section 2.5 we go beyond into this topic, by exploring the most recent contributes of the literature on this matters, first by presenting the different indexes recently used to search for evidence of a processing trade phenomenon among developing countries and second by surveying the main results from empirical literature, either from purely descriptive studies or those ones applying more robust econometric techniques. Section 2.6 concludes and delineates the hypotheses to be empirically tested.

2.2 INTRODUCTORY BACKGROUND

There has always been a craving for economic growth achievement by all countries. As can be noticed by the literature review made by Fagerberg (1996), innovation and indigenous R&D may influence the trade performance of a country and enhance its economic performance. Furthermore, the industries that support such relationship are found to be the chemical and machinery industries as well as instruments and computers industries.

In the traditional theory of comparative advantages, the Heckscher-Ohlin (H-O) theory did not account for technology and skills. Furthermore, one of the assumptions of the model was that all countries possess the same production function. The differentiation between countries would be their capital-labour ratio, with developed countries being endowed with capital-intensive techniques and developing countries being endowed with labour-intensive production methods. Consequently, after the countries’ choice, there was no effort or learning process and thus countries would not be able to achieve greater development than that they had already achieved (Keesing, 1966). As denoted by Feenstra (2004), the H-O theory, by assuming that factor endowments are the main purpose for trade between countries it fails to present a good performance in practice. Even so, despite the assumptions of these theories seem to be reasonable, they cannot explain both the historical and modern trade patterns unless we allow for technological differences across countries.

Towards a more dynamic approach of the interactions in trade dynamics, Lu (2007) presents us a theory based on North-South models. In the dynamics of old technology and new technology, the technological leader – which is assumed to be a developed country (North) – loses his primacy in face two options: "moving-in" or "moving-out". The "moving-in" option accounts for a counter R&D investment to create a newer technology to take the lead again and stay with his business in the North. The "moving-out" option accounts for the displacement of the activity from the North to the South through Foreign Direct Investment (FDI) towards developing countries. This option allows a larger length of his current technology as the leader is going to compete with developing countries – South - which do not possess the most advanced technology as do the North countries.

Based on these theoretical contributions, it is clear that developing countries may face a trade-off between specializing according to the existing comparative advantage – in low-technology goods – and entering sectors in which they currently lack a comparative advantage, but where they may acquire such an advantage in the future as a result of the potential productivity growth – in high-technology goods (Redding, 1999).

2.3 Fragmentation and Processing Trade

Krugman (1995) presents an overview of the growth of world trade since 1850 to 1993 identifying two of four new aspects of modern world trade the intra-trade and the slicing up of the value chain. The intra-trade is reliant on the complex process of manufacturing of today's standards, which not only are more finely differentiated, but also involve the use of a much greater variety of specialized intermediate goods. The intra-trade phenomenon consists basically in the trade of intermediate goods between industries. The second phenomenon is the slicing up of the value chain, where the specialization of different countries in different phases of production can lead to a final product being exported many times during their intermediary phases. More precisely, a good that is produced in one country may be assembled from components produced in other countries and, further on, sub components can be assembled elsewhere.

Hummels et al. (2001) highlight the increasing connection of production processes in a vertical trading chain, which extends across many countries, with each country specializing in particular stages of a good's production sequence. This is known by "vertical specialization". Nonetheless, this phenomenon can be found in the literature also as "outsourcing", "disintegration of production", "fragmentation", "multi-stage production", "intra-product specialization" and "processing trade" (Hummels et al., 2001; Cui and Syed, 2007). Lall et al. (2004) present a definition of fragmentation as the ability to competitively make not the whole product but selected segments of the value chain. Although, this process can be referred in so many ways, we will refer it as "processing trade". In order to give a proper definition of processing-trade, we next present some definitions found in the reviewed literature:

"...factories assemble and process imported inputs from the West and other parts of Asia into final goods to be sold abroad (often referred to as "processing trade")..."

Cui and Syed (2007)

"...Processing exports are characterized by imports for exports with favourable tariff treatment: firms import parts and other intermediate materials from abroad, with tariff exemptions on the imported inputs and other tax preferences from local or central governments, and, after processing or assembling, export the finished products to the international market…" Koopman et al. (2008)

"...exports involve contracting manufacturing in China for goods that are designed elsewhere. This phenomenon is known as "processing trade", and involved importing inputs into China, which are assembled there and then exported again" Feenstra and Wei (2009)

The main reminder from the above definitions is that processing trade is a phenomenon where the skill-intensive parts and components are imported and then processed and assembled in a low skilled and cheaper labour country. This process can only be done due to the vertical international disintegration of production processes, which can make each country, specialise itself in some stages of the production chain. The production chain, although different across products, has skill-intensive stages and labour-intensive stages (low skill stages), where countries, which are on processing trade, import the parts and components from countries specialized in skill-intensive stages and assemble them in the labour-intensive stages (which are the last stages) to re-export again as final products. This process leads to the specialization by countries in certain stages of production but not in the production of a particular good. Figure 1 gives an illustrative definition of processing trade.

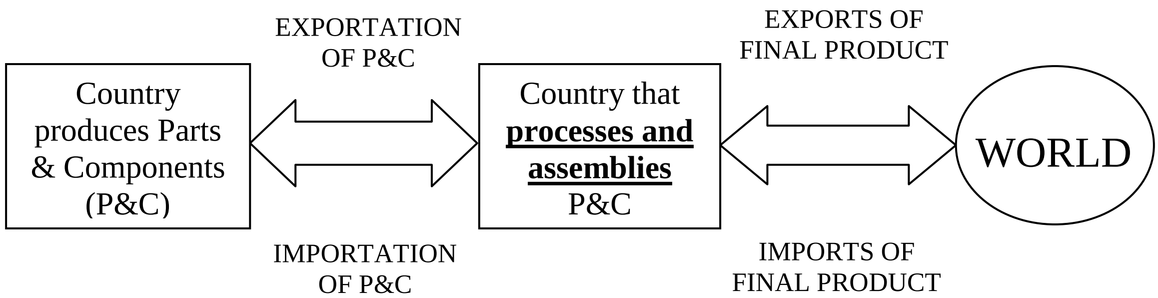

Figure 2.1 Illustration of the processing trade phenomenon

Lall et al. (2004) report the increase of the Global Production Networks (GPN) which are international systems set up to optimise production and other factors by locating products, processes or functions in different countries to benefit from cost, technological, marketing, logistic and other differences across countries' current endowments. The size and dynamism presented by GPN may create and transform the export and industrial structures of the insider countries.

2.4 Low Developed Countries in Developed Countries World

The awareness of the high-tech exports by Low Developed Countries (LDC) was brought by Lall's (1998) study, where he denotes the changing of high-tech exports from Developed Countries (DC) to Low Developed Countries (LDC). He states that LDC have moved away from traditional resource and labour-intensive products to high-technology manufacturing. Although this statement is quite aggressive, his study was focused on the "emerging Asia" which comprises the East Asian countries, with the exception of Japan. He denotes that the reduction of transport and communication costs have enabled the reordering of comparative advantage between countries. His article indicates that the transfer of new technologies is made by individual firms which learn, adapt and improve the new technologies to create new knowledge. Concerning the developing countries' experience, the main conclusion of Lall (1998) is the concentration of high-tech exports mainly on electronics and electrical assembly activity, for instance, in Malaysia. Similarly for Singapore, high-tech exports are mainly driven by Multinational Enterprises (MNEs) that use higher levels of sophistication, more advanced skills and incorporate more local technological activity. Even so, the phases of design and development are made overseas by the MNEs involved. The most developed countries in terms of technological capabilities were found to be Korea and Taiwan, with Korea positioned ahead of Taiwan.

The export performance of East Asian countries has brought much research on export performance with the East Asian countries as the central focus of research (e.g. Lall, 2000; Mani 2000; Srholec, 2007; Wang and Wei, 2008; Yao, 2009). The main conclusion of the intrusion of LDC in high-tech exports is that LDC are currently established in low-value added phases of the global production chain of some high-tech products like the electronics. Therefore, in the next sections we aim to present the methodological issues of the literature and the indexes that measure comparative advantage and also discuss in what extent they can capture the fragmentation of production.

2.4.1 Methodological issues

2.4.1.1 How to measure sophistication of exports?

In order to obtain consistent results on countries technological capabilities, the researchers have been using some well known competitiveness indexes like the *Revealed Comparative Advantage (RCA) Index,* used by Lall (2000), Mani (2000), Lemoine and Ünal – Kesenci (2004) and Adams et al. (2006). Other index commonly used is the *Lafay Index* applied by Marconi and Rolli (2007) who argue that it is a better index to use for fragmentation of production than the *Balassa index*. Lall et al. (2006) and Rodrik (2006) use more complex indexes in order to uncover the real sophistication of exports made by countries, namely the *Sophistication index* and the *EXPY index*, respectively. We will next explain the major goals and methodology of these indexes.

A. *REVEALED COMPARATIVE ADVANTAGE INDEX*

The RCA index measures the world market share of a given exporter in a particular product or product group relative to its market share for all products (Lall, 2000). To make the index witness the comparative advantage from one country to another the share of export of a product group of a country is then divided by its total share of world exports (Mani, 2000; Fernandes, 2008).

The formalization of the RCA, for high-tech products (ht), is as follows:

$$RCA_{cht} = \left(\frac{X_{cht}/\sum X_{ct}}{X_{wht}/\sum X_{wt}}\right)$$

Where *c* stands for group of countries and *w* for the world trade.

The values of this index vary from 0 to ∞, but when the index is higher than 1, it can be said that particular country has a revealed comparative advantage relatively to another country.

Another characteristic of RCA is that it is static, but can be transformed into a dynamic index by focusing on comparisons over time and in terms of rate of change (Adams et al., 2006). The problem that RCAs also faces is the current fragmentation of production in some industries, where a country can have a comparative advantage in a segment of production of a product but not in all of the segments of production of that product (Baldone et al., 2001; Lemoine and Ünal-Kesenci, 2002). In order to achieve accurate conclusions about the state of fragmentation of production in a particular country, this index is used by stages of production to observe for patterns of fragmentation.

The vertical specialization that some countries exhibit occurs when countries possess comparative advantages on some stages of production, and do not have comparative advantages in the remainder stages of production of the same product. The major outline of comparative advantages of LDC on high-tech exports has been in owning comparative advantages in latter stages of production, but a huge deficit in parts and components of the respective product. If we look through the import side we can observe this pattern by screening a comparative advantage in imports of parts and components and a “deficit” in later stages of production (Lemoine and Ünal-Kesenci, 2004).

B. *LAFAY INDEX*

The fragmentation of production has taken global dimensions with different parts of production taking place in different countries. The main limitation of the RCA index in this context is that it loses some veracity with fragmentation of production. In this case, Lemoine and Ünal-Kesenci (2003) and Marconi and Rolli (2007) argue that the use of the Lafay index is better than the *Balassa* index because it takes into account not only export shares, but also on the imports' information. The Lafay index is based on net trade flows and is therefore more suitable to deal with the problem of fragmented production (Marconi and Rolli, 2007).

The specification of the Lafay index is as follows:

$$LA_i^c = \left(\frac{x_i^c - m_i^c}{m_i^c + x_i^c} - \frac{\sum_{i=1}^n x_i^c - \sum_{i=1}^n m_i^c}{\sum_{i=1}^n x_i^c + \sum_{i=1}^n m_i^c}\right) \times \frac{m_i^c + x_i^c}{\sum_{i=1}^n x_i^c + \sum_{i=1}^n m_i^c} \times 100$$

where x_i^c and m_i^c are total exports and imports of product *i* by country *c* and the sum terms over the *n* products are total manufacture exports and imports (Marconi and Rolli, 2007).

When it comes to the interpretation of the index is has some differences from the Balassa index relatively to the values that the Lafay index can assume. The index takes negative and positive values when the country has a comparative disadvantage or a comparative advantage, respectively. According to Marconi and Rolli (2007), the values goes from -50 (full despecialization) and +50 (full specialization). By definition, the sum over all products is zero.

C. *SOPHISTICATION INDEX*

The Sophistication index was introduced by Lall et al. (2006) with the assumption that an export is more sophisticated the higher the average income of its exporter. They assume that higher income countries possess superior embodiment of technology as an important determinant. The index can be used with different degrees of data desegregate level, but the more disaggregated data is used the more likely it will be that differences in the index reflect differences in technological depth rather that other location-specific factors.

The values of the sophistication index vary between 0 and 100. Being specified as follows:

$$SI(i) = 100 \times \frac{\left(US(i) - US(\min)\right)}{US(\max) - US(min))}$$

where *SI* is the normalized sophistication index of product *(i)*, US is the unique sophistication score as a dollar value for product *(i)*, US*(max)* is the maximum unique sophistication dollar value for all products, and US*(min)* is the minimum unique sophistication score dollar value for all products.

To account for the fragmentation of production, Lall et al. (2006) state that a combination of high-technology and low levels of sophistication is an indication of fragmentation of production, specific natural resource, logistical, or other needs that are out of reach of poorer countries. Its main advantage is that it can be calculated at any level of detail and for any period. Its main disadvantage is that it is not a specific technology measure, so it captures many other factors affecting export location, and care is needed in interpreting the results.

D. *EXPY INDEX*

The EXPY index was created by Rodrik (2006) and it is a measure calculated from export statistics, aiming to capture the productivity levels. The construction of this index is made by steps. First it is constructed an index named PRODY, which corresponds to a weighted average of the per capita GDPs of countries exporting a given product, representing the income level associated with that product. The formula of PRODY is as follows:

$$PRODY_k = \sum_j \frac{(x_{jk}/X_j)}{\sum_j (x_{jk}/X_j)} Y_j$$

Where x_{jk}/X_j is the value-share of the commodity in the country's overall export basket. The denominator aggregates the value-shares across all countries exporting that good. The weighted average corresponds to the revealed comparative advantage of each country in good *k*, which is then multiplied by per-capita GDPs giving a weighted average of per-capita GDPs.

