Industrial Structure and Development: Hunting for the *"Flying Geese"*

A Cross-Country Analysis of Patterns of Specialization in the Manufacturing Industry, 1976-2004

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"The dramatic modernization of the Asian economies ranks alongside the Renaissance and the Industrial Revolution as one of the most important developments in economic history." - Lawrence Summers

Illustration made by my sister, Charlotte Soon Kvebek.

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A study of 86 countries and 28 manufacturing sectors over the years 1976-2004

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Preface

This Master Thesis is submitted for the degree of Master in Philosophy in Economics at the University of Oslo, fall 2012.

I would like to express my sincerest gratitude to my supervisor at NUPI, Senior Researcher Arne Melchior, for excellent academic advice, guidance, discussions and comments throughout the process. A great thank you for all the non-academic talks as well: To find someone as fascinated by Korea and East Asia as I am is a rarity.

I am grateful to my family, especially my mom and dad. Someday I will (hopefully) buy you that house in Spain. A thank you to my boyfriend, Anders: You are an extremely patient person. For the times I couldn’t stop talking about things you probably don’t find that interesting, I sincerely apologize. I cannot, however promise that I will not continue to talk excessively about my work. I genuinely like what I am doing. What I can promise, is that you will always be a solid reminder of what life is really about.

To all my study friends: Thank you for some amazing years at Blindern. To Linn, Carina and Benedicte: Thank you for being who you are.

Lastly, to my high school teachers: Karin Arnesen and Eirin Skjerve. You taught me that enjoying school and studies is not necessarily a bad thing. Hard work is OK and curiosity is a blessing. Thank you both.

Any errors or inaccuracies in this thesis are, of course, all my own responsibility.

Christine Mee Lie,

Oslo, October 1st 2012

Summary

This is a study searching for proof of universal patterns of structural change in the process of development. More specifically what is pursued answered is: *Is there a universal pattern of structural change, so that at a particular income level, a country has a particular pattern of manufacturing production?* While it is known that low-skill sectors such as clothing tends to be located in low- or middle-income countries, and high-skilled sectors such as electrical machinery tends to be located in high-income countries, a systematic study spawning the whole range of industrial sectors in the search for universal cyclicality, is missing. This study, thus econometrically with use of the software Stata, searches for evidence of inverse U`s in empirical data covering *86 countries and 28 manufacturing sectors, from 1976-2004.* Hence a main question is whether there is a general (inverse) U-shaped pattern of industrial development, similar to the Kuznets-Curve of inequality.

Potential explanations for such developments is surveyed to find out of why this should be the case. Well known theories like Vernon`s product cycle theory and theories of economic geography, as well as the more unknown Asian theories by Akamatsu and Kojima, are considered. All share a fascination of the Asian "miracle economies". As Akamatsu`s flying geese theory is so famous in Asia while almost unknown in the West, the largest emphasis will be on this theory as a contribution to the increased knowledge of Asian economic theories. Another contribution is adding to the discussion of measuring specialization and relative importance in sectors.

The main trend seen from the empirical evidence and the econometrical analysis is the clear cyclicality in *all* type of sectors, irrespective of technology level and degree of sophistication. Cyclicality was found as expected in Low-Tech sectors, but they were found in the more technology intensive sectors *too* - and surprisingly to a *larger* extent. This is an important finding because technology barriers, knowledge specificity and other aspects of production and trade tying sectors to specific locations, seems to work less restrictively than assumed. Type of sectors and changes *between* sectors thus seem to matter, even as the alternative approach of *within*-sector change and firm heterogeneity has convincingly been proven. Such structural change is not in any way dismissed, but the focus in this study has been on the classical sector approach. To what extent there *also* exists structural change *within* sectors, is a hypothesis not tested. This study`s contribution is that sectors still matter.

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1 Introduction

When countries grow from poor to rich, we normally see a parallel transformation of their patterns of production. A main question in regards to this is then to what extent there are universal patterns of structural change in this process of development? In the research literature, some empirical regularities have been observed: As countries grow richer the share of agriculture in employment and GDP decreases, and the share of services rises (Syrquin 1986). In addition, most countries have experienced huge growth in manufacturing production, and scarcely any countries have developed without upgrading and changing their manufacturing industry. For some of the currently richest countries, however, the share of manufacturing in GDP is now falling (Chenery and Syrquin 1986, UNIDO 2009). Hence a main question is whether there is a general (inverse) U-shaped pattern of industrial development, similar to the Kuznets-Curve of inequality.

