Determinants of Comparative Advantage in the ICT Goods Market

- A Cross-Country Analysis

Bachelor's thesis within Economics
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Abstract

This paper analyzes the determinants of revealed comparative advantage that accounts for the ICT goods market. A thorough exploration of the factors and literature related to geographical clustering, innovation, R&D, labor productivity and FDI is provided to promote a complete overview of the ICT sector. Moreover, a brief comparison is made to the ICT service sector. Technological progress resulting from investments in R&D, high innovation activity, and capital accumulation, is the main indicator of dynamic comparative advantage and export specialization. Our analysis is conducted with a special focus on 21 OECD countries and China, whose presence has provided the goods market with substantial dynamism. The results obtained provide an interesting outlook in regards to comparative advantage, with two of our variables yielding unexpected outcomes. The potential for future research is high concerning the ICT industry, in particular the recent surge of exports in services.
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I Introduction

Globalization and expansion of some emerging economies, has changed the global market of high-tech electronics. During the last decades, the exports of Information Communication Technology (ICT) goods have increased remarkably. The world market faced an immense shift in the exports of ICT goods over the period 2000-2007, where they increased by 57 per cent, devoting most of this change to telecommunications equipment exports. In 2007 the export of ICT goods accounted for 20 percent of the total world’s exports (WTO, 2010). ICT goods are considered to be one of the most dynamic product groups worldwide (UNCTAD, 2007). Additionally, many studies suggest that strong export specialization and performance in ICT-related products yields higher economic growth rates and productivity for the country, since it is one of the sectors with the highest FDI inflows, value added, and employment (Greenaway et al. 1999; Farberger, 2000; Rodrik, 2006; Hausmann et al. 2007).

Given this, many countries establish policies and allocate national resources that will foster their technological specialization and their exports of high-tech products in the world-market. However, statistics show that the ICT product export diagram has been substantially fluctuating for the vast majority of countries, regardless if they are developed or emerging economies. The share of OECD countries in ICT trade has dropped drastically from 88 percent in 1996 to 56 percent in 2006.

Many studies suggest that in order to understand trade patterns, the analysis should dedicate importance to technology and innovation (Vernon, 1966; Hirsch, 1967). According to Posner (1961), an important factor in describing trade patterns is the difference between countries’ technological knowledge, and that knowledge depends on R&D investments.

The purpose of this study is to analyze the shift in the ICT market that OECD countries have experienced during the last years, including China as one of recent giants in this market. This approach will be reached by considering some determinants of ICT trade. Additionally, since OECD countries have been, and still are, the main actors in the ICT market and since China is becoming one of the main influential markets, the results of this study can be of high importance in evaluating the foundation of the shift.

While assembling the data necessary for this study we encountered a few setbacks. Mainly these obstacles consisted in the data availability for the ICT sector, specifically
in the case of China. As a consequence, holding China to be one of the main actors in the ICT market, the lack of data complicated the process of choosing the proper explanatory variables. Moreover, a crucial barrier for our approach was the lack of data for ICT services. Thus our study has mainly been concentrated in the ICT goods’ market.

The focal point of our paper will be to explore and analyze the patterns of revealed comparative advantage for the 22 countries. The RCA index proposed by Balassa (1965) is widely renowned for illuminating the comparative advantage or disadvantage of countries in the international context. This index is based on world market shares of a product in terms of export shares of that product in a country. In this study this is applied on ICT goods for the purpose of exploring the shifts in the market that this product group has undergone during the last years, making a brief comparison to the market share of ICT services. The second step of the analysis is to explain how the observed revealed comparative advantage relates to factors emphasized in the literature on dynamic comparative advantage. Moreover, the inclusion of R&D, FDI, labor productivity, number of technicians in absolute and relative terms, provides us with substantial awareness regarding the ICT sector’s expansion. Additional focus will be put on China, which experiences a rapid growing market share in ICT goods.

The empirical analysis is based on a panel dataset of 21 OECD countries and China. This data is analyzed with several regressions; where RCA is the dependent variable and FDI, R&D, labor productivity, number of technicians and associate professionals in absolute and relative terms, as explanatory variables. The FDI component represents the net inflows of investment to obtain a long-term benefit in an enterprise operating in an economy other than that of the investor. Data are in constant U.S. dollars (WBS, 2011). The remaining variables comprise of R&D public expenditure by industry calculated as a stock per number of technicians, labor productivity (total output/number of hours), and absolute value of number of technicians and associate professions, as well as the relative value of this number as a share of labor force.