EXPY is then calculated through the formula:

$$EXPY_i = \sum_l (x_{il}/X_i)\ PRODY_l$$

where the weights are simply the value shares of the products in the country's total exports, giving the productivity level associated with the country's export basket.

Yao (2009) disagree about the use of GDP per capita as a measure of human capital. Even more, he argues along the premise of following the thought that higher income countries will have more sophisticated exports which is not a linear fact. This argument can also be used to criticize the Sophistication index of Lall et al. (2006) although it is not mentioned by Yao (2009), Actually, there is not much to be surprised with the lack of critics to Lall et al. (2006) index, since it is cited only 4 times against 13 times of Rodrik (2006)[2]. This result demonstrates a less exploration of the Sophistication index of Lall et al. (2006) when comparing to the EXPY index of Rodrik (2006).

2.4.1.2 Problems raised by taxonomies

The term "technology" is quite used in countless economic literature. Nevertheless, its meaning can vary according to different researchers and its precise definition can raise some research problems. Consequently, there are numerous definitions of "technology" which can lead to different results according to the definition used by each researcher. In this study, the distinction that we want to achieve is the classification between low-tech and high-tech products.

The increase in the number of classifications of high-tech products had its peak in the 1990's, when a new classification emerged based on subjective experts' opinion (Peneder, 2003). It is clear that the main differentiation between low-tech and high-tech products is the technological-intensive content contained in each group of products. Such a classification can provide a simple and consistent approach for international comparisons, but the effectiveness of the results are limited to the degree of disaggregation of the data available (Hatzichronoglou, 1997; Peneder, 2003). Another limitation that needs to be noticed is the non-retrospective of the estimations of embodied R&D between a couple of

[2] Based on the number of citations of each article in ISI Web of Knowledge.

decades, where many of the items that were considered high-tech in the earlier decades are unlikely to be considered high-tech in the most recent decades (Mani, 2000).

Mani (2000) uses the classification of high-tech products of Hatzichronoglou (1997), which compromises the categories of aerospace, computing and office equipment, electronics and telecommunications, electrical equipment and some non electrical equipment, scientific instruments, chemical products, pharmaceutical and armaments which include the main categories most commonly accepted in the literature (e.g. Lall, 2000; Srholec, 2007; Huang et al., 2008).

However, it is noticed by several studies the concentration of developing countries on exports of high-tech products. Nevertheless, these countries are also more prone to the production fragmentation, so that their high-tech exports may not be a signal of technological competences (e.g., Lall, 1998, 2000; Mani, 2000; Mayer et al., 2003). The category of high-tech products more likely to suffer from fragmentation of in their production are electrical and electronic products. Accordingly, Lall (2000) carries out a distinction among high-tech products, isolating electrical and electronic products from other high-tech products (e.g. aerospace, pharmaceutical, chemical products). As a result, the future analysis will bear this fact in consideration.

The other problem raised by taxonomies is the categorization of countries in developed and developing countries. The study of Fernandes (2008) which attempts to update the data of Mani's (2000) study, encounters the problem that some of the developing countries of Mani's study are now considered developed countries, such as Singapore and Korea. As the classification of products, the categorization of countries is subject to revision over time. This problem is more problematic when comparing studies from different time periods. In the literature, this topic is not discussed as the authors keep referring developed and developing countries without the specification of the criteria used.

2.4.2 EVIDENCE FROM EMPIRICAL LITERATURE

2.4.2.1 Evidence from descriptive studies

A. *INCREMENT OF DEVELOPING COUNTRIES HIGH-TECH EXPORTS AND THE CONCENTRATION IN EAST ASIAN COUNTRIES*

The increment of the high-tech exports of developing countries was not disregarded. In fact, due to this reality, there were several investigations conducted to study this trend. Lall (1998) focused his attention on the high-tech exports of developing countries. The study was conducted to a sample of 10 East Asian countries and verified the increasing role of developing countries in high-tech exports, with Korea standing out as the high-tech exporter. With a larger sample, Mani (2000) differentiates developing from developed countries and also denotes the rise of high-tech exports from developing countries. It is noticed that three quarters of the total high-tech exports are supplied by 10 countries, 5 of with are developing countries. Lall (2000) finds that for the period of 1985-1998 growth of high-tech exports was higher than developed countries, 21.4% versus 11.3%, respectively. The findings of Mayer et al. (2003) also indicate a high portion of developing countries in dynamic products, nonetheless developed countries account for almost 90% of the total export value in eight products that require high R&D expenditures. Srholec (2007) also refer the growth of high-tech exports, more precisely in electronic products, from developing countries.

More recently, Gallagher and Porzecanski (2008) and Fernandes (2008) also state that developed countries have lost substantial market share to the developing world, especially in the high-tech sector.

Although there has been a quite growth in developing countries high-tech exports, they are fairly uneven in the main developing countries exporters and high-tech products exported. High-tech exports are concentrated in East Asian countries and main high-tech products exported by developing countries are mainly on electrical and electronic products. According to the Average Export Intensity[3] calculated by Mani (2000), the top 5 high-tech exporters from developing countries are Singapore, Malaysia, Philippines, Thailand and Korea, in ranking order. On the other side, the 5 developed countries are Ireland, USA, Japan, UK and Netherlands. Furthermore, it is noticed that the first 2 developing countries

[3] Average during the period 1988-1998

(Singapore and Malaysia) have an Average Export Index higher than the first ranked developed country (Ireland). Lall (2000) encounters almost the same ranking in developing countries with the exceptions that Taiwan exports more than Thailand and Korea is found at the sixth place.

Porter et al. (2001) declare that high-tech exports ‘belonged to’ the OECD countries. However, their results point for a real competition from Malaysia, Singapore, China, Taiwan and South Korea, which were among the ‘Top 10’ high-tech exporters in 1997

Srholec (2007) states that China has already overtaken some of the developed countries like Ireland in R&D intensity.

Gallagher and Porzecanski (2008) study the climbing up the technological ladder of the Latin-American and the Caribbean (LAC) and China, as they have moved away from low-tech exports to medium-high-tech exports. They also stress the evidence that China is exporting more products to the LAC than importing from them.

Fernandes (2008) finds that the Top 5 of average export intensity[4] from developing countries are Philippines, Malaysia, Hungary, China and Mexico, which 3 of 5 are East Asian countries.

Hausmann et al. (2005) find a high significance and positive correlation between EXPY and per-capita GDP, indicating that rich/poor countries export products that tend to be exported by other rich/poor countries. Rodrik (2006) states that China stands out from the traditional economic theory by having an export structure with labour-intensive exports, for instance toys, garments and simple electronics assembly. However, China also exports a wide range of highly sophisticated products. Rodrik (2006) declares that China has an export structure of a country with an income-per-capita level three times higher than China’s. Rodrik (2006) uses the EXPY index to attend for the sophistication of exports of China. The author argues that Bangladesh has a similar set of relative factor endowments – abundant in labour and scarce in human and physical capital – presenting a 50% EXPY index lower than China. South Korea and Hong Kong have greater EXPY values but the catching up accomplished by China has steadily closed over time.

[4] Average during the period 2001-2005

B. *MEASURING SOPHISTICATION*

Mani (2000) uses the RCA in order to measure the competitiveness of the high-tech exports from developing countries. The first conclusion from the appliance of the RCA index is that developing countries are more competitive than the developed countries, especially since the mid-90s. Moreover, the Singapore and Malaysia were the ones with the highest RCA from the developing countries' set in 1998. Furthermore he found that the ratio of high-tech exports from developed countries possess a positive but declining ratio, while developing countries present a negative but increasing ratio. The main developing countries that stand out were Singapore, Malaysia and Korea. This finding is not supported by Fernandes (2008), who encountered a change on the trends of these two groups of countries. Developed countries have a higher net export ratio than developing countries and it is positive until 2003. However since then both groups exhibit a negative ratio. No catching-up is observed in the Fernandes' (2008) study, firstly because of the time period and the main high-tech exports from developing countries in Mani's (2000) are now considered developed countries and by that their performance do not contribute to the overall performance of developing countries.

Fagerberg and Srholec (2007) identify a technological competitiveness[5] catching-up effect among Taiwan, Korea, Turkey, Malta, Cyprus and Portugal in which only Malta and Cyprus were considered developing countries. They also identify the countries that had already a solid technological competitiveness and are further enhancing their capabilities. The number of countries in this group is 24 and all belong to the set of developed countries[6].

The study of Lall et al. (2006) constructs the *Sophistication index* to account for the sophistication of the countries' exports. The *Sophistication index* is obtained for two periods of time, 1990 and 2000. The country that stands as the leader in 2000 is the United States, with Japan and Germany in the second and third positions, respectively. For the set of developing countries, the leading country was Singapore[7] with Mexico following behind

[5] Technological competitiveness is defined by Fagerberg and Srholec (2007) as the ability to compete successfully in markets for new goods and services. The technological competitiveness was measured by patent statistics, articles published in scientific and technical journals and the number of telephone mainlines per head.
[6] All countries belong to the high-income classification of World Bank
[7] Note that in 2000 the country was a developing country.

in the eighth position. In Table 1.1 is presented the some rankings of this study are presented.

It can be noticed that in 2000 almost all countries had a low *Sophistication index*. The only exception was Philippines, whose export structure moved from apparel and other low technology items to semiconductors and automotive components. In terms of predicted values of the index, the United States and Japan had lower values than those predicted, due to the large share in their exports of fragmenting products such as electronics. Nevertheless, the United Kingdom and Germany, with stronger specialization in less fragmented products like pharmaceuticals, machinery, and automotives, have more sophisticated exports than those predicted by their incomes.

Marconi and Rolli (2007) applied the Lafay index to a set of emerging economies and used the high-tech classification of Lall (2000). In Table 1.2 we can observe some rankings in the comparative advantage of high-tech exports using the Lafay index for the period of 1999-2001.

It can be observed that 3 of the Asian Tigers have a clear international advantage in the exports of electrical and electronic exports, even more than the 3 developed countries of control. These results are in line with the previous studies reviewed that account for the developing countries performed better performance, when compared to developed countries.

As for the other products of high-technology, such as pharmaceuticals and aeronautics, it is not observed any international advantage among the emerging countries analyzed. Hence, the developed countries show a different result for this category. United States and Germany have an international advantage in this category and Japan presents an international disadvantage, though not too distant from Israel. Marconi and Rolli (2007) conclude by stating that East Asian countries have a better performance from their high and increasing international specialization in electric and electronic products. Even so, the majority of countries in their sample still have their revealed comparative advantage quite concentrated in low-tech-intensive goods.

Table 2.1 Country's export sophistication (ranked by 2000 index)

Score	Country	1990	2000
1	United States	84.44	74.83
2	Japan	85.14	74.62
3	Germany	83.87	74.57
...	...	...	...
7	Singapore	74.59	68.11
8	Mexico	80.38	67.42
9	Taipei, China	73.37	67.05
10	Republic of Korea	69.21	66.52
...	...	...	...
13	Philippines	60.53	64.08
14	Malaysia	68.08	63.43
...	...	...	...
17	Thailand	65.12	61.88
...	...	...	...
20	People Republic of China	65.04	56.55
...	...	...	...
25	Hong Kong, China	67.62	53.74
...	...	...	...
30	Bangladesh	46.62	35.64

SOURCE: Adapted from Lall et al. (2006)

Table 2.2 Ranking of the countries with high-tech export specialization (1999-2001)

HT1 – Electrical and Electronics		HT2 – Others	
Countries	**Lafay Index**	**Countries**	**Lafay Index**
Phillipines	11.4	Israel	-0.3
Singapore	6.0	Mexico	-0.4
Taiwan	4.7	Hungary	-1.0
...	...	...	...
India	-5.2	South Korea	-3.2
Brazil	-7.1	South Africa	-3.7
South Africa	-7.1	Taiwan	-4.0
Control		Control	
United States	1.0	United States	3.3
Japan	0.7	Japan	-0.5
Germany	-3.0	Germany	0.9

SOURCE: Adapted from Marconi and Rolli (2007)

C. *PROCESSING TRADE*

The direct impact of processing trade is that the international fragmentation of production chain can lead to misleading indicators of comparative advantage, which make difficult to directly observe the detailed mechanics of global production networks with comprehensive statistics (Ando and Kimura, 2003; Baldone et al., 2007).

Mayer et al. (2003) state that the three more dynamic products[8] are the electrical and electronic goods (including parts and components), goods from other technology-intensive industries, and labour-intensive products, particular clothing. The authors stress that the robust growth achieved by these three groups of products is probably an evidence of the deepening of the international division of labour, which has given rise to the increasingly internationalized production network. Hence, the few products where developing countries are more concentrated are precisely these three groups. Lall et al. (2004) compare the industry of electronics and automotive and concludes that electronics network is larger and more widespread in East Asian region. They also suggest that the main players in GPN are multinational enterprises appropriating favourable FDI policies from host countries. It is also noticed that global parts and components exports grow slightly faster than finished products (Li, 2002; Fan and Scott, 2003). Rasiah (2009) suggests that the electronic firms from Malaysian, Indonesia, Philippines and Thailand lack the embedding support from institutions to participate in knowledge-intensive activities. Korea, Taiwan and Singapore perform better concerning skill intensity[9] than the four countries mentioned above.

Lall (2000), Portet et al. (2001), Mayer et al. (2003), Lall et al. (2004) and Fernandes (2008) reveal the lack of diversity in high-tech exports from developing countries as they are mainly concentrated on electronics and it is mostly clustered in East Asian countries with China, India, Philippines, Thailand and Malaysia standing-out, although with a large portion of the high-tech exports made by multinationals enterprises. Brazil, Mexico and Turkey are the only developing countries that stand-out in their high-tech exports performance without belonging to the East-Asian geography. The concentration in electronics by developing countries as their high-tech sector of exports raises the question about the possibility of processing-trade.

[8] Mayer et al. (2003) define dynamism as the basis of past average export value growth of a specific product.
[9] Skill Intensity is proxied by the human capital in labour force – number of professionals, managers, technicians, engineers, foreman and machinists in workforce.