At the more detailed level, there also seems to be structural changes within the manufacturing industry. Hence another issue is searching for universal patterns just within different sectors of manufacturing. The ladder is the topic for this study: *Is there a universal pattern of structural change, so that at a particular income level, a country has a particular pattern of manufacturing production?* And thus, when income level increases, the countries move along in this similar pattern on their way up the industrial hierarchy. Potential explanations for such developments is surveyed to find out of why this should be the case, and a cross-country econometric analysis of the relationship between income levels and industrial specialization, is undertaken. If such general (inverse) U-shaped patterns are found in all type of sectors independent of technology level, i.e. even in the High-Tech sectors, then this is in conformity with the observed phenomenon of deindustrialization (Rowthorn and Ramaswamy 1997, Rowthorn and Coutts 2004, Palma 2008, Tregenna 2009, Ghani 2011).

The study is inspired by the “miracle economies” of East Asia, and their rapid industrial upgrading and spectacular economic performance over the last decades. With the rise of Japan and their rapid transition from labor-intensive manufacturing to capital-intensive high-tech products, East Asia`s miraculous development began. The Asian “tigers” followed closely in Japan’s footprints, and later China and the new ASEAN[1] countries. The perhaps first theory

[1] ASEAN-countries: Malaysia, Indonesia, Singapore, Thailand and the Philippines. ASEAN stands for The Association of Southeast Asian Nations.

of economic growth and structural change describing such developments, was formulated by a Japanese economist in 1932: *"The wild-geese-flying pattern of industrial development denotes the development after the less-advanced country`s economy enters into an international economic relationship with the advanced countries."*. This quote is from one of the most famous papers by Akamatsu - extremely famous in East Asia, but surprisingly unknown in the rest of the world. As an economics student I find this highly curious. This Japanese theory and versions of it will therefore have the largest emphasis in this thesis, as a mean to increase the knowledge and understanding of them. I will also in the survey, show that although not explicitly quoted many times, Akamatsu`s ideas are present in many modern and Western theories.

On the topic of economic growth and structural change in manufacturing, many theories exist as well as a number of country-level studies. However, a surprisingly low number of rigorous cross-country studies covering many countries have been made. Adding to this literature, the main contribution of the thesis is: *To undertake a comprehensive empirical analysis, using a panel data set covering 86 countries and 28 sectors over the period 1976-2004.* In the analysis, another contribution is also reconsidering how industrial specialization should be appropriately measured, in order to avoid potential bias. For example, large countries tend to be more diversified than small countries, and this affects measures of specialization such as GDP shares or commonly used indexes of comparative advantage.

Although very general patterns say little about policy or specific causal effects, it does show important universal relations. As most theories are aiming at saying universal things, the question of common patterns in industrial upgrading seems important. Identifying similarities can help discover crucial phases in development that are needed in order to advance. With this I am not saying that I believe that all countries have or will develop the exact same way. What I am saying, is that I do *not* believe that all countries develop in *completely* different ways. Thus in this thesis I will be searching for universal patterns the same way Syrquin (1986) did in the agriculture industry.

In this thesis I will be hunting for the flying geese.

1.1 Layout

Chapter 2 surveys the literature of structural change with a particular focus on the Japanese flying geese theory. The survey shows that although the theories differ in many ways, and have different origins, they have strong similarities. Since Asian economic theories are less known in general, they are presented in greater detail.

Chapter 3 will discuss different ways to measure specialization and relative importance. Both a formal presentation of formulas and a discussion of strengths and weaknesses with the respective measures, are undertaken. This holds especially for measurements of comparative advantage. Here both the classical RCA index and the normalized RSCA index are discussed in more detail.

In Chapter 4 the data set used in the thesis is presented: Alessandro Nicita and Marcelo Olarreaga`s *"Trade, Production and Protection 1976-2004".* The advantage with using this panel is that the authors have merged data from different sources together in a common industry classification, so both trade and production data is *comparable*. Following this, descriptive evidence focusing especially on identification of inverse U-patterns, are done both with regards to relative shares of output, import and export data, and with respect to calculated RCA.

In light of the econometric analysis in Chapter 5 a set of pre-tests are formulated and described, and the econometric model used to test for inverse U`s, are presented and ran. In Chapter 6 the results for output, import and export are all are presented and discussed, and many figures showing the predicted value plots based on the regressions are used as illustrations. A brief discussion of the study`s main implications for future research is also presented.