The outline of our paper involves the following: Section 2 (Background and limitation) - This section will provide descriptive statistics that may give the reader an overview on the topic with graphs and important values. Moreover, the subsection also discusses the obstacles that have been encountered during the making of this paper. Section 3 (Theoretical Frameworks) - The theoretical part is included to shed insight into the theory be-
hind our hypothesis. Large emphasis is put on the role of technology and innovation within specialization and trade patterns, as well as general growth theories. Section 4 (Data and Method) - This section discusses our data selection and the method behind our testing. Section 5 (Empirical Results) - In this part we will analyze the results after computing the regression, searching for significance of the independent variables in regards to RCA and additional discussion about the variables. Other econometric measures will also be incorporated to display statistical significance. Section 6 (Conclusion) - Further analysis of our results obtained and a briefing of the content overall. The chapter will also, suggest recommendations for further studies.
2 Global ICT Exports

This section of the paper provides and discusses descriptive measures regarding the ICT sector and the continuous globalization process in this sector. It is noticeable from Figure 2.1 below that the world exports of ICT have undergone some remarkable changes in terms of revealed comparative advantage. Western countries have endured the biggest drop in RCA relative to the countries located in the East. Some emerging economies mostly located in Eastern Europe such as Hungary and Czech Republic have experienced enormous increases in RCA from 1996 to 2009. Moreover, China’s major role is becoming increasingly evident as it possesses the highest RCA value in 2009.

![Figure 2-1: Revealed comparative advantage in ICT goods, 1996 and 2009](source: OECD (2011)).

The share of OECD countries in the world’s ICT trade has dropped constantly from 88 percent in 1996 to 52 percent in 2007 (OECD, 2010). The total Global ICT in 2008 was worth 4 trillion USD, which is a threefold increase since 1996. Conversely, there is an increasing trend in the Chinese ICT trade, where their share of ICT exports in the world’s ICT market has outstandingly increased from 2.5 percent in 1996 to 19.5 percent in 2007 (WBS 2011). In 2009, the ICT sector experienced a severe drop in world
trade due to the economic crisis in 2007-2008. A rebound in 2010 was evident, predominantly due to Japan and Korea who had robust trading bonds with many countries. The G7 countries trade volumes and merchandise trade values increased, reflecting a worldwide recovery (OECD, 2010).

The goods market has endured fluctuations for the past decade, with stabilizing increases of 12.5 percent from 2003 to 2008 before experiencing a severe slowdown relative to other goods (OECD, 2008). Despite the steady growth and due to the increasing globalization and the emergence of new economies such as China and India, OECD countries lost significant market shares. Conversely, the export portion of non-OECD countries grew significantly for communication equipment and electronic components, while the other product groups experienced a downfall (see Appendix 1). The economic recession mostly affected OECD countries negatively, whereas the eastern Asian block continued to grow, but at slower rates. Initially, the slowdown hit the United States, then spread into Europe where the ICT production and export performance fell by 6% in 2007 and 2008.

The fluctuations concerning the ICT goods market have recently been leaning more towards a steady downfall for most OECD countries in terms of their share in the market. China’s position has outcompeted many countries in the manufacturing industry; however, many countries have diverted their focus and specialization into trade in ICT services. This is evident by looking at Figure 2-2, where the share of exports in services compared to trade of total services in the world is increasing while the share of goods production has decreased.
The trend of ICT related services is manifested by a 14 percent yearly increase from 1996-2008, reaching to a level of USD 325 billion in 2008 compared to USD 70 billion in 1996 (OECD, 2010). Despite the economic slowdown in 2007, many nations concentrated in services managed to withstand the storm and avoid major downfalls.
Table 2-1 will provide a definition of the ICT sector in terms of goods and services. In addition, specific product groups will be presented to give the reader a more detailed outlook.