As already stated there has been a rather focus on the case of China in the processing trade phenomenon and in their ability to export high-tech products (e.g., Lemoine and Ünal-Kesenci, 2004; Gaulier et al., 2005; Rodrik, 2006; Vaidya et al., 2007).

Lemoine and Ünal-Kesenci (2004), Gaulier et al (2005), Adams et al. (2006) and Amiti and Freund (2008) assert that the specialization of China in assembly trade is due to its unlimited resources in cheap labour, which gives China a comparative advantage in labour-intensive products. It is also stressed that latecomers, such as China and other South East Asian countries, specialize in the assembly of the final products while more advanced countries supply the capital and technology-intensive intermediate goods, with the exports of China comprising a high import content. China has became an export platform for Asian industries at world markets such as the Taiwanese electronic and South Korean firms, with the Chinese policy of FDI and Chinese exchange rates as favourable determinants for the rising exports' sophistication of China. Nevertheless, the skill content of China's manufacturing exports remained unchanged once processing trade is excluded. Koopman et al. (2008) stress the low values of domestic value-added of China, stating that the indirect foreign value added content comes from directly imported foreign inputs. Regarding the high-tech export from electrical and electronic industries, the processing exports account for over two-thirds of the industries exports. These results suggest that the sophistication of China exports is a statistical mirage.

Vaidya et al. (2007) denote the non-existence of a single Chinese firm in the top 700 regarding research and development expenditure. It is also noted the shift of specialization in export specialisation towards high-tech sectors. Even so, the pharmaceuticals and aircraft are not well developed in China with the electrical and electronic products gaining momentum. However, these are the sectors where the foreign presence has more incidence.

Mani (2000) tests for the existence of a statistical artefact on these facts, since he accounts that, although semiconductor exports might involve a complex design and fabrication, the latter stages of production of these products do not require very high competences, technology or knowledge, as they are based on a relatively simple, labour-intensive assembly of imported components. The phenomenon where the parts and components are imported from one country to be re-exported as final goods has the designation of processing-trade. An additional suspicion of the evidence of processing trade is the concentration of developing countries' exports in a relatively small group of products. Developing countries are specialized in the exports of electronic items and office and computing equipments, while a dissimilar high-tech export structure is revealed by developed countries, as they have a much better distributed export structure. Consequently, to test for the lack of indigenous competences of developing countries, Mani (2000) draws on the patenting record of developing countries to measure the technological capability of the countries. With this criteria, it noticed the increasing rate of patenting growth of many developing countries in recent years, specially the case of Korea and Taiwan where the information technology patent issued had overcame the UK and Germany. Although it has been shown a quite performance from Singapore and Malaysia, these two countries do not show any evidence of patenting activity in the high-tech sectors. Consequently, Lall (2000) and Porter et al. (2001) state that the exports of high-technology products from these countries are largely contributed by multinationals with very little local R&D effort. Archibugi and Pietrobilli (2003) infer that the technology and innovation production from developing countries is still scarce. The scientific papers in journals are dreadfully concentrated in developed countries with 84% of scientific publications to 16% from developing countries. There is an exception represented by the East Asian Tigers (South Korea, Taiwan, Hong Kong, and Singapore, which have managed to generate a scientific output comparable to some OECD countries. Furthermore, patents are even more concentrated in developed countries with 96% belonging to this group. Fernandes (2008) also denotes that the group of pharmaceuticals and aerospace products, which are probably the two of the most knowledge-based industries, show the worst results for developing countries, being also strongly concentrated in developed countries.

2.4.2.2 Evidence from Econometric Studies

To gather further evidence on the current problematic, we now present several econometric studies trying to clarify the determinants of exporting capacity and the determinants of processing trade. Ideally, this section would explore the findings on the determinants of high-tech exports from developing countries, but that is not possible due the lack of empirical evidence on this matter. So, alternatively, we try to identify the determinants of exports and the determinants of processing trade.

A. *FDI*

We first instigate about the findings on FDI since it is referred in the literature as a conducive of the urge of developing countries in high-tech exports. The study of Johansson and Nilsson (1997) uses a version of the gravity models to investigate the impact of the establishment of Export Processing Zones[10] (EPZs) on the exports of the host country. They establish a two-fold result: first, a negative impact of the distances between the 11 developing countries and the 12 EU countries on the group of developing countries and, second, a positive impact of the existence of EPZs on the developing countries' exports.

Jenkins (2006) presents a study where he conducts the identification of the determinants of Export Processing Zones (EPZs). The evidence for the effect of foreign presence is supported by the prone of majority-owned firms by local investors to purchase intermediate inputs locally, because of the dominance of local ownership.

Görg (2000) uses the ratio of inward processing[11] to total imports of the United States. He founds a positive link between the FDI made by the USA and the EU member countries, which implies the more FDI the USA made in the EU, more inward processing the USA will perform, by that increasing the intra-industry trade.

Montobbio and Rampa (2005) analyse 9 developing countries for the hypothesis that technological activity affects export performance. The FDI inflows appear to have a statistically significant impact on the chance to high-tech sectors export structure, relating the FDI to the high-tech exports from developing countries.

The study of Liu and Shu (2001) found a positive impact of the FDI in the analysis of the determinants of China's exports. Even when the authors only use the high-tech exports from China, the FDI still presents a positive and significant impact on the exports of high-tech products.

[10] EPZs or Export Processing Zones are geographically or juridically bounded areas in which free trade, including duty-free import of intermediate goods, is permitted provided that all goods produced within the zone are exported (Johanson and Nilsson, 1997). Also from a premnote of World Bank (1998), it is stated that EPZs are potentially useful tools for export promotion. Johanson and Nilsson (1997) find that EPZ have significant effect on the increment of exports of developing countries, specially in Hong Kong, Malaysia, Mauritius, Singapore and Sri Lanka. The effect varies across countries, but a country with an outward-oriented trade strategy is more likely to experience a positive impact on exports.

[11] Inward processing is the duty relief procedure allowing goods to be imported into the EU for processing and subsequent export outside the EU without payment of duty.

The results comprehending the impact of FDI do not appear all positive. Baldone et al. (2001) aim to understand the determinants of trade patterns in the presence of international fragmentation of production. They use 4 Central Eastern European Countries (CEECs)[12] to attend on the motives of the delocalization of the production of an EU country to a CEEC. Regarding the impact of FDI, it is not found to be statistically significant on the outward processing trade. This result can be due to the sample used, as the literature reviewed often points that East Asian countries are the major receivers of FDI, rather than the CEECs.

Wang and Wei (2008) infer about the determinants of the rising performance of China's exports, using micro-level data. Wang and Wei (2008) use the dissimilarity index (EDI)[13] between Chinese export structure and the G3 economies – United States, Japan and European Union – and the unit value of exports to account for the rise in the sophistication of China's export. The FDI is not found to have a statistically significant major role in the sophistication of exports, after controlling for policy zones.

Xu and Lu (2009) use the PRODY index to account for the sophistication of China's exports. They do not find a significant impact of the FDI, as a whole, made by the OECD countries upon the sophistication of China's exports. Nevertheless, when they break into the sophistication of exports, foreign firms in processing trade activities are found to have a positive impact on the sophistication of exports, while domestic firms do not have any impact on the sophistication in the same activities.

B. *IMPORTS OF PARTS AND COMPONENTS*

The link of FDI is also connected to the imports of parts and components, given that the foreign presence of multinationals complete the link of international value chain as multinationals import parts and components from developed countries counterparts and assembly them in developing countries (Li, 2002; Srholec, 2007)

Srholec (2007) looks for the evidence of the statistical artefact mentioned by Mani (2000) and Lall (2000). He accounts for the outstanding growth of the import side along the export performance of developing countries in high-tech exports. In his econometric analysis,

[12] The four CEECs analyzed by Baldone et al. (2001) are Hungary, Poland, Bulgaria and Romania.

[13] This index will attain for smaller values as the similarity between G3 economies and China exports structure is higher.

Srholec (2007) finds that the imports of intermediate goods by developing countries have a positive and significant impact on the high-tech exports from these economies.

The study of Cui and Cyed (2007) directly instigates about the importance of the imports on the exports of high-tech products from China. They carry an econometric study for two periods, 1994-1999 and 2000-2005. They found a weakening effect of the imports of parts and components in China exports in the last period. Although the authors realize that China is still distant to produce the more knowledge intensive products, it is believed that there is a delinking of the imports of parts and components and the exports of high-tech of China.

C. *GEOGRAPHIC DISTANCE*

The geographic distance is a determinant that can prejudice the offshore location of assembly facilities (Clark, 2007) so this variable is also studied in the current review.

Swenson (2005) finds distance as a negative determinant of outsourcing trade. This determinant has a lower impact over the most recent years, probably due to the communication improvements over time. The differentiation of the countries in developed and developing countries[14] allows to observing that the distance variable is more harmful to the developing countries than to developed ones.

The study of Clark (2007) also tries to analyze the Offshore Assembly Provisions (OAPs) of the USA. Clark (2007) does not find any significant impact arising from the geographical distance as a driving force for the decision to perform an offshore production. Nevertheless the transportation costs are found to exert a negative influence on the OAP trade.

The study of Baldone et al. (2001) presents us a puzzling result related to geographic distance. The conclusion is that geographic proximity is harmful to the delocalization of the production of an EU country to a CEEC. This result can be due to the fact of delocalization being related to other factors, such as cultural ones, rather than the cost of the distance. Nonetheless this variable is not always significant, which does not invalidate the prior comment.

[14] Swenson (2005, 2006) classifies a country as a developed one if it belonged to the OECD in 1985.

D. *Labour Costs*

We also look to the evidence on labour cost as the suspicion of developing countries to concentrate their competitiveness on labour-intensive segments of high-tech products production (Lemoine-Ünal Kesenci, 2004).

The labour costs are found to exert a negative impact on the determinants of delocalization of production of an EU country to a CEEC (Baldone et al., 2001), which supports the assumption that delocalization takes place in the most labour-intensive segments.

The same result is achieved by Marconi and Rolli (2007), who use the Lafay index as the dependent variable. For a sample of 16 emerging economies, they find that the higher RCAs in high-tech sector tend to be explained by low unit labour costs of the countries in the sample.

A strange result is attained by Görg (2000), who finds a positive link between labour costs and the dependent variable – inward processing trade. An explanation for this result is the possibility of the processing trade made by the United States also attends to search for skill levels.

Liu and Shu (2001) attend on the determinants of Chinas' exports. It is found that the labour costs have a negative impact on the total exports of China. Nevertheless, when the dependent variable is restricted to the high-tech exports, the labour costs' significance vanishes.

An opposing result of that from the Liu and Shu (2001) study was obtained by Huang et al. (2008). Their results concerning the impact of labour costs show a positive relationship between them and the exports of China. The difference in the conclusions of these two studies can be due to the highly disaggregated data of the Huang et al.'s (2008) study, which uses micro-level data and can capture different characteristics than macro-level data.

E. *Exchange Rates*

The exchange rates, which is way which developing countries attempt to influence costs and prices on tradable goods are lower for developing countries are also a competitive advantage against countries with higher exchange rates countries, most of them, developed countries (Adams et al., 2006).

The study of Clark (2007) identifies a negative relationship between the exchange rate of the partner country and the OAP trade performed by the USA.

Egger and Egger (2005) try to bridge the literature on the determinants of outward and inward processing trade with a large sample of bilateral trade. Real effective exchange rate ratio is found to have a positive impact on the dependent variable. This strange result is sustained by the authors evidence for EU's specialisation in high-quality and capital-intensive production stages, where small changes in economic size or comparative advantage are less relevant.

F. *R&D*

We also study the effects of R&D and human capital, as they are the major contents of high-tech exports and are also indicators of technological capabilities (Hatzichronoglou, 1997; Liu and Shu, 2001; Peneder, 2003). Therefore we study the impact of this variable as we know that developed countries are more favoured in these two variables (Montobbio and Rampa, 2005).

Braunerhjelm and Thulin (2006) analyze the impact of R&D expenditures in the OECD high-tech exports for a sample of 19 OECD countries. They find that R&D expenditures have a positive impact on the high-tech export intensity, which corresponds to our prior expectations.

However, the finding obtained by Braunerhjelm and Thulin (2006) is not obtained in developing countries' studies. Hopelessly, there are few studies with a large sample of developing countries.

Liu and Shu (2001) use the case of China to infer about the impact of this variable. They do not find R&D as a significant variable to explain the urge of China's exports.

Ando and Kimura (2003) study the characteristics of Japanese firms in East Asian countries and realize that Japanese affiliates are smaller than Japanese affiliates located in

America or Europe[15]. This finding also compromises the R&D activity performed by these affiliates and it is also distinct as it is more intense in American and European countries rather than East Asian Countries. It has been already demonstrated the highly concentrated high-tech exports made by developing countries in East Asian countries. This result shows that the reason for the foreign presence in East Asian countries can be related to other factors which do not relate to knowledge resources.

The study of Huang et al. (2008) finds little significance of R&D expenditures to explain the rise in exports of China. This variable even acquires negative impact in high-tech exports made by foreign enterprises. The explanation can be the highly presence of China in processing trade activities.

G. *HUMAN CAPITAL*

The determinants of human capital are expected to exert a positive impact on the high-tech exports. Montobbio and Rampa (2005) analyse 9 developing countries for the hypothesis that technological activity affects export performance. The researchers found a positive link between tertiary enrolment in technical subjects per capita and the total exports of the countries in the sample. This result remains valid when the dependent variable is changed to the high-tech exports, showing the contribution of this variable in the increment of high-tech exports.

Marconi and Rolli (2007) use the Lafay index as the dependent variable. For their sample of 16 emerging economies they find that the higher values of the RCAs in high-tech sector are explained by relatively high human capital endowments.

Wang and Wei (2008) use the case of China and finds that high-tech zones and higher human capital levels have a positive impact on the sophistication of its exports.