Chapter 7 will lastly conclude the thesis with a summarizing comment, and a brief discussion of the thesis` contribution to the general literature.

2 A Survey of The Literature: Development and Structural Change

The oldest and most traditional industry is the agriculture one, and the transformation of this sector has in retrospect been a remarkably uniform process. The decline in share of agriculture in a country`s labor force and total production as income per capita grows, is in both cross-section and time-series studies extremely well documented (see e.g. (Clark 1940, Kuznets 1966, Chenery and Syrquin 1975)). This declining importance is very persuasive since it is seen in all countries: Rich and poor, socialist or capitalist, democratic or authoritarian - all around the globe. This decline is the starting point for the strong link drawn in Lewis` theories between agriculture and industrial growth, promoting surplus labor in the agriculture sector as a driver for the transformation (Lewis 1954). His “dual-sector models” have been tested and confirmed extensively.

Later on, after the decline of agriculture and the rise of manufacturing could be observed, Kuznets (1966) stated that what he called *“the transition to modern growth”* was under way: More and more countries, having emerged from agrarianism into dualism following England`s lead, were now undergoing a transition from a dualistic structure into a one-sector modern economic growth system. This modern economy had combination of agriculture, manufacturing and services. As this “modern growth system” spread geographically, it not only spread across Western Europe (England`s neighboring territory), but also to what he called “late comers” – Japan, Germany and the US, as well as to the “overseas territories” and the developing countries (in a post WW2 terminology). Thus his economic transformation was a worldwide phenomenon.

As Kuznet`s transition evolved, we observed a rapid increase in the importance of manufacturing production for all countries. However, developed countries also saw a declining importance in this sector as they got increasingly richer. Between 1950 and 1973 these countries saw their combined share of manufacturing decline from 72 to 56 percent. Thus there seems to be cyclicality in manufacturing similar to the one in agriculture. As a substantial geographical shift and redistribution of manufacturing production also took place, the shifting patterns of production locations, indicated by Kuznets in his transition to modern growth, seems well proven: The share of manufacturing production for middle income countries increased by more than 50 percent within the same time period (1950-1973) (Chenery 1977).

Now in the study of agriculture, models tracing out different phases of the agriculture sectors` transformation, are proposed and argued for, and clear patterns are both described and empirically proven (Chenery and Srinivasan 1988). As for the transformation within the manufacturing sector, various theoretical approaches are also here attempting to explain the structural change. Some of these are descriptive or "narratives", in the sense that they describe some pattern of change that should apply throughout the process of growth. In the West, a well-known approach along these lines is the "product cycle theory" of Raymond Vernon (1966). According to him, each industrial sector passes through stages of development where product and production technology, as well as demand patterns, change over time. For this reason, the location of production will change between countries during the process. A typical example is consumer electronics: Products were initially developed, produced , consumed in, and exported from, the richest and most advanced country (USA), and gradually spread to a second tier of countries (Western Europe) and finally, after production technology and products had become standardized, to the low-cost producers in Asia (Firstly Japan, then the NIEs[2], the ASEAN and China).

While Vernon's theory was well known and celebrated in the West, it was more or less completely unknown that a very similar narrative was presented more than 30 years earlier in Japan, by Kaname Akamatsu (1932). In the pattern described by Vernon, with an emphasis on innovation, sectors change but countries are the same - and thus the location across countries changes. For Akamatsu, although not considering innovation at all, the pattern is the opposite: Sectors are constant but the countries change - since sectors have different characteristics. Hence the dynamics of Akamatsu, as well as Vernon, create cyclical patterns over time with the location of production changing continuously.

Contrary to standard economic theories, the theories of Akamatsu and Vernon did not have equations and algebra leading mathematically to the results: They were broader and more holistic and verbal. These theories have however been formalized later by various authors. One potential driving force behind Akamatsu's cycles could be changes in factor endowments, as described by the Heckscher-Ohlin-Samuelson (HOS) trade theory. This

[2] The Newly Industrialized Economies: South Korea, Singapore, Taiwan and Hong Kong.

approach underlies Kojima`s attempt to both modernize and formalize flying geese. As Akamatsu took the viewpoint of the follower country, Kojima, living in a very different Japan, took the viewpoint of a developed one. He diverted the focus allowing FDI (Foreign Direct Investments) to play a role in the dynamic, and explained the different phases in a classical HOS framework. Another potential driver of structural change could be the forces of agglomeration described in recent theories of economic geography (see e.g. (Fujita, Krugman et al. 1999)). Along these lines Puga and Venables model of *"the spread of industry"* offer a more formal theoretic approach in line with Vernon, in the sense that more firm and sector specific characteristics are considered. Vernon focuses on innovation and restructuring with regards to more or less innovated sectors, while Puga and Venables focuses on restructuring with regards to differences in labor-intensities and real wages. In the following all these theories will be surveyed, but a stronger focus will be on the Asian contributions almost unknown in the West.