Table 2-1: Definition of ICT sector

| Definition of the ICT sector according to the OECD Glossary of Statistical Terms |
| (Main product groups) |
| ICT goods: |
| • Electronic data processing (EDP) equipment |
| • Office equipment |
| • Control and instrumentation |
| • Radio communications (including mobiles) and radar |
| • Telecommunications |
| • Consumer equipment |
| • Components |
| Data on production, trade and sales of ICT goods are compiled from Reed Electronics Research, Yearbook of World Electronics Data. Production statistics are collected from government and manufacturer’s association sources where available. Markets are forecast in real terms for the next five years, with production forecast for the next two years, using constant exchange rates and excluding inflation. The yearbook uses the latest available Harmonised System classification for each individual country. For the majority of countries this is now HS2007 although HS2002 is still used and for some countries HS1996 or even HS1992 are the only ones available. |

| ICT services: |
| • Communication services |
| • Computer and information services |
| Data are provided by the International Monetary Fund, BOPS (Balance of Payments Statistics) database. For ICT services, an industry-based definition is used. The two ICT services sectors correspond to the Balance of Payments Coding System (BPM5) categories. |

Source: OECD 2011.
3 Theoretical Frameworks

Understanding the essence of the Ricardian and Hecksher model introduces us to the fundamental idea of comparative advantage. Comparative advantage depends on countries’ opportunity cost of producing different types of goods and thus explaining specialization patterns. Comparative advantage is determined by differences in total factor productivity (TFP) across countries (Echevarria, 2008). The welfare at a global scale increases if all countries specialize in the areas where they are relatively productive, in other words a country should specialize according to its comparative advantages.

The ICT sector is heavily dependent on technological advancement, which is mainly accumulated through investment in R&D. Persistent investments in R&D are widely known to alter comparative advantages over time (Fagerberg, 1995; Bernard et al. 1999; Bleaney and Wakelin, 2002; Barrios et al. 2003). This is particularly relevant for the ICT sector, as the product life cycle associated with ICT products is relatively short. Accordingly, persistent R&D investments are essential for comparative advantage in this sector.

According to Vernon (1966) four stages of product development exists, each signifying a vital component. Firstly a new product is introduced to the market by an innovative country. During this stage, the interaction between the market and the agents involved with the new product is smooth, implying an easy gathering of inputs to begin production. However, this phase is characterized by higher cost of investment in production platforms, human capital and R&D. The second stage is considered to be the market growth stage, where the product becomes homogeneous and the production development becomes normalized. Product life cycle is strongly attached to incoming and outgoing FDI, therefore considering the nature of Multinational Enterprises’ (MNE) and their economic incentives; foreign production commencement is part of Vernon’s second stage of product development where production is commonly established in another developed country to satisfy the increased market demand. The product becomes saturated by entering the third stage where the rise in competition yields lower market shares. Throughout this stage, the production can transfer to underdeveloped countries, where the lowest possible cost production is preferred. The final stage(product standardization) asserts the decline of the product, where the manufacturing of the good shifts to least developed countries. The stages are visually represented in Figure 3-1 below.
R&D knowledge spillovers, the sharing of ideas and information, give insight to the manufacturing clustering in certain regions in a country, as showed in the recent trends of specialization in ICT (Coe et al. 1995; Andersson, 1998). Innovation and prosperous growth within micro-level companies paves to the path to export surges. It is argued by economists, that R&D is the main contributor to development within an industry and there is generally a lag in the direct influence of the investment. For the most part, it takes several years for the investment to generate revenue streams.

The most prominent areas of research:

- Pure Research
- Applied Research
- Product Research
- Manufacturing Research
- Materials Research
- Market Research
- Operations Research.

Considering the comparative advantage context related to ICT, points to the hypothesis, that R&D rich countries enjoy a higher export specialization through intensive utilization of R&D factors. Technological progress is the leading factor of development/growth in industrialized countries (Boskin and Lau, 1992). The Ricardian model states that increasing technological inputs causes a rise in production capabilities and labor productivity, ensuing comparative advantage and an increase in export-specialization (Vogiatzoglou, 2009).
Thus, how does technology affect the influx of FDI and consequently FDI’s impact on comparative advantage? Technology is the key outcome accrued through knowledge capital assets and it provides the biggest benefit in firm specific environments. Moreover, technology or the technological development provides a relationship between FDI and economic growth/specialization (Johnson, 2005). The latter was empirically studied and analyzed by Claro (2008) in the case of China. Aside from the conventional theories suggested to explain China’s boom in world export shares, it was concluded that major foreign direct investments inflows in labor-intensive sectors is a stronghold in China’s exceptional position. On the whole, China’s immense labor-intensive export segment in terms of world exports is a direct contribution of a large labor force and also high relative productivity in labor-intensive sectors, much thanks to the high amount of FDI.