In Table 1.3 we can find a summary of the reviewed empirical studies.

[15] The criteria of dimension used were the number of workers per affiliates.

Table 2.3 Summary of empirical studies

Studies	Time Span	Sample (nº countries)	Methodology	Dependent Variable	Determinants
Johansson and Nilsson (1997)	1980-1992	11 LDC 12 EU	OLS regression	Total Export	Host country GNP (+) Distance (-) EPZ (+)
Görg (2000)	1988-1994	USA and 12 EU	Panel Regression	US Inward processing trade	Presence of US FDI (+) Home Costs (+) Revealed comparative advantage (+)
Baldone et al. (2001)	1989-1996	EU-15 and ROW	Panel regression	Share of Outward processing trade	Wage (-) Geographic proximity (+)
Liu and Shu (2001)	1995	1 – China	OLS	Total Export	Labour costs (-) Labour intensity (+) FDI (+) Firm Size (+)
Ando and Kimura (2003)	1995, 1998, 2000	3 (Japan, Asia, and ROW)	Logit regression	Dummy - Japanese firm has foreign affiliate or not in EA	R&D (+) number of regular workers (+) tangible assets per regular workers (+)
Egger and Egger (2005)	1988-1999	12 EU and 44 ROW	Panel Regression	Outward Processing Trade	Labour abundance (+) Costs (-)
Montobbio and Rampa (2005)	1985-1998	9 LDC	LSDV regression	Total Export	Value added (+) FDI inflows (+) Tertiary enrolments in technical subjects (+)
Swenson (2005)	1980-2000	≥ 60	Panel Tobit random effects	Share of outsourcing	Host GDP pc (-) Host labour cost (-) Home labour cost (+)

Table 2.3 Summary of empirical studies (continuation)

Studies	Time Span	Sample (nº countries)	Methodology	Dependent Variable	Determinants
Braunerhjelm and Thulin (2006)	1981-1999	19 OECD	Panel regression fixed effects	HT export intensity	R&D expenditures (+)
Swenson (2006)	1991-2000	LDC from OAP program	Panel Tobit fixed effects	Quantity of a product imported	Host labour cost (-) Competitors cost (+) Host tax costs (-)
Cui and Syed (2007)	1993-2005	1 - China	Panel regression	Export Elasticity	Exchange rate (-)
Marconi and Rolli (2007)	1985-2000	16	LSDV regression	Lafay Index	Labour costs (-) Physical capital Accumulation (+)
Srholec (2007)	2001-2003	83	OLS	Export specialization	Technological capabilities (+) Intra-product imports (+) Final product imports (+) Size of Population (+)
Huang et al. (2008)	2001-2003	1 - China	Panel Tobit regression	HT export intensity	Labour costs (-) R&D (-)
Wang and Wei (2008)	1996-2005	1 - China	Panel regression	Similarity structure to G3 countries	EPZ (+) Processing exports in HT zones (+) Student enrollment in higher education (+)
Xu and Lu (2009)	2000-2005	1 - China	Panel regression	PRODY index	Processing exports of Foreign enterprises (+)

2.5 CONCLUDING REMARKS AND HYPOTHESES

In this chapter we reviewed works about the focus f this thesis and overview the taxonomy on products classification. Additionally, we discussed the findings of the literature and the determinants that may influence the high-tech exports.

The major conclusions of this chapter are that developing countries can overcome the scarce of capital and skill endowments with a trade of between R&D investments or continue to focus on labour-intensive products with their abundant and cheap labour factor, as R&D may influence the trade performance of a country and enhance its economic performance. As we reviewed the main taxonomy used to classify high-tech products are based on their R&D content and these products have less probability to suffer a drop in their price.

The increase of globalization, the growth of telecommunications and the drop in their prices enabled the increase of intermediate goods and the growth of the processing trade phenomenon. This phenomenon is the cause pointed in the literature for the increase of high-tech exports from developing countries as they do not demonstrate a clear evolution on technological and skill competencies and are concentrated in labour-intensive production segments of high-tech products, importing parts and components for further processing and assembly. The imports of parts and components are also boosted with the presence of foreign presence on developing countries, making part of the global chain of production of the existent multinationals. The lack of skill competencies – human capital – and technological capabilities – R&D – from developing countries makes us suspect of their involvement in the phenomenon of processing trade, rather than possessing indigenous capabilities like developed countries.

With these facts, we formulate our main alternative hypotheses:

H1: The increasing role of developing countries in HT trade is associated to the development of their indigenous technological capacity,

Or, otherwise,

H2: The increasing role of developing countries in HT trade is mainly related to processing trade, and less to the development of their indigenous technological capacity.

CHAPTER 3

A FIRST LOOK INTO THE DATA – TRENDS AND FACTS

3.1 INITIAL CONSIDERATIONS

In order to conduct an econometric study on the reviewed problematic, there is the need to bridge the gap between the literature reviewed and the following econometric analysis. Hence, this chapter will focus on the explanation of the sources of data used and the trends observed on the main variables introduced in out empirical estimations. There are three databases that will be used along the chapter 3 and chapter 4: World Bank database[16], World Trade Organization[17] and Penn World Tables[18]. The use of three databases is due the restrictions that every database contains, namely the fact that each database does not contain all the variables needed to carry on this econometric study. Hence we try to cover the needed variables to bear this study. In this chapter, after a brief review of the databases used, we will offer a descriptive analysis of the trends found in the main variables. The appliance of the EXPY index is also exploited. The direct results of the use of this index cannot be totally comparable to other studies, such as Hausmann et al. (2005) and Rodrik (2006), since the sample of countries and the disaggregation level of products' exports does not match. Nonetheless, the application of the EXPY is still valid as it can bring some novel results to the academic debate.

3.2 DATABASES AND COUNTRIES

3.2.1 WORLD BANK DATA

The World Bank Data undertook a massive change in their policy for free statistical figures in 20th April of 2010. Prior to that day, the free database of World Bank was restricted to only 56 "World Development Indicators". From 20th April onwards there is access to more than 2,000 financial, business, health, economic and human development statistics with no paying subscriber needing for more than 200 countries. The World Bank data source was used for the retrieving of data on Human Capital proxies and R&D expenditures.

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[16] Available at http://data.worldbank.org/
[17] Available at http://stat.wto.org/StatisticalProgram/WSDBStatProgramHome.aspx?Language=E
[18] Available at http://pwt.econ.upenn.edu/

3.2.2 World Trade Organization Data

The World Trade Organization provides a time-series database of merchandise trade by commodity for the period of 1980-2008. The products provided by the database are presented in the Table 3.1

Since the level of disaggregation of the products exports can not be well extended, it was adopted a broader categorization over the high-tech products. In this work it will be adopted the group of products of chemicals and electronic equipment as the high-tech products.

3.2.3 Penn World Tables

The Penn World Tables provide an international comparison between countries for the period of 1950-2007. In its most recent version (PWT 6.3), it presents a group of 189 countries and has 2005 as the base year. This database was used for the variables population, real GDP, real GDP per capita and exchange rate between countries

3.2.4 Countries in the database

In order to attain a robust set of countries in this study, we use the Research and Development (R&D) expenditures variable to account for the missing-values in countries and remove the countries with higher level of missing values. The criteria to drop countries from the sample was when the missing values by country were higher than 4/11 (35,36%) of the variable R&D expenditures[19]. The initial timeline intended to study was 1990-2007, but due to the lack of data on R&D expenditures, the period was shortened to 1996-2006. From the 236 countries from the World Bank Data Centre, and because of compatibility issues between different data sources for the different variables, the final sample of countries was composed by 71 panel units.

[19] This criterion of "4/11 missing values" to exclude countries from the database was chosen because it was the closest proportion to the 1/3 threshold. It seems reasonable to exclude from the analysis those panel units whose data are missing at more than 33% of the time period.

Table 3.1 Products and SITC classifications of WTO time-series on international trade

PRODUCTS	SITC CLASSIFICATION (Rev.3)
Primary products	-
Agricultural products	Sections 0, 1, 2, 4 excepting 27 and 28
Food	Sections 0, 1, 4 and division 22
Fuels and mining products	Section 3, divisions 27, 28, 68
Fuels	Section 3
Manufactures	Section 5, 6, 7, 8, excepting division 68 and group 891
Iron and Steel	Division 67
Chemicals and related products	Section 5
Medicinal and Pharmaceutical	Division 54
Machinery and transport equipment	Section 7
Office and telecommunications equipment	Divisions 75, 76 and group 776
Office equipment and automatic data-processing machines	Division 75
Telecommunications equipment	Division 76
Integrated circuits and electronic components	Group 776
Automotive products	Groups 781, 782, 783, 784, and subgroups 7132, 7783
Textiles	Division 65
Clothing	Division 84

The next obvious step was to determine which countries were classified into 'developed' or 'developing' countries. The criteria used was the categorization of countries from World Bank[20], where developed countries were considered to be those which belong to the high-income group – countries whose GNI per capita was superior to $11,909. The application of this criterion leads us to a number of developing and developed countries of 38 and 33, respectively. A list of the countries can be found in Table 3.2.

As previous stated in section 2.3.2.1., Singapore and Korea are now considered developed countries.

[20] The list of countries can be obtained at: http://go.worldbank.org/D7SN0B8YU0

Table 3.2 List of Developed and Developing Countries present in the sample

Developed Countries			
Austria	France	Japan	Slovenia
Belgium	Germany	Korea Rep.	Spain
Canada	Greece	Kuwait	Sweden
Croatia	Hong Kong	Kyrgyzstan	Trinidad and Tobago
Cyprus	Hungary	Netherlands	United Kingdom
Czech Republic	Iceland	Norway	United States
Denmark	Ireland	Portugal	
Estonia	Israel	Singapore	
Finland	Italy	Slovakia	
Developing Countries			
Argentina	Colombia	Macedonia	Russian Federation
Armenia	Costa Rica	Madagascar	Serbia
Azerbaijan	Cuba	Mauritius	Sudan
Belarus	Ecuador	Mexico	Thailand
Bolivia	Egypt	Mongolia	Tunisia
Brazil	Georgia	Pakistan	Turkey
Bulgaria	India	Panama	Ukraine
Burkina Faso	Kazakhstan	Peru	Uruguay
Chile	Latvia	Poland	
China	Lithuania	Romania	

3.3 DESCRIPTIVE ANALYSIS

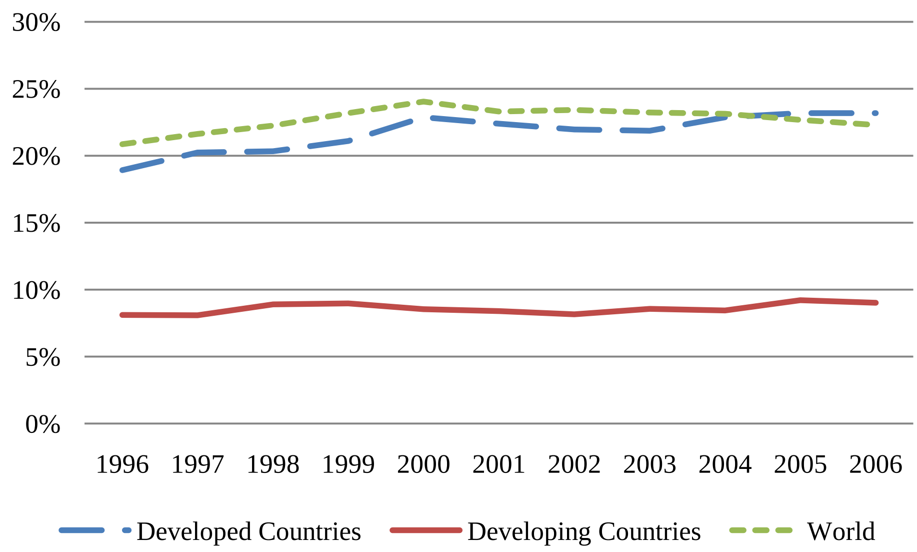

Figure 3.1 High-tech exports in percentage of total exports

In Figure 3.1 we can observe that developing countries are still lagging behind compared to developed countries high-tech exports. The trend observed is an upward trend by developed and developing countries, although developing countries present a flatter evolution trend. Developing countries are getting close to 10% of total exports and developed countries are approaching the 25%. It is also noticed the evolution of the World high-tech exports, which after the peak in 2000, is moving to the same levels as 1996, near to 20%.

In order to attain for the robustness of the WTO data used, Figure 3.2 illustrates us the tendency in high-tech exports[21] for the developed and developing countries, as well as for the World. The trends verified are quite similar for developed and developing countries. Even so, the developing countries trend is not as flatter as developed ones and developing countries have lower export levels of high-tech products compared to the developed group. This evidence could be due to the lack or inclusion of some categories of products included in the WB classification that is not captured in our WTO database. Nonetheless the World pattern is quite similar in both databases.

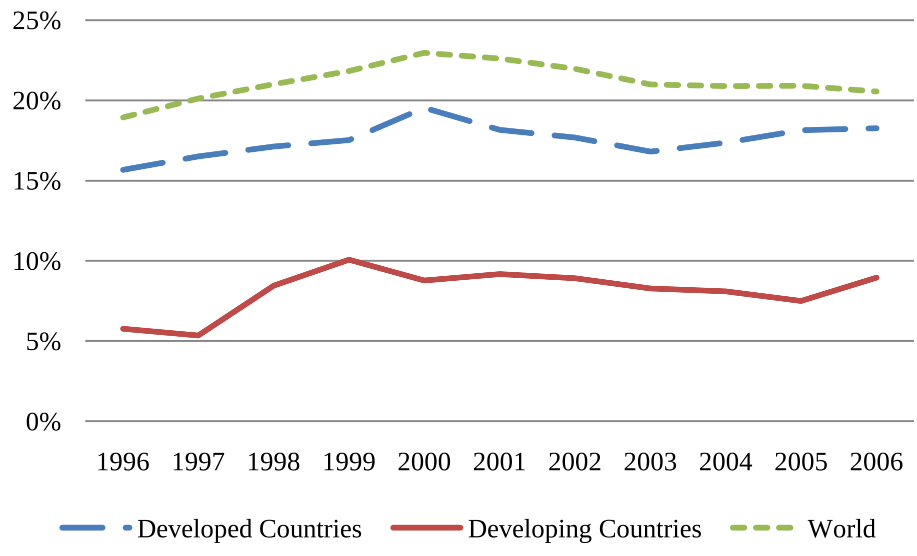

Figure 3.2 High-tech exports from WB database

[21] Variable High-technology exports from WB database compromises products with high R&D intensity, such as aerospace, computers, pharmaceuticals, scientific instruments, and electrical machinery.