According to these theories, structural changes occur in the form of cycles related to sectors. Alternatively, structural changes could occur *within* sectors, if firms or workers are heterogeneous. This is the focus of recent research on trade and firm heterogeneity (see e.g. (Melitz 2003)), and the empirical literature has convincingly shown that firms are indeed heterogeneous, and they may differ in scale, skills and technology. A possibility is therefore that structural change occurs within sectors rather than between them. If this is the case there may be fast structural change with no changes in sector patterns of comparative advantage. While this possibility is not dismissed, this study will focus on the sector approach. Hence the aim in this thesis is to show to what extent sectorial patterns change in the process of development. To what extent there *also* exists structural change *within* sectors is a hypothesis not tested.

2.1 Flying Geese Theory

"The wild-geese-flying pattern of industrial development denotes the development after the less-advanced country`s economy enters into an international economic relationship with the advanced countries."(Akamatsu 1962).

The flying geese model of industrial development was developed in the 1930s by Japanese economist, Kaname Akamatsu. The theory became well known first in the early 1960s when the 1930s articles where republished in English, and Japanese scholars showed renewed interest. Later, in the 1980s, it became common public knowledge in Japan and East Asia when Japanese foreign minister, Saburõ Õkita, introduced the model at the 4th Pacific Economic Cooperation Conference (PECC). While the popularity of the theory has declined since its heyday, the theory has had huge influence in East Asia both academically and politically, and is still one of the most well-known theories in this region explaining industrialization and development.

Akamatsu presented his theory graphically and verbally, with good argumentation and explanations of the mechanisms at work. The theory were later further developed and formalized by many economists in East Asia, but the essence of the theory remains: The attempt to explain the dynamic catching-up process of industrialization of latecomer economies, through structural changes over time. The theory follows developing countries through different stages, classically from labor intensive to capital intensive manufacturing production, with countries graduating from different levels while moving up the industrial ladder. The theory is originally based on observations in Japan from the 18th century, but more commonly applied to Japan`s remarkable industrialization since the late 19$^{th}$ century, and East Asia`s rapid economic development after the Second World War.

The theory is highly prominent in Japan and East Asia and has at times been seen as vindicated by the "East Asian Miracle Study" done by the World Bank in 1993. The theory is also associated with the "Greater East Asian Co-Prosperity Sphere", a propaganda term invented and used actively by the Japanese government during their expansionism in Asia in the 1930s and 1940s (Furuoa 2005). The original theory is however based on the three time series curves denoting import, domestic production and export of manufactured goods in less advanced countries – and it is *this* pattern that was coined *"flying geese"*. The three curves formation looks similar to the pattern created by wild geese in the sky, flying in orderly ranks forming an inverse V. Each goose in the rank represents a different country, and their order reflects the countries` production structure and level of industrialization.

As the theory is not well known or used in literature in the West, the theory is commonly mistaken for just being a descriptive account for industrial development and the catching-up process of latecomer economies, or seen in light of Raymond Vernon`s product cycle theory – a Western theory in the same field. The original flying geese theory does however, as will be demonstrated in this chapter, differ from Vernon`s and other neoclassical theories. The most common modernization, namely Kojima`s formalization, is though inspired by western economists. While bringing in the aspects of FDI and regional integration he leans on Swedish economist, Gunnar Myrdal, and German economist, Wilhelm Röpke (Korhonen 1994a). The former represents the New School of Internationalist, the ladder the Old[3]. Together with Hecksher-Ohlin type comparative advantage and factor accumulation driven dynamics, Kojima - Akamatsu`s principal pupil (Kojima 2000b), stands for the most extensive modern and formalized version of the original theory.