An important element of FDI is knowledge capital asset. It contains intangible assets such as brand name, human capital, patents, trademarks and technology (Johnson, 2005). According to Markusen (1995 and 2002), knowledge-capital is a vital part of MNE’s nucleus, because they tend to put large emphasis on R&D, high employment among engineers, and innovations with technology, all which yield opportunities for profits in numerous economies. Knowledge capital includes two features that contribute to the effectiveness of FDI - the simplicity to allocate knowledge to new geographical locations and facilitating the movement of services in various production schemes without affecting productivity (Markusen, 1995).

In order to maintain competitiveness in a large industry such as the ICT, MNE’s strive to defend their technology by patents or exploiting brand names. Technology is the most vital component in growth prospect for the ICT industry and trying to keep the knowledge and technology hidden without letting other firms have access to the same information, is a large concern for many firms (Hymer, 1960). However, the occurrence of spillovers to other firms is often causing a difficulty in internalizing all the earnings. As a result, positive externalities appear in the economy due to a high social return on investment. Consequently due to the social benefits brought by positive externalities, FDI is able to promote economic growth (Johnson, 2005).

To better understand the ICT surge theoretically in the past two decades, we mend our attention to the importance of technology and innovation in the trade, agglomeration,
specialization, and growth context. Past studies have displayed different perspectives and explanations concerning technology, which is portrayed to be a product of knowledge capital (Fuhrer, 1996). However, recent theories argue the knowledge behind technological developments is different compared to other forms of capital.

Learning by doing tactic involving capital accumulation’s impact on technological change, was introduced by Paul Romer (1986) as a first generation model of new growth theories. Learning by doing was not applicable internally within firms, instead it was assumed to arise externally and to the benefit of all firms. As a result, the models had constant returns to factor accumulation in the micro level and increasing returns of each factor at the macro level. A second-generation model was also introduced by Romer (1990), where he indicated that innovation does not appear solely from externalities, but rather intentions of the firms. Newly accumulated technology is exempted from the model to provide private and public mechanisms within innovation.

Thus how do we define innovation and go about measuring it? It is indeed a challenge to define innovation and generally people view it as a new product (Kline and Rosenberg, 1986), but there are other dimensions to it such as: an original production development, exploration in the fields of cost deduction in producing the good, and enhancements of methodology concerning innovation. In addition, there is a strong argument that innovation is related to location, introduced by Dosi’s five stylised facts (1988): Innovation is a tentative process; innovation is highly dependent upon research; innovation is multifaceted, learning by doing; and that innovation is a accumulative procedure.

The localized capabilities approach by Peter Maskell and Anders Malmberg merged the components of innovation and economic geography, i.e. geographic clustering. The fundamental idea behind this track is that industries/firms build their competitive nature by interrelating with location competences. There are four factors that attempt to explain this (Maskell et al., 1998).

- Infrastructure and environment of the region.
- Availability of resources
- Institutional establishments
- Knowledge and expertise
The historical components of the factors are of high importance. Generally, one can go back a century to see the infrastructural influence, meanwhile natural resources are prone to be more historic. The availability of resources is a vital element of firms’ competitiveness and specialization (Maskell and Malmberg, 1999). The spreading of fresh knowledge is overpriced and complicated with larger geographic distance, thus making local knowledge more advantageous. The division of opinions between theory of knowledge spillovers impact on economic growth via increasing returns of Romer (1986), Grossman and Helpman (1994) differ in the description of knowledge spillovers compared to Krugman’s (1991) view. The idea is that knowledge spillovers are in occurrence infinitely over geographical areas. The “Death of Distance”, renowned to be a paradox due to the diminishing cost of communication in knowledge spillover and interactions. Nevertheless, the complication of knowledge introduces us to a distinction of knowledge and information. The main difference between the two variations is that information is codified and easily transferable, while knowledge is much more complex.

How about the perception of industrial life cycles and innovation in explaining dynamic comparative advantage in ICT? One perspective is that the stage of the industry life cycle influences agglomeration instruments. Tacit knowledge within an industry helps regions’ innovative intensity to cluster spatially. According to Audretsch (1998), it is the early phases of the product life cycle where implicit knowledge has the biggest impact.