The other finding well documented in the reviewed literature is the concentration of developing countries' high-tech exports in electronic and electric products. As a result we plotted the evolution of exports of electronic and office equipment and office and telecommunication equipment in Figures 3.3 and 3.4, respectively.

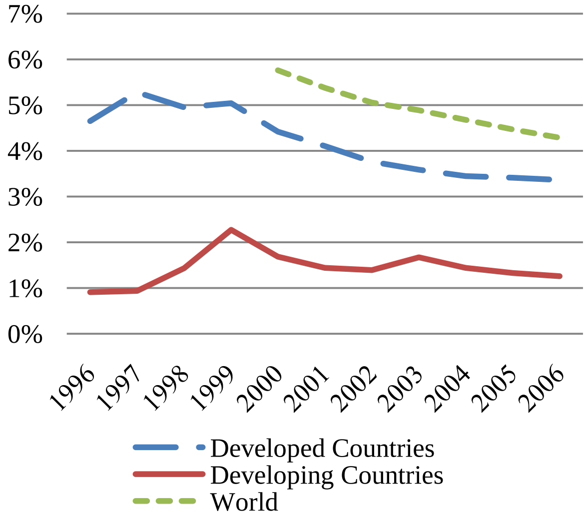

Figure 3.3 Office equipment and automatic data-processing machines

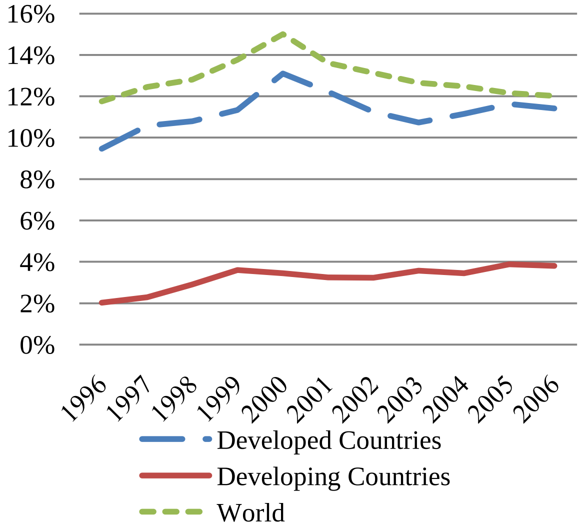

Figure 3.4 Office and telecommunication equipment

As can be observed in Figure 3.3 and Figure 3.4, developing countries are still lagging behind but with different trends than developed countries. In electronic and office equipment developed countries present a downward pattern through the analyzed period, with almost 5% in total exports share in 1996, down to near 3% in total exports share a decade latter. On the other side, developing countries have an increase in the share of these products in total exports although they also present a downward evolution after 2003, but with a smoother decline in the end of the period analyzed. Is must be also noticed that over 1997-1999 developing countries have increased their share in total exports and developed countries saw their share in total exports decline.

In Figure 3.4, we can observe an increase in total exports share in terms of office and telecommunication equipment for both groups of countries. Developed countries saw their share increase from near 10% in 1996 to almost 12% in 2006, though with some volatility throughout the period. On the other hand, developing countries present an upward trend with a smoother trend than developed countries and saw their share of office and telecommunication equipment rose from 2% to near 4% in 2006.

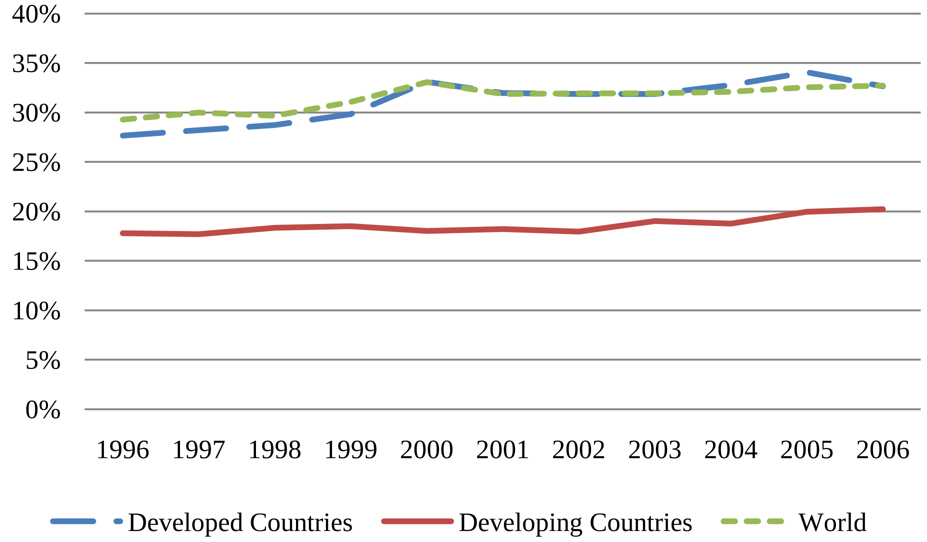

Figure 3.5 High-tech exports in manufactures exports

The literature has also been pointing an increasing share of overall high-tech exports by the group of developing countries. In Figure 3.5 we present that plot with our collected data. There is an upward trend in both groups of countries, despite developed countries reveal a higher share in total manufactures exported than developing countries. Moreover, developed countries have a more consistent upward trend than developing countries.

The debate about the high-tech exports of developing countries is related to the processing-trade phenomenon. Due to this argument we have plotted the progress in imports of parts and components, R&D expenditures and FDI in Figures 3.6, 3.7, and 3.8, respectively.

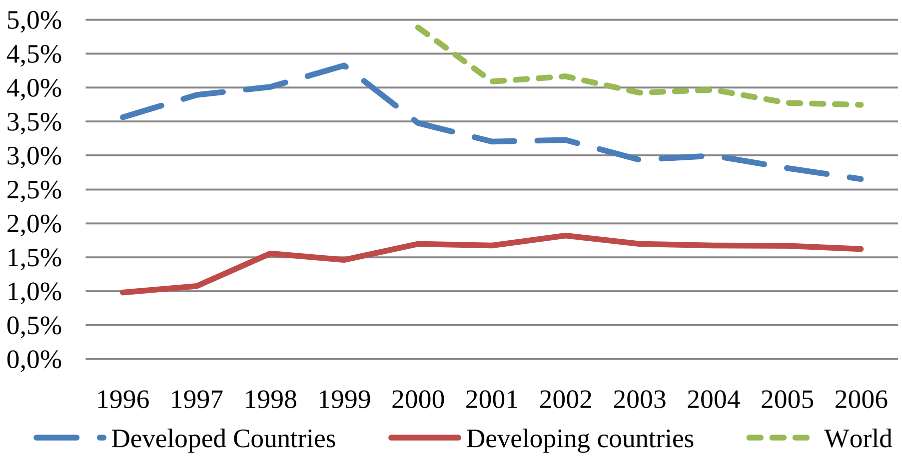

Figure 3.6 Imports of parts and components in total imports

In Figure 3.6 we observe two opposite trends. Developed countries show a downward trend on imports' share of parts and components while developing countries show an upward trend. Developed countries show a decline from near 3,5% to almost 2,5%, with a major decline from 1999 to 2000. Contrarily, developing countries have increased their share of parts and components in their total imports in more than 0,5 percentage points. This group presents an increase of imports of parts in components in the period of 1999 to 2000, contrary to the group of developed countries. According to the reviewed literature, this evidence can be a sign of the processing trade phenomenon among developing countries.

Another statement that had some impetus on the reviewed literature is the role of FDI in developing countries, so in Figure 3.7 we present the inward FDI stock of both groups in percentage of GDP.

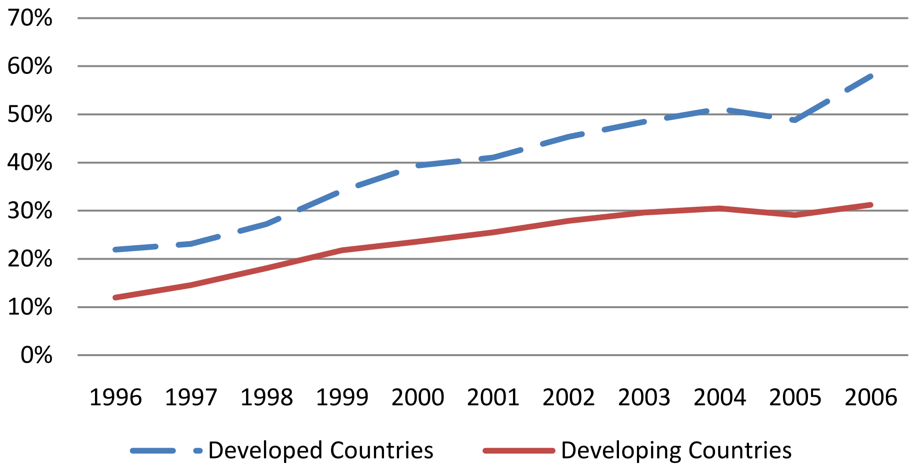

Figure 3.7 Inward FDI stocks in percentage of GDP

It can be noticed that the evidence of the Figure 3.7 does not support a great impact of FDI in developing countries since developed countries have relatively higher shares of FDI and are increasing their ratios faster than developing countries. Nonetheless, it is noticed an upward trend in both groups of countries. Since developing countries do not possess the same technology as developed countries, the FDI impact could be higher. A closer look to the data shows that FDI in percentage of GDP in Belgium, Hong Kong and Singapore have an average of 111%, 236 % and 132% respectively. After removing these three countries we obtain the results of Figure 3.8.

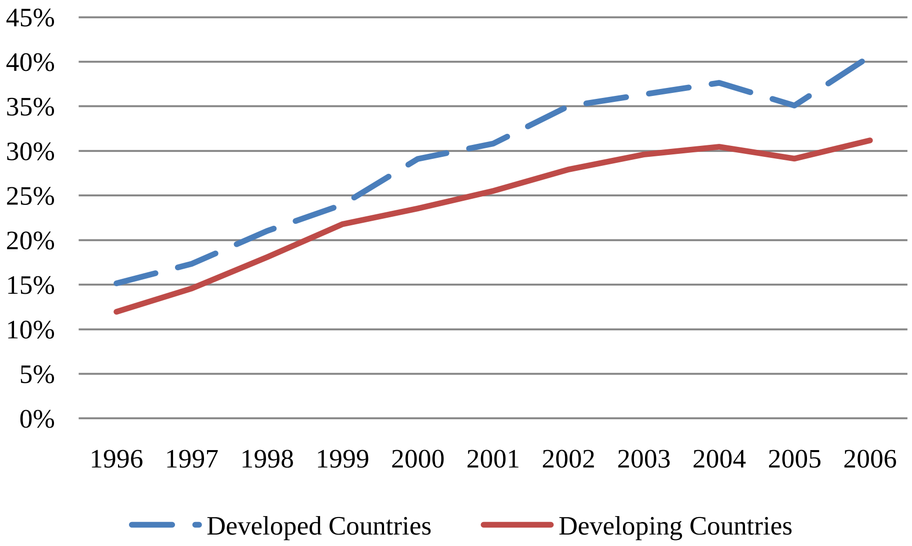

Figure 3.8 Percentage of GDP of FDI in stock without Belgium, Hong Kong and Singapore

As can be stated from Figure 3.8, the differences between both groups have now narrowed. Nonetheless, after 1999, developed countries have distanced from developing countries. The upward trend shows that FDI is gradually becoming a more important component in both economies groups.

There is also the need to investigate the trends that may influence the indigenous capabilities of the analyzed groups of countries. Hence we plot in Figure 3.9 and 3.10 the R&D expenditures and the rate of gross enrolment in tertiary education, respectively.

From Figure 3.9, it is clear that developing countries are far behind than developed countries. Hence, this evidence make us suspect that developed countries should export more high-tech products than developing countries, since high-tech products are R&D intensive.

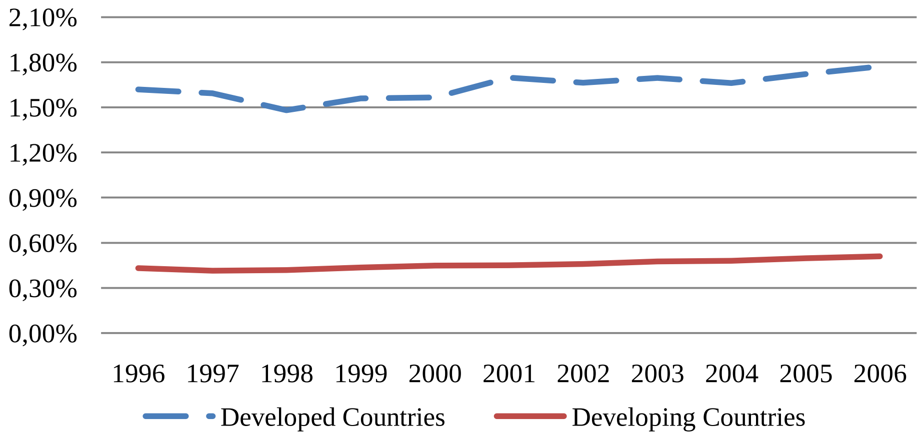

Figure 3.9 R&D expenditures by developed and developing countries

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To furthermore instigate about the technological capabilities of developing and developed countries, we plot the gross enrolment rate in tertiary education in Figure 3.10. As can be seen, the rate of gross enrolment in tertiary education shows a similar trend in both groups of countries. The behaviour through the time is quite similar between the two groups. The only fact to state is that developed countries show a higher rate than developing countries, as a difference of almost 20 percentage points separates the two groups during the entire period.