2.1.1 Early Insight: Akamatsu`s Original Model

Akamatsu (1996 – 1974) was, as the dean of the Faculty of Economics at Hitotsubashi University, Tokyo, a highly influential economist. In his early years as an economist he visited Germany where he attended lectures in Berlin and Heidelberg, and his influence by the German Historical School[4] on his thinking is evident. Some basic features in his flying geese

[3] This categorization is made by Gunnar Myrdal himself.
[4] The German Historical School was an approach to academic economics and public government policy that emerged in the 19th century within the circle of the German academic elite in Prussia. They held history as the key to knowledge about human actions and economic matters, since economics in nature was culture-specific and not generalizable. They emphasized theories stemming from empirical and historical analysis. Known economist from this school is: Friedrich List, Max Weber, Gustav von Schmoller and Joseph Schumpeter.

The policy *"Import-Substitution Industrialization"* (ISI), advocating replacing foreign imports with domestic production securing economic independency, is connected to the school. Friedrich List was an advocate of this policy together with classical economist such as David Ricardo and John Stuart Mill.

The question of whether this is a true economic "school" or not is highly discussed, since there is a wide spectrum of opinions between the connected economists. As Dorfman (1955) , Shionoya (2005) and Caldwell (2001) argue however, this could be said for most academic "schools".

Dorfman, J. (1955). "The Role of the German Historical School in American Economic Thought." The American Economic Review **45**(2): 17 - 28.
, Pearson, H. (1999). "Was There really a German Historical School of Economics?" HOPE **31**(3): 547 - 562.

theory were for example already discussed by economists connected to the School. Akamatsu himself mentions that his basic idea is similar to an earlier version formulated by Friedrich List (Schröppel and Mariko 2002). Akamatsu`s modeling inhibits much more optimism than List, however, which follows the mainstream more pessimistic view among the German Historical School. The more philosophical aspect on industrialization drawn from flying geese`s deterministic optimism regarding the long-term evolution, are considered to reflect impulses drawn from Hegel and other offshoots of Hegelianism (Korhonen 1994b).

The original theory can be divided into three main aspects: The *intra-industry* aspect, the *inter-industry* aspect and the *international aspect*[5]. The first aspect is the basic one of the model and analyzes development within a particular industry. The second one has a broader look on the country`s economy, and focuses on the sequential appearance and development of different industries. The latter looks at the world as a whole, and sees the country`s economy in light of the world economy, with sequential appearance and relocation of industries from advanced to developing countries[6]. Together these aspects is what is known as Akamatsu`s flying geese theory.

The Intra-Industry Aspect

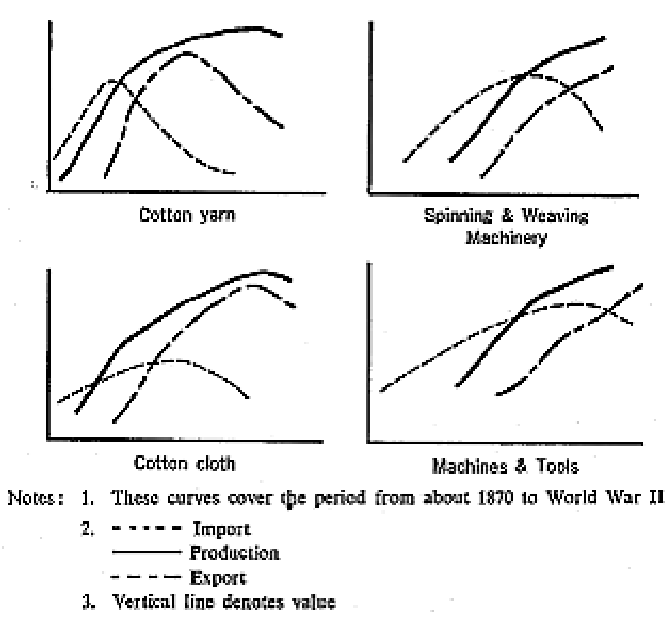
The original figure Akamatsu deducted the classical flying geese pattern from is one based on Japan`s woolen industry, as seen in Figure 1. The name refers to the three time series curves that look like wedges of wild flying geese chasing each other on the sky. As time went by however, the expression came to describe the international aspect and the sequential development of industries in different countries.

, Caldwell, B. J. (2001). "There Really Was a German Historical School of Economics: A Comment of Heath Pearson." History of Political Economy **33**(3).
, Shionoya, Y. (2005). "The Soul of the German Historical School: Methodological Essays on Schmoller, Weber and Scumpeter." The European heritage in Economics and the Social Sciences **2**.

[5] This aspect is also called the international division of labor aspect.
[6] The international aspect of flying geese was