Industrial agglomeration is heavily influenced by the geographically facilitated knowledge spillovers (Jaffe et al. 1993; Acs et al. 1992; Acs et al. 1994; Feldman, 1994; Feldman, 1999; Audretsch et al. 1996). Industries should strive to attain low geographical gaps between the firms since that’s the condition that makes knowledge spillovers most efficient (Audretsch, 1996). The implications that knowledge spillovers provide in the market are further explicated by (Porter, 1990; Steinle and Schiele, 2002). The collaboration firms’ exercise in terms of knowledge within industry sectors, such as labor return, similar vendors, swapping information, and others, intensifies the clustering mechanism. Moreover, companies are also subject to joint use of resources and infrastructure (Sonobe and Otsuka, 2006). Also, agglomeration is a major cause of innovation activities, due to availability of educated labor (engineers, technicians, etc.) and a variety of suppliers.
Bearing in mind the Ricardian model, labor productivity and the cost of labor are the main determinants of comparative advantage. Labor productivity is an economic indicator, which reveals the effectiveness of a worker performing a task given output and time. Labor productivity is related to the standard of living of nation and for the economic welfare to prosper. Thus, economic growth needs to be sustained through an increase in output in contrast to the population (Ukoha, 2009).

Krugman (1994) added to the concept of specialization contributing to successes within trade. The economic phenomenon arises from the neo-classical trade theory and some recent theories, which stress factor endowments to be the sources of comparative advantage and specialization. Moreover, export competitiveness within industries is accounted for by the accumulation of technology and specialization. As a result, the trade fluctuation a country undergoes is representative of the magnitude of specialization and technological level of that specific country. Posner’s (1961) work on the relationship between trade and technology provided new theories that offered insight in economic visions. The technological gap theory predicted that monopolistic enterprises utilized their profits from technological advantages, which consequently lead to maturity in many sectors. There is little doubt that technology causes comparative advantage in many industries *ceteris paribus*, but it is a greater challenge to directly relate trade and technology. Exporting firms tend to have larger efficiency compared to firms focused on domestic markets, which arises from experience of trading and more importantly, low cost production (Clerides et al., 1998).

As a result of competition in a market, enterprises that hold a strong position in a particular industry are often driven to innovate to restrict new entrants from gaining rapid market shares (Dasgupta and Stiglitz, 1980). It is argued that in industries characterized by rapid technological change, as for example in the telecommunications sector, competition for the market through standard-setting innovations is likely to be more significant than cost-reducing static efficiency (Ahn, 2002).
4 Data and Method

Our data is collected from the OECD statistical database, World Bank, LABORSTA (the International Labor Office) and the National Bureau of Statistics of China. These following countries were included in the sample: Australia, Canada, China, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Netherlands, Norway, Spain, Sweden, United Kingdom, United States.

Revealed comparative advantage (RCA), a method of detecting comparative advantage from actual specialization patterns introduced by Bela Balassa (1965), is used to define the specialization in exports of a specific product in relation to the market share of that product. This represents our dependent variable (RCA) for each of the countries in our study, determined by the following formula:

\[ RCA_{ij} = \frac{\left( \frac{x_{ij}}{X_i} \right)}{\left( \frac{x_{aj}}{X_a} \right)} \]  

(1)

where \( x_{ij} \) stands for a country’s exports of product \( j \) (in our case ICT goods); \( X_i \) denotes total exports of country \( i \); \( x_{aj} \) represents total exports of product \( j \) from the reference area (in our case the world); \( X_a \) symbolizes total exports from the reference area.

A country has a comparative advantage in a certain product, if it produces that product at a lower opportunity cost than another country. The country that enjoys comparative advantage in a product will tend to export it and import those products that it has a comparative disadvantage in. The RCA index defines the existence of comparative advantage or disadvantage of a country compared to the others, depending if this index is higher or lower, respectively. It takes on values from zero to infinity. Distortions in trade patterns, such as trade barriers, directly affect the RCA’s validity.