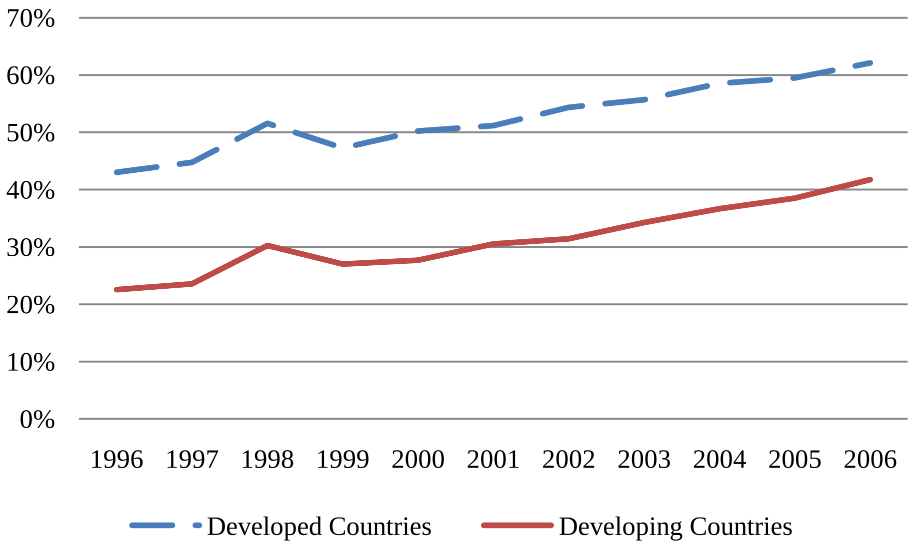

Figure 3.10 Rate of gross enrolment tertiary

To account for the possibility of disparities between countries that the statistical averages cannot show, the Table 3.3 presents the 5 highest exporters in the sample in different periods of time.

Table 3.3 Top 5 High-tech exporters

1996-2006	%	1996	%	2000	%	2006	%
Ireland	64,1	Singapore	57,2	Ireland	65,5	Ireland	67,8
Singapore	58,2	Ireland	50,0	Singapore	60,5	Singapore	54,8
Korea	37,4	Korea	31,6	Korea	42,0	Hong Kong	43,4
Hong Kong	32,8	Japan	29,9	Israel	35,0	Korea	35,5
Netherlands	31,9	Netherlands	28,8	Costa Rica	33,9	China	34,2

In Table 3.3 we can observe that the Top 5 high-tech exporters for the entire period analyzed contains 3 East Asian countries, as already stated in the chapter 2. Singapore, Korea and Hong Kong continue to stand out in high-tech exports, but are now considered developed countries. The last entering in the Top 5 ranking is China, which validates the robustness of the database, since it capture the involvement of China as a major high-tech exporter in recent years.

3.4 COMPUTATION OF EXPORTS' SOPHISTICATION THROUGH EXPY INDEX

The computation of this index would be ideal with a high level of disaggregation at product level exports. Since we are confined to the WTO free database, we had to consider only the segments of agricultural products, fuel and mining, iron and steel, chemicals, office equipment and automatic data-processing machines, telecommunication equipment, integrated circuits and electronic components, automotive products, textiles and clothing to avoid double counting.

The first conclusions of the application of the EXPY can be found in Figure 3.11, where we depict the evolution of the EXPY for developing and developed countries for the period analysed. It can be observed that developed countries are still ahead of developing countries and that the differences are larger after 1999 in detriment of developing countries. Nonetheless, the trend in both types of countries is upward, which indicates an increasing sophistication of its exports.

In comparison with the study conducted by Hausmann et al. (2005) the countries with smallest EXPY are not present in the current database due the criteria of missing values. As for the largest countries with EXPY, only Ireland and Iceland are present in the database. These two countries also appear as greater exporters in the current use of EXPY, although the values assumed by these two countries are higher in this study. In the Hausmann et al. (2005) Ireland and Iceland had an EXPY value of 19232 and 18705, respectively and Iceland had a greater

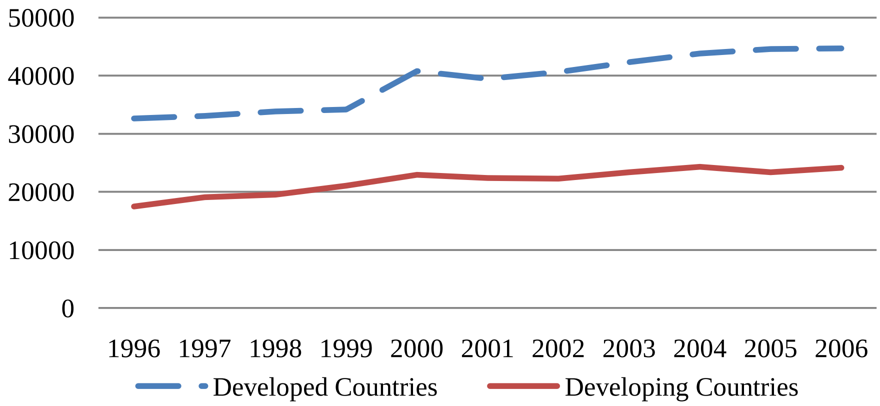

Figure 3.11 Evolution of EXPY by type of countries

value of EXPY than Ireland. The outstanding performance of Kuwait in this index was not expected, but we can not perfectly compare the results with other studies since we do have knowledge of any study containing Kuwait in the sample used. The reason for so high value of EXPY from Kuwait is due to the methodology of the Index, where the RCA in a particular product is then multiplied by the GDP per capita of the respective country. The Kuwait possesses a RCA of 5 to 8 in fuels and mining products, which boosts its EXPY value. This is also the reason for Kuwait to do not appear in the previous descriptive analysis, since fuel and mining products were not considered high-tech products. Nonetheless, the Top 5 ranking is similar to the Hausmann et al.'s (2005) one, so we believe that the results are still valid.

Table 3.4 Top 5 countries with largest and smallest EXPY

Top 5. Countries with largest EXPY							
1996-2006	**Value**	**1996**	**Value**	**2000**	**Value**	**2006**	**Value**
Kuwait	262.686	Kuwait	331.458	Kuwait	237.639	Kuwait	200.103
Iceland	162.602	Iceland	142.153	Mauritius	193.396	Iceland	161.143
Mauritius	145.907	Norway	123.775	Iceland	171.493	Norway	140.831
Norway	145.262	Mauritius	122.917	Norway	157.181	Ireland	115.398
Ireland	68.576	Cyprus	57.034	Singapore	87.033	Mauritius	107.974
Top 5. Countries with smallest EXPY							
1996-2006	**Value**	**1996**	**Value**	**2000**	**Value**	**2006**	**Value**
Kyrgyzstan	2183	Finland	3518	Armenia	3244	Kyrgyzstan	3066
India	4195	Burkina Faso	4131	India	4700	Madagascar	3888
Armenia	5009	India	4248	China	5323	India	4239
Mongolia	5272	China	4351	Cyprus	5867	Mongolia	5482
Madagascar	5610	Madagascar	4358	Sudan	6022	Sudan	8161

In the Top 5 countries with largest EXPY values, there are little changes across time. The case of Singapore is remarkable because in 1996 it was the 6th country with smallest EXPY in the sample and reached to the 5th position with the largest EXPY in 2000. As previously stated, Singapore is a case of high-tech exports success and the EXPY index also seemed to capture this fact. Iceland has a high RCA in agricultural products. Mauritius possesses a prominent RCA mainly on clothing. Norway has high RCA in fuel and mining products. Ireland possesses greater RCAs in chemicals and in office equipment.

Besides Ireland, it is clear that the other countries that do possess high values of EXPY were not considered high-tech exporters in the previous analysis due to the products in which they had a comparative advantage were not considered high-tech products is the taxonomy used. In terms of developed and developing countries, the countries with largest EXPY values are developed countries with the exception of Mauritius. As for the countries with smallest EXPY, with the exception of Kyrgyzstan, they are developing countries. As a result we can observe that EXPY can also capture the development of the countries analyzed.

3.5 CONCLUDING REMARKS

In this chapter we developed a descriptive analysis of the database used in order to verify if the trends and facts stated in previous studies were also captured with our data. We can observe that developed countries are still ahead of developing countries, especially in human capital and R&D capabilities, which predicts a better performance of high-tech exports from developed countries in detriment of developing countries. Since the Singapore and Korea are not considered developing countries, we can observe that developed countries have a clear advantage in high-tech exports over developing ones. Nonetheless, the imports of parts and components have increased more in developing countries compared to developed ones. This fact goes in line with the literature reviewed and enhances the possibility of processing trade phenomenon in developing countries.

The FDI activity is also a suspicion of processing trade in developing countries, although our preliminary results point to a larger FDI stock in developed countries rather developing ones.

The high-tech exports is mainly dominated by developed countries, but as the literature already stated, China is emerging as a major high-tech exporter, as we can see it in the 5th position of major high-tech exporters in 2006. This proves that the database can capture the facts and trends already found in the previous literature review.

Regarding to the results of EXPY index, we show that Kuwait, Iceland, Mauritius Norway and Ireland possess the most sophisticated exports of the sample. They possess high-values of EXPY because, with Ireland as the exception, they hold high levels of RCAs in agricultural, fuel and mining products. This is the reason why they do not appear as major high-tech exporters since this type of products are not considered high-tech products in the taxonomy used. Although the best applicable framework for the EXPY index would be a highly disaggregated product-level data, the results are similar to the results found at studies like Hausmann et al. (2005) and Rodrik (2006).

CHAPTER 4

ECONOMETRIC ANALYSIS – DETERMINANTS OF HIGH-TECH EXPORTS

4.1 INITIAL CONSIDERATIONS

The descriptive analysis presented in chapter 3 was the first step for the application of the empirical study performed in this chapter. First of all, we will present the methodological issues of our study. Afterwards, present the empirical results obtained from our panel data models, first applied to all countries in the sample and then applied to the separate samples of developed and developing countries. Three different dependent variables were used to achieve the main purpose of the current study: an assessment of the determinants of high-tech exports. First, we used the high-tech exports share. Subsequently, we used the Balassa index to measure the determinants influencing the increasing competitiveness of developed and developing countries in high-tech exports. The third approach was the use of EXPY index in order to use a more complex index of sophistication of exports.

4.2 METHODOLOGICAL ISSUES

Our empirical strategy will consist in the analysis of the determinants of exports' sophistication through three different measures. The general equation is specified by the following model:

$$Y_{ij} = \beta_0 + \beta_1 \text{ FDI}_{ij} + \beta_2 \text{ Human Capital}_{ij} + \beta_3 \text{ R\&D}_{ij} + \beta_4 \text{ GDPpc}_{ij} + \beta_5 \text{ Xrat}_{ij} +$$
$$+ \beta_6 \text{ Openess}_{ij} + \beta_7 \text{ Im P\&C}_{ij} + \beta_8 \log(\text{pop})_{ij} + \beta_9 \text{ Manufacturing value added pc}_{ij} + \mu_{ij}$$

where *Y* will assume three different *proxies* for high-tech exports, with first being the share of exports in high-tech products, the second accounting for the *Balassa index* for revealed comparative advantage in high-tech products and the third being represented by the EXPY index in logs.

The coefficient β_1 reflects the effect of FDI stocks in percentage of GDP and is also expected to have a positive impact on the increase of countries' competitiveness at high-tech exports, namely for the group of developing countries. The coefficient of β_2 captures the effect of Human Capital on the dependent variable. The Human Capital is *proxied* by the gross enrolment ratio on tertiary education. The coefficient β_3 captures the effect of R&D expenditures in percentage of GDP on the dependent variable. R&D variable is intended to have a positive impact in high-tech exports from developed countries and to be irrelevant for developing countries' exports. The coefficient β_4 measures the impact of Real GDP per capita, which is introduced as a *proxy* for countries' labour costs and which is expected to have a significant negative impact on developing countries' sample due to the suspicion of their cheaper labour costs. The coefficient β_5 measures the impact of the exchange rate (US as benchmark (US=1)), being expected to exert a negative impact on the dependent variable for developing countries, due to the depreciation that their currencies exhibit. The coefficient β_6 shows the impact of Openness, which is also expected to be greater for developing countries rather than developed ones. The coefficient β_7 is associated to the imports of integrated circuits and parts and components, measured in percentage of total imports. This variable is expected to be positively significant for developing countries and statistically insignificant for developed countries. The coefficients β_8 and β_9 are associated to control variables, so there are no certainties about their possible impact. Regarding the variable of the coefficient β_9 was obtained as manufacturing value added from the World Bank data in constant prices of 2000 and then divided by the countries current population. In Table 4.11 we provide a summary of the variables used, the respective sources, as well as the expected signals associated to each variable.

In Table 4.2, we can observe the correlation matrix. The major correlated determinants are FDI with GDP per capita and the degree of openness. R&D expenditures are also highly positively correlated with GDP per capita. These correlations are the confirmation of the descriptive findings in chapter 3, where FDI and R&D expenditures were more concentrated in developed countries.