In analyzing RCA for ICT goods, countries with intensive input of R&D and specialized labor force are expected to produce and export ICT products by maximizing the usage of these factors. Referring to the Ricardian framework, it can be stated that an increase in technology-related inputs, such as FDI inflows, followed by high productivity will lead to higher revealed comparative advantage.
Thus, referring to the above-mentioned we choose a pattern of explanatory variables that we believe give a solid and thorough analysis for the changes and alternations of RCA. The model to be tested is recapitulated as follows:

\[ RCA_{it} = f (GERDTEch_{it-5}, TAPav_{it}, FDI_{it}, TAPrv_{it}, LP_{it}) \]  

(2)

The empirical analysis of this paper of the determinants of RCA in ICT goods is built upon an econometric framework based on panel data. Specifically, for the function displayed in Equation (2), we choose a linear regression model for estimation, which is shown in Equation (3) below:

\[ RCA_{it} = \beta_0 + \beta_1 GERDTEch_{it-5} + \beta_2 TAPav_{it} + \beta_3 FDI_{it} \]

\[ + \beta_4 TAPrv_{it} + \beta_5 LP_{it} + \mu_i + \gamma_t + \epsilon_{it} \]  

(3)

where \( i \) represents countries \((i=1,2,3...,22)\), \( t \) indicates time (i.e. yearly observations: \( t = 1996, ..., 2009 \)), \( \mu_i \) denotes the unobserved effects in each country, \( \gamma_t \) represents the unobserved effects in every year, and \( \epsilon_{it} \) reflects the stochastic error term.

The enclosure of the unobserved effects for each country and for every year is of particular importance since it allows us to control for biasedness deriving from omitted variables or other effects. For this model we use a cross-section and period fixed effect, which allows the data to be more robust by capturing the noise that can appear.

Moreover, while including the R&D expenditure by industry in our model and reading the international literature we realized that, as a determinant, R&D has a time lag in delivering the expected outcomes and effects upon industries. According to Griliches (1998) for R&D expenditure a time lag of 3 to 5 years is recommended to deliver its impact. For this reason, we assume a 5-year time lag for this variable and estimate a stock that corresponds to this time lag. The R&D stock is divided by the number of technicians and associate professionals for each country in order to find the expenditure devoted by the government for each technician. Further, the second independent variable computed is the labor productivity. It is a measure of economic performance that relates the total output of a country with the labor input or the total working hours of the
labor force of that country. The third and the fourth independent variables stand for the number of technicians in a country as absolute value and relative value (percentage of labor force), respectively. The fifth explanatory variable represents the amount of FDI inflows in each country, measured in constant prices.

After computing collinearity diagnostics by using the Variance Inflating Factor (VIF), we can conclude that there are no signs of multicollinearity, and thus we maintain our variables in the model for estimation. Moreover, the application of cross-section and period fixed effects absorbs elements that cause heteroskedasticity and autocorrelation problems.

In order to get a better overview of our variables, see Table 4-1 below.
<table>
<thead>
<tr>
<th>Variables</th>
<th>Expected Sign</th>
<th>Description</th>
<th>Data Source</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>RCA</em>: Revealed comparative advantage</td>
<td>(+, -)</td>
<td>Balassa Index, Explained in Equation (2)</td>
<td>Self-made calculations based upon trade statistics from the World Bank Statistics Database</td>
</tr>
<tr>
<td><em>GERD/Tech</em>: Research and Development expenditure per technician</td>
<td>Fagerberg, 1995; Bernard et al. 1999; Bleaney and Wakelin, 2002; Barrios et al. 2003</td>
<td>Government expenditure in research and Development by industry (Total Business Enterprise) per technician and associate professional</td>
<td>Own calculations based upon data from OECD and LABORSTA (United Nations’ International Labor Office)</td>
</tr>
<tr>
<td><em>TAP_AV</em>: Technicians and associate professionals</td>
<td>(-)</td>
<td>Dudley and Moenius (2001)</td>
<td>LABORSTA (United Nations’ International Labor Office)</td>
</tr>
<tr>
<td><em>TAP_RV</em>: Technicians and associate professionals as relative value</td>
<td>(+)</td>
<td>Technicians and associate professionals as share of labor force</td>
<td>LABORSTA (United Nations’ International Labor Office)</td>
</tr>
<tr>
<td><em>LP</em>: Labor Productivity</td>
<td>(+)</td>
<td>Ricardian</td>
<td>Total economy labor productivity</td>
</tr>
</tbody>
</table>
5 Empirical Results and Analysis

The econometric results on the determinants of RCA in ICT goods are presented in Table 5-1 below.