Table 4.1 Description, expected signals and data sources of the variables used

Variables	Description	Expected signals		Data Source
		Developed Countries	*Developing Countries*	
HT exports	High-tech exports / total exports			Own calculations based on WTO
Balassa Index	Revealed Comparative Advantage in HT products			Own calculations based on WTO
Expy Index	Expy index in logs			Own calculation based on WTO
FDI	Inward FDI (STOCKS) - % of GDP	n.s[a].	+	UNCTAD FDIStat
Human Capital	Gross enrolment ratio in tertiary education	+	n.s[a].	World Bank Data
R&D	Research and Development expenditures - % of GDP	+	- / n.s[a].	UNESCO
GDP pc	Real GDP per capita in 2005 constant prices (Laspeyres)	+	-	Penn World Tables
Exchange rate	Exchange rate - US=1	n.s[a].	-	Penn World Tables
Openness	Openness in current prices - % of GDP ([X+M]/GDP)	n.s[a].	+	Penn World Tables
Imports P&C	Logarithm of imports of integrated circuits and parts and components	n.s[a].	+	WTO
Log (pop)	Logarithm of total population			Penn World Tables
MVApc	Manufacturing value added per capita			On calculations based on WDI

Notes: [a] n.s. – no significant effect

Table 4.2 Correlation Matrix

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
FDI	**(1)**								
Human Capital	**(2)**	0.05							
R&D	**(3)**	-0.03	0.60						
GDP pc	**(4)**	0.27	0.60	0.66					
Xrat	**(5)**	-0.12	-0.12	-0.13	-0.21				
Openc	**(6)**	0.75	0.09	0.03	0.29	-0.06			
Imports P&C	**(7)**	0.40	0.06	0.26	0.25	0.00	0.55		
Log (pop)	**(8)**	-0.23	-0.04	0.11	-0.13	0.02	-0.42	0.16	
MVApc	**(9)**	0.08	0.62	0.90	0.82	-0.17	0.14	0.32	0.11

4.3 DETERMINANTS OF HIGH-TECH EXPORTS: ALL COUNTRIES

In Table 4.3 we can observe the impact of the studied determinants in the export of high-tech products considering the all sample of countries available in this study. In models (1) and (3), after controlling for the population and manufacturing value added per capita, we can observe that FDI and R&D expenditures have a positive and significant impact on the increase of the share of high-tech products exported in total exports, respectively. Nonetheless, FDI has lower impact compared to R&D expenditures. In Model (4) it is denoted that FDI and R&D expenditures are no longer significant in explaining the dependent variable. Exchange rate has a marginal negative impact on the dependent variable implying that an exchange rate lower to US dollar can increase their exports in high-tech products compared to a higher exchange rate. The imports of parts and components show a highly significant and greater impact on the dependent variable.

In Table 4.4 the models are regressed with the Balassa index as the dependent variable. The global findings are quite similar to the Table 4.3, with high-tech exports in the dependent variable. The increase in the competitiveness of high-tech exports is enhanced by lower exchange rates and with the imports of parts and components. The only exception to the findings the dependent variable as high-tech exports is that FDI alone, controlling for population and manufacturing value added per capita, does not have statistically impact on the increase of competitiveness of high-tech export products. These two measures only captured the determinants that we expected to have a major influence on developing countries. A possible explanation for these results can be the number of developing countries being relatively higher than developed countries. With the EXPY index it was found that FDI, human capital and GDP pc have a positive impact on this dependent variable.

In Table 4.5 we run the models with the EXPY index in logs in the dependent variable. The findings of these estimations are different from the previous ones. The FDI, Human Capital, GDP per capita and imports of parts and components are now found to be statistically significant and exerting a positive effect on the variations of the EXPY index. The finding of GDP per capita as a positive determinant is not surprising since this variable is one of the components in the calculation of the EXPY index. Nonetheless, Hausmann et al. (2005) consider this relation more than a mechanical one as they state that due to the weighted average of the income levels of nations the variations on EXPY are lower than the variations on GDP pc. FDI is the only significant, though weakly, variable.

Table 4.3 Regressions for all countries with high-tech exports

Dep. Var: HT exports	(1)	(2)	(3)	(4)
FDI	0.023 ** (0.0102)			-0.016 (0.0137)
Human Capital		0.02 (0.0201)		0.037 (0.0271)
R&D			5.478 *** (1.0742)	1.091 (1.3822)
GDP pc				-1.253E-04 (1.313E-04)
Exchange Rate				-0.002 * (8.297E-04)
Openness				0.42 (1.6172)
Imports P&C				1.358 *** (0.1236)
Log (Pop)	9.468 *** (3.1656)	12.779 *** (3.738)	8.471 ** (3.6957)	10.687 ** (4.5511)
MVA pc	6.38E-07 (4.56E-07)	1.43E-06 ** (5.65E-07)	-2.52E-07 (5.04E-07)	1.80E-06 ** (8.54E-07)
Constant	-77.878 *** (30.1149)	-110.66 *** (35.3951)	-71.1536 ** (35.1307)	-94.007 ** (43.2421)
No. of obs.	665	567	601	448
No. of groups	67	67	67	64
Hausman Test	FE	FE	FE	FE
R^2 Within[(a)]	**0.0425**	**0.0548**	**0.0809**	**0.3003**
R^2 Between	0.0363	0.0360	0.0539	0.1325
R^2 Overall	0.0403	0.0752	0.0866	0.1944

Note: [(a)] when the hausman test indicates FE effects, only the R^2 within is valid.

4.4 DETERMINANTS OF HIGH-TECH EXPORTS: DEVELOPED VS. DEVELOPING COUNTRIES

The models presented for the all sample are now performed differentiating for developed and developing countries, based on the categorization presented in section 3.2.4. In Table 4.6 we can observe the regression results for the determinants of high-tech exports.

The determinants of the high-tech exports are dissimilar between the both groups of countries. FDI has a statistically significance upon the developing countries performance although with a contrary effect from the expected. The negative signal of FDI coefficient can be due to the degree of aggregation of the dependent variable which could not capture the specific products where FDI has a more positive impact on their high-tech exports.

Table 4.4 Regressions for all countries with Balassa index

Dep. Var: Balassa Index	(1)		(2)		(3)		(4)	
FDI	0.001						-0.001	
	(0.0004)						(0.0006)	
Human Capital			2.74E-04				0.002	
			(0.0009)				(0.0012)	
R&D					0.1947	***	0.038	
					(0.0429)		(0.0621)	
GDP pc							-3.65E-06	
							(5.90E-06)	
Exchange Rate							-8.44E-05	**
							(3.73E-05)	
Openness							0.032	
							(0.0727)	
Imports P&C							0.053	***
							(0.0056)	
Log (Pop)	0.354	**	0.505	***	0.03		0.381	*
	(0.1388)		(0.0009)		(0.0317)		(0.2046)	
MVA pc	1.08E-08		4.82E-08	*	2.44E-08		7.90E-08	**
	(2.00E-08)		(2.47E-08)		(2.02E-08)		(3.84-08)	
Constant	-2.786	**	-4.282	***	0.125		-3.311	**
	(1.3208)		(1.5464)		(0.3039)		(1.9437)	
No. of obs.	665		567		601		448	
No. of groups	67		67		67		64	
Hausman Test	FE		FE		RE		FE	
R^2 Within	**0.0205**		**0.0343**		0.0397		**0.2523**	
R^2 Between	0.0242		0.0305		0.2871		0.1766	
R^2 Overall	0.0283		0.0666		0.3356		0.2301	

Human capital is only significant for developed countries, indicating that the indigenous capabilities are more important for developed countries to achieve higher shares of high-tech product exports in their total export basket.

The GDP per capita is our proxy for the cost of labour in the sample of countries. Despite the impact of this variable is negative for both groups of countries, it is only significant for developing countries. This result indicates that the cheap-labour offered by developing countries can boost their export share in high-tech products. As already stated in chapter 2, the categorization of high-tech products also compromises some products where the final segments of construction can be labour-intensive. This result can furthermore provide evidence for the involvement of developing countries in the phenomenon of processing trade.

Table 4.5 Regressions for all countries with Log (EXPY)

Dep. Var: Log (EXPY)		(1)	(2)	(3)	(4)
FDI		0.004 ***			0.002 *
		(0.001)			(0.0011)
Human Capital			0.007 ***		0.006 ***
			(0.0018)		(0.0022)
R&D				0.448 ***	0.15
				(0.108)	(0.1141)
GDP pc					7.80E-05 ***
					(1.08E-05)
Exchange Rate					-1.48E-05
					(6.85E-05)
Openness					-0.218
					(0.1332)
Imports P&C					0.022 **
					(0.0102)
Log (Pop)		0.219	-0.276	0.463	-0.77 **
		(0.001)	(0.3268)	(0.3695)	(0.3753)
MVA pc		5.60E-07 ***	4.49E-07 ***	5.50E-07 ***	-4.70E-08
		(4.58E-08)	(4.95E-08)	(5.10E-08)	(7.05E-08)
Constant		6.696 **	11.416 ***	4.011	15.765 ***
		(2.9767)	(3.094)	(3.514)	(3.563)
No. of obs.		674	571	608	450
No. of groups		67	67	67	64
Hausman test		FE	FE	FE	FE
R^2	Within	**0.2976**	**0.2628**	**0.3217**	**0.3306**
	Between	0.0330	0.1245	0.0032	0.3005
	Overall	0.0208	0.0944	0.0017	0.2571

Another evidence for the suspicion of processing trade would be the significant and positive impact of imports of parts and components from developing countries, and the non-significance of this variable in developed countries performance. Contrary to our expectation, the variable has a positive significant effect for both groups of countries. Even so, there seems to be a higher magnitude of this variable for developing countries rather than developed ones.

In Table 4.7, we run the models for both group of countries with the Balassa index as the dependent variable. The results are similar to the results of the Table 4.6 with a minor difference. The imports of parts and components are now positively significant only for the developing countries. Since the Balassa index is a measure of comparative advantage, this result suggests that developing countries can increase their global competitiveness in high-tech exports through the imports of parts and components rather than through the increment of indigenous capabilities, as developed countries often do, which is shown by the positive significance of human capital proxy. GDP per capita and FDI present a negative impact on developing countries high-tech exports index. Although GDP per capita result is in line with the expectations, the FDI variable still possess a negative impact on the dependent variable. The results comprising the regressions for developed and developing countries with the log (EXPY) in the dependent variable are presented in Table 4.8.

The results shown by this specification are in line with some of our prior expectations. The FDI has a positive and significant impact on the increase of the sophistication of exports by developing countries, which points out that a positive contribute from foreign presence arises in these group of countries. The openness affects negatively the sophistication of exports of developing countries, which is contrary to our expectations. In our previous regressions this variable was not significant but the sign was positive, so we do not have a proper reason for this result.

The indigenous capabilities, measured by the human capital and R&D expenditures are only positive and significant for developed countries. This result confirms that a differentiation exists on the type of effort presented by developed and developing countries to achieve higher levels of sophistication of its exports.

GDP per capita, once again, has a positive and significant impact on developed and developing countries sophistication of exports. This result can be due to the method of construction of the EXPY index and by that it is expected a significant contribution to the explanation of the dependent variable. Even so, the magnitude of its impact is minor.

The imports of parts and components show a dissimilar pattern across the two types of countries. This variable takes a positive and significant impact for developing countries and does not statistically influence the developed countries sophistication of exports measured by the log (EXPY).

Table 4.6 Regressions for developed and developing countries with high-tech exports

Dep. Var: HT exports	Developed Countries (1)	Developing Countries (1)	Developed Countries (2)	Developing Countries (2)	Developed Countries (3)	Developing Countries (3)	Developed Countries (4)	Developing Countries (4)
FDI	0.075 ***	-0.056 ***					0.019	-0.035 **
	(0.0122)	(0.015)					(0.024)	(0.0165)
Human Capital			0.124 ***	-0.135 ***			0.122 ***	-0.011
			(0.0299)	(0.0285)			(0.0419)	(0.0362)
R&D					4.236 ***	8.167 ***	0.532	0.761
					(1.3717)	(1.6399)	(2.0129)	(1.9454)
GDP pc							-1.753e-04	-4.811e-04 **
							(1.91e-04)	(0.002)
Exchange Rate							-0.006	-0.001
							(0.0064)	(0.008)
Openness							2.567	0. 442
							(3.3765)	(1.7018)
Imports P&C							1.035 ***	1.368 ***
							(0.3897)	(0.1345)
Log (Pop)	1.859 *	13.878 ***	6.94	17.196 ***	8.099	1.315 **	25.916 *	10.812 **
	(1.0674)	(3.1522)	(10.0306)	(3.6767)	(9.2938)	(0.6431)	(13.19)	(4.57)
MVA pc	5.15e-07	7.30e-06 ***	7.84e-10	1.37e-05 ***	-1.26e-07	4.93e-06 ***	-1.02e-07	1.01e-05 ***
	(4.43e-07)	(1.91e-06)	(6.29e-07)	(2.58e-06)	(5.84e-07)	(1.75e-06)	(1.09e-06)	(3.26e-086)
Constant	-0.341	-128.824 ***	-50.752	-160.463 ***	-60.425	-9.82	-228.871 *	-98.9840 **
	(9.686)	(30.7434)	(92.4626)	(35.6441)	(85.8731)	(6.3341)	(122.6467)	(44.3756)
No. of obs	304	361	264	303	288	313	197	251
No. of groups	32	35	32	35	32	35	31	33
Hausman Test	RE	FE	FE	FE	FE	RE	FE	FE
R^2 Within	0.1038	**0.1062**	**0.1134**	**0.1508**	**0.0610**	0.1170	**0.1532**	**0.5048**
R^2 Between	0.5282	0.1611	0.0364	0.1741	0.0481	0.3422	0.0873	0.3017
R^2 Overall	0.4331	0.1511	0.1261	0.1659	0.0600	0.3347	0.1557	0.3339