Table 5-1: Determinants of RCA in ICT goods (cross-section and period fixed effect)

<table>
<thead>
<tr>
<th>Dependent Variable: RCA in ICT goods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of observations: 308</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Independent Variables</strong></td>
</tr>
<tr>
<td>---------------------------</td>
</tr>
<tr>
<td>FDI</td>
</tr>
<tr>
<td>Technicians_AV</td>
</tr>
<tr>
<td>Technicians_RV</td>
</tr>
<tr>
<td>Labor Productivity</td>
</tr>
<tr>
<td>GERD/Tech</td>
</tr>
<tr>
<td>R-squared</td>
</tr>
<tr>
<td>Adj. R-squared</td>
</tr>
<tr>
<td>F-statistics</td>
</tr>
</tbody>
</table>

The results reported show that two out of five explanatory variables have the expected sign, two of them do not have the expected sign and one variable is statistically insignificant, i.e. FDI inflows\(^1\). However, our expectations of a positive impact of the number of technicians (TAP_AV) and of R&D intensive technical labor force (GERD/Tech) must not be generally true. A possible way to interpret the negative sign of the R&D intensive technician labor force can be found in the proportion of government R&D expenditure stock (GERD) to the absolute value of technicians and associate professionals\(^2\). One probable scenario can be the case that the number of technicians has increased in higher rates than the amount of GERD during the observed years, which according to our results increases revealed comparative advantage.

\(^1\) Refering to the variable’s p-value in Table 5-1.

\(^2\) \(\text{Government Expenditure on R&D} \div \text{Technicians in absolute value} \) - This algebraic expression is presented to provide a clearer understanding of our approach.
An alternative explanation for this negative relationship for countries in where the revealed comparative advantage increases, can be explained by the decreasing rates of GERD, due to re-orientations of governmental policies, and an almost constant or relatively lower growth of technicians. Moreover, the results of the regression provided above can possibly imply that government expenditure on R&D per technician can be concentrated in other industries where technicians and associate professional are located, not necessarily in the ICT manufacturing production. Additionally, referring to Figure 2-2, the market shift that the ICT sector has experienced during the last years, has also shifted the orientation of GERD from the manufacturing industries to service firms (OECD Outlook 2010). Hence, countries that concentrated their inputs and specialized in ICT goods are now investing and specializing in ICT services. Additionally, as a very new, dynamic and innovative sector, the product-life-cycle of ICT products, as well as that of ICT services, is relatively short, leading to a high demand of R&D investment.

Considering the countries that have leading ICT firms account for most ICT exports have also very developed and world leading industries in the goods market (i.e. automobiles), we discover another reason for justifying the negative sign that the coefficient of the number of technicians reveals in our model. Continuing this analysis and focusing upon the notion of specialization, we can determine if the changes in countries’ RCA indices during the time-period of our sample are sizable or not. Considering the shares that Balassa’s measure incorporates, an increase of RCA in one industry implies a reduction of RCA in other industries. Hence, intensive specialization in exports of a certain industry can be possible only at the expense of at least one other sector. This implies that, the more industries the country has with a value of RCA around 1, the less specialized are the country’s exports and the more spread is the specialized labor force (Dudley and Moenius 2001).

On the other hand, the two other variables, labor productivity (LP) and the technician share of labor force (TAP_RV) show the expected signs in the model. In analyzing the relative importance, the technician share of labor force is found to exert the strongest influence on the level of revealed comparative advantage for ICT goods. The estimate of the technician labor force indicates that a 1% increase in this variable leads to a 0.381381% increase in the dependent variable. The next most important determinant is labor productivity, which has a weaker impact on the dependent variable, corresponding
to the coefficient value. Additionally, the empirical results of the last two variables match the pattern of our theoretical approach. Observing the importance of technical labor force as a determinant of ICT goods’ trade, and acknowledging that ICT sector products are characterized by a short product-life-cycle; the efficiency of labor force is of crucial importance. Hence, high labor productivity, considering other factors to be constant, boosts production, which enables a short product-life-cycle to be feasible.

New technology gives birth to new products and ultimately industries, which is known as the technology-product-industry (TPI) life cycle (Klepper, 1996 and Klepper, 1997). This theory brings together the concepts of technology, innovation, agglomeration, and product life cycle to establish a connection between agglomeration dynamics and local industry. The evolution of technology and products through innovative activity, has a great impact on the size and number of firms. Initially, in the TPI, doubt concerning the product is often present in terms of both technological attributes and innovation. As a result, tacit knowledge becomes of high importance (Audretsch and Feldman, 1995). To make sure a business or company sells its products with producing an excess, a division of labor is often present. At this stage, it is evident that advantages from geographic proximity is present, also due to lower transaction costs (Storper, 1995).

Throughout the second stage, the production is accelerated and larger quantities are produced as the changes necessary for the new product become minor. This is where high rates of labor productivity and a specialized pool of labor force play an important role. Firms are now also more focused on the process of innovation rather then the product and there is generally a decrease in the number of firms due to the inability of manufacturing the product effectively and also the situation where a established company’s accumulated knowledge becomes a barrier to entry. As a result, the firms in the market experience growth due to the increase in demand over time and the benefits that were retrieved from the first stage are not present.

In the third and forth stages as the product becomes saturated and standardized shift focuses to cost instead of performance. This implies that the competition between industry leaders is located in places with lower production costs such as China and Eastern Europe. During this stage, different advances are possible (Tichy, 2001). Firms can move their production to lower cost areas, the existence of industry migration can occur where firms can relocate to cheaper areas and replace the original leaders, and lastly the firm
can seek to reach higher market sectors to avoid price competition (product differentiation). The second case causes the industry to vanish from its initial position, while the other two cases comprise of a general decrease of local economic activity. As a result, the idea behind the TPI is that agglomeration economies are shaped in the initial stages of industry development and can only be persistent for a limited period.
6 Conclusion

The empirical analysis of this paper on the revealed comparative advantage of the global ICT sector with a focus on 22 countries over the 1996-2009 period, has delivered an evocative and explanatory approach for the determinants that yield a lower opportunity cost in exporting ICT products. Considering the short product-life-cycle of ICT goods, innovation occupies a heavy and strong position in fostering the production process to meet the demands of the market, which increases constantly contemplating the evolution of this sector in the past years. Moreover, the knowledge spillovers clustered in industrial areas and the intensity of R&D investments are considered as the most important pillars of innovation, which constitutes the main input for ICT manufacturing.

The main finding uncovered in this paper is that it is not necessarily the countries with the highest specialized pool of workers or the countries with the largest R&D intensive technical labor forces that ensure comparative advantage in ICT product exports. In fact, high labor productivity and high technological accumulation are prone factors to a stronger RCA in the international context. This is a rational conclusion since the utilization of advanced technology is beneficial to laborers, hence increasing labor productivity.

Considering the above mentioned, for several countries that are considered to be leaders in this market, the RCA in exporting these products has experienced a slight decrease. On the other hand, most of the countries have reprioritized their position in this market by orientating their inputs towards another category of this market, i.e. ICT services. The recent evolution that the Chinese ICT industry has undergone during the last decade, accompanied by a highly agglomerated and specialized labor force, has outcompeted many of the leading countries in the ICT goods market and redistributed the share in this market. Refering to the third stage of Vernon’s product life cycle (see Section 3), the production of a product is shifted to underdeveloped countries with the scope of seeking low production cost and lower wages. In this transposition, the product is manufactured by a less specialized and less R&D intensive labor force. In addition, to make up for the gap created by the lack of R&D, underdeveloped countries import the needed services from developed countries, in order to facilitate the production of these products. Reaching the end of this cycle, the product is ready for export, mostly in the same markets where it got developed.
The RCA shift in the goods market versus that of the services has ignited an interest concerning the motivations behind this phenomenon. Despite this shift, the market of ICT services is weaker compared to that of ICT goods in terms of value added in international exports. ICT services have been growing more rapidly in the last 15 years compared to that of goods. The main determinants of ICT services range from a stock of mid to high skilled labor as well as the confidence between the exporter and importer which is highly conditional upon the government policies set to ensure quality. The variations in regulations are empirically proven in previous studies to affect a nation’s trade directly (Van der Marel 2011). On the other hand, observing the evolution of the ICT market, projections deliver a parallel development of the service sector as that of the goods sector. The increasing demand of ICT goods requests an increase of supply of ICT services as well.

In this framework, underlining the immediate growth of ICT, we suggest further studies to explore and analyze the field of ICT services. In addition, a different approach can be executed by investigating the factors that explain the alterations of this market, from goods to services.
List of references


Appendix

Appendix 1 World trade in ICT goods, 1996-2008

Note: No data for the Slovak Republic for 1996. Partly estimated for non-OECD and the United Kingdom (HS code 852520 in 2005/06). The classification system adopted is for ICT+, i.e. ICT goods plus measuring and precision equipment.