Table 4.7 Regressions for developed and developing countries with Balassa index

Dep. Var: Balassa Index	**Developed Countries (1)**	**Developing Countries (1)**	**Developed Countries (2)**	**Developing Countries (2)**	**Developed Countries (3)**	**Developing Countries (3)**	**Developed Countries (4)**	**Developing Countries (4)**
FDI	0.003 ***	-0.003 ***					0.002	-0.002 **
	(0.0005)	(0.0007)					(0.0011)	(0.0007)
Human Capital			0.005 ***	-0.006 ***			0.006 ***	-2.078e-04
			(0.0013)	(0.0012)			(0.0019)	(0.0016)
R&D					0.101 *	0.336 ***	-0.017	0.22
					(0.0561)	(0.0715)	(0.0894)	(0.0854)
GDP pc							-8.19e-06	-2.2e-05 **
							(8.48e-06)	(9.25e-06)
Exchange Rate							-3.519e-04	-4.74e-05
							(0.003)	(3.38e-05)
Openness							0.166	0.027
							(0.1499)	(0.0747)
Imports P&C							0.028	0.056 ***
							(0.017)	(0.0059)
Log (Pop)	0.084 *	0.577 ***	0.2	0.704 ***	0.044	0.057 **	0.913	0.397 **
	(0.0464)	(0.1370)	(0.4393)	(0.1607)	(0.0609)	(0.0281)	(0.5856)	(0.2005)
MVA pc	8.73e-09	3.02e-07 ***	-1.27e-08	5.81e-07 ***	1.52e-08	1.89e-07 **	-1.47e-08	4.79e-07 ***
	(1.95e-08)	(8.30e-08)	(2.76e-08)	(1.13e-07)	(2.42e-08)	(7.65e-08)	(4.83e-08)	(1.43e-07)
Constant	0.019	-5.320 ***	-1.182	-6.527 ***	0.332	-0.401	-7.906	-3.586 *
	(0.4209)	(1.3364)	(4.0494)	(1.5578)	(0.5522)	(0.2766)	(5.4456)	(1.9473)
No. of obs.	306	361	264	303	288	313	197	251
No. of groups	31	35	32	35	32	35	31	33
Hausman Test	RE	FE	FE	FE	RE	RE	FE	FE
R^2 Within	0.0643	**0.1088**	**0.0766**	**0.1451**	0.0223	0.0989	**0.1523**	**0.4796**
R^2 Between	0.4632	0.1609	0.0256	0.1722	0.1002	0.3355	0.0977	0.3262
R^2 Overall	0.3757	0.1515	0.1138	0.1661	0.1296	0.3286	0.1543	0.3571

Table 4.8. Regressions for developed and developing countries with Log (Expy)

Dep. Var: Log(EXPY)	**Developed Countries (1)**	**Developing Countries (1)**	**Developed Countries (2)**	**Developing Countries (2)**	**Developed Countries (3)**	**Developing Countries (3)**	**Developed Countries (4)**	**Developing Countries (4)**
FDI	0.003 **	0.005 ***					4.475e-04	0.004 ***
	(0.0016)	(0.0012)					(0.0018)	(0.0015)
Human Capital			0.005 *	0.008 ***			0.008 ***	-2.931e-04
			(0.0028)	(0.0025)			(0.0031)	(0.0033)
R&D					0.612 ***	0.021	0.0458 ***	-0.135
					(0.1458)	(0.1479)	(0.1477)	(0.1755)
GDP pc							4.77e-05 ***	1.569e-04 ***
							(1.4e-05)	(1.9e-05)
Exchange Rate							4.137e-04	-1.078e-04
							(0.0005)	(0.0001)
Openess							-0.073	-0.272 *
							(0.2477)	(0.1528)
Imports P&C							0.012	0.034 ***
							(0.0286)	(0.0122)
Log (Pop)	2.097 **	-0.159 **	-1.437	-0.144 **	3.9898 ***	-0.167 **	1.127	-0.711 *
	(0.9487)	(0.0696)	(0.9274)	(0.073)	(0.9881)	(0.0738)	(0.9676)	(0.4118)
MVA pc	5.33e-07 ***	9.01e-07 ***	4.75e-07 ***	6.78e-07 ***	4.30e-07 ***	1.02e-06 ***	-1.60e-08	-8.20e-07 ***
	(5.86e-08)	(1.51e-07)	(5.82e-08)	(1.98e-07)	(6.21e-08)	(1.66e-07)	(7.98e-08)	(2.93e-07)
Constant	-11.127	10.685 ***	21.607 **	10.550 ***	-29.451 ***	10.848 ***	-2.815	15.942 ***
	(8.7354)	(0.6923)	(8.5486)	(0.7245)	(9.1296)	(0.7283)	(8.9973)	(3.9930)
No. of obs.	304	370	264	307	288	320	197	253
No. of groups	32	35	32	35	32	35	31	33
Hausman Test	FE	RE	FE	RE	FE	RE	FE	FE
R^2 Within	**0.3731**	0.1524	**0.3534**	0.1394	**0.4556**	0.1116	**0.3694**	**0.4275**
R^2 Between	0.0472	0.2911	0.1027	0.2189	0.0608	0.2562	0.0027	0.2497
R^2 Overall	0.0055	0.2831	0.0379	0.2150	0.0091	0.2484	0.0015	0.2398

The results presented in the Tables 4.6, 4.7 and 4.8 shows that developed and developing countries rely on different determinants in order to increase their high-tech export products share, the competitiveness of high-tech exports or the increase of sophistication of exports measured by the EXPY index. Developed countries rely more on indigenous capabilities and the developing countries rely more on determinants, which increasingly supports our suspicion of involvement in the phenomenon of processing trade.

4.5 Concluding remarks

In this chapter we were able to implement an econometric approach to a problematic that was scarcely studied though empirical tools. After presented the methodological issues of this study, we have presented our econometric results, first for all countries and second for the separate samples of developed and developing countries. Three different dependent variables were used to achieve the purpose of the current study. First we used the high-tech exports share. Subsequently we used the Balassa index to measure the determinants influencing the increasing competitiveness of developing countries in high-tech exports. The third approach was the use of EXPY index in order to use a more complex index of sophistication of exports. A summary of results are presented in Table 4.9.

Table 4.9 Summary of regression results

	High-Tech exports	Balassa Index	EXPY index
All Countries	• Exchange Rate (-) • Imports of P&C (+)	• Exchange Rate (-) • Imports of P&C (+)	• FDI (+) • Human Capital (+) • GDP pc (+)
Developed Countries	• Human Capital (+) • Imported P&C (+)	• Human Capital (+)	• Human Capital (+) • R&D (+) • GDP pc (+)
Developing Countries	• FDI (-) • GDP pc (-) • Imports of P&C (+)	• FDI (-) • GDP pc (-) • Imports of P&C (+)	• FDI (+) • GDP pc (+) • Openness (-) • Imports of P&C (+)

As can be examined in Table 4.9, accounting for the evidence comprising all countries the exchange rate has a negative impact on high-tech exports and on Balassa Index. The imports of parts and components contribute to the increase of high-tech exports and in the competitiveness in high-tech exports, measured by the Balassa index. With the EXPY index it was found that FDI, human capital and GDP pc have a positive impact on this dependent variable.

For developed countries it was found that indigenous capabilities have a great impact on the three variables used. The human capital proxy contributed always positively to the increase of the dependent variable. The R&D expenditures were also found to contribute positively to the sophistication of exports measured by the EXPY index.

The group of developing countries use determinants that raise the suspicions of the involvement of these countries in the phenomenon of processing trade. The imports of parts and components were always significant in the three specifications mentioned. The result of a negative impact of FDI in high-tech exports and in Balassa index was not expected but this can be due to the high level of aggregation of the dependent variable, as it includes some products that are not considered high-tech products in some classifications, since FDI is pointed to be a major source of processing-trade on high-tech products in developing countries. Even so, the FDI is found to have a positive impact in the sophistication of exports measured by EXPY. Furthermore, the openness variable was found to have a negative impact on this measure which is contrary to our expectations, but we do not have any robust explanation for this result.

CHAPTER 5

CONCLUSIONS AND POLICY IMPLICATIONS

The main aim of this dissertation was to investigate the differences of determinants across developed countries and developing countries in what concerns their high-tech exports. The suspicion of the involvement of developing countries in the processing-trade phenomenon due to the increasing share of developing countries in high-tech exports was prompted by the lack in technological capabilities and skill competencies, measured by R&D and human capital proxies by this group of countries.

From Chapter 2, our literature review stressed that the taxonomies used in the classification of high-tech and low-tech products are based on R&D content, with the high-tech products containing the large part of R&D intensive substance. It was also stressed that developing countries were suspected to be involved in the phenomenon of processing trade as they focused on their competitiveness in abundant and cheap-labour, as well as the imports of parts and components boosted by foreign enterprises. It is suspected that developing countries concentrate their competitiveness on the latter segments of production of high-tech products where the factor used is basically labour-intensive production.

In Chapter 3 we presented the database and countries comprised in the current dissertation to perform a first descriptive analysis. The sample included 33 developed countries and 38 developing countries, through the period of 1996-2006. The intention of the descriptive analysis is to prove the trends and facts of the reviewed literature. It was found that developing countries still lag behind from developed countries in every aspect. The high-tech exports of developing countries had a slightly growth but is far less when compared to developed countries. The catching up from developing countries is observed when we break down the high-tech exports and only count for office and telecommunication exports. Developing countries are increasing their share on exports of office and telecommunication products, and their growth was more consistent than developed countries' one. The analysis taken to the imports of parts and components reveals that these products have also more importance in developed countries than in developing countries. The great difference between the both groups are their trends, where developed countries have a downward trend and developing ones have an upward trend, showing the importance of this component on their imports. The R&D expenditures present an upward trend in both group of countries, but the developed countries have higher R&D expenditures compared to developing ones. The human capital is proxied by the rate of gross enrolment in tertiary education and shows a similar pattern across the period analyzed for both groups. As for R&D expenditures, the developed countries have higher rates than developing ones. The computation of the EXPY index is also performed and the results presented. This sophistication index is found to take higher values for developed countries than for developing ones. Even so, there are upward trends for both groups. The results presented in this chapter denote the need of developing countries to step-up to catch-up with developed countries. Although, developing countries are found in the reviewed literature as catching-up the developed countries in high-tech exports, the outline of this chapter points to a need to upgrade their knowledge and innovation skills to reach higher steps of development. The concentration of high-tech exports in electrical and electronic goods by developing countries is suspicious about their indigenous capabilities and the possibility for them to be involved in the processing trade phenomenon. The lack of disaggregated data and the information of processing trade exports by the countries used would be a great value to determine the suspicions mentioned.

In Chapter 4 we advance to our econometric approach. We run multiple regressions for countries as a whole, and then we run the same regressions for developed and developing countries separately. This procedure was repeated for three dependent variables: the high-tech intensive exports, the Balassa index and the EXPY index in logs. For the evidence comprising all countries the exchange rate has a negative impact on high-tech intensive exports and on the Balassa Index. The imports of parts and components contribute to the increase of high-tech exports and for the competitiveness in high-tech exports, measured by the Balassa index. These two measures only captured the determinants that we expected to have a major influence on developing countries. A possible explanation for these results can be the number of developing countries in the sample being relatively higher than developed countries. With the EXPY index it was found that FDI, human capital and GDP pc have a positive impact on this dependent variable. The positive relation of GDP pc can be due the mechanical link of the construction of the EXPY index.

For developed countries it was found that indigenous capabilities have a great impact on the three variables used. The human capital proxy contributed always positively to the increase of the dependent variable. The R&D expenditures were also found to contribute positively to the sophistication of exports measured by the EXPY index. The results presented show that developed countries rely more on their indigenous capabilities with variables of innovation and human capital with a positive impact on the dependent variables used. These results are consistent with prior expectations as we have reviewed the positive link between high-tech products and R&D content on them. It is also in line with expectation that developed countries would export products where they possess more endowments – human capital and innovation skills.

For the group of developing countries it was found that the imports of parts and components were always significant and with a positive impact in the three specifications mentioned. The FDI was found to have a positive impact in the sophistication of exports measured by EXPY. Furthermore, the openness variable was found to have a negative impact on this measure which is contrary to our expectations, but we do not have any robust explanation for this result. In terms of policy implications, these results represent that developing countries are exporting high-tech products with less quality and with no upgrade on their indigenous capabilities. The lack of capabilities of developing countries can be overcome if the government impose a policy on R&D performance that is sufficiently strong. In this case, the economy might catch up the initial technological disadvantage. This policy can pass to acknowledge to private firms for the future benefits of R&D. (Montobbio and Rampa, 2005; Hardi et al., 2009). Even more, the electronic sector, which is the main sector where developing countries are focusing, is found to create less domestic linkages than other sectors (Jenkins, 2006). With this finding, governments should direct their industrial policy interventions for business industries and orchestrate with innovation and education policies to capitalize fully on the potential for catching up (Srholec 2007). The FDI policy should not be designed as a single policy, and should be combined with policies to increment the human capital capabilities, technological capacity and infrastructural development to absorb the full potential of foreign presence (Lall, 2000; Rasiah, 2004; Rajan, 2005).

The case of China is also especially documented in terms of policies of their government. It is stressed the promotion of labour-intensive industries, mostly for export, as well as economic zones where these industries can grow (Fan and Scott, 2003). In terms of the quality of China's exports Lemoine and Ünal-Kesenci (2004) and Liang (2008) infer about the favourable regime of China for processing activities, which beneficiated mainly foreign firms, while domestic firms have not been in position to take advantage of the concessional programs. These processing activities did not upgrade the China's traditional exporting sector, based on domestic inputs. They also declare the need to reform the financial system to allow for the expansion of the new private sector.

The results presented in this dissertation show that developed countries rely more on their indigenous capabilities, rather than determinants that may urge the suspicion of processing trade, in opposition to the case of developing countries. This later group rely more heavenly on other determinants as foreign presence, labour costs and imports of parts and components to increase their share of high-tech exports.

The econometric study performed in this dissertation lacks in containing disaggregated data to increment the quality of results and to infer about the statistical artefact of the raise of high-tech exports from developing countries raised by Many (2000). The FDI variable should be separated in FDI by country of origin or the industry where the FDI is allocated. The information on the amount of processing trade should also be available to every country and by sector of activity. The information about processing trade can be found in the literature, but only for China. The availability of the innovation variables like R&D is still scarce and it was the major determinant on the number of countries used. The availability of a time-series disaggregating trade data would be a positive factor for this study. The only source available is the COMTRADE database, which is only accessible through subscription. Perhaps, like the World Bank did, they will change their policy and enable the access to their database free of charge.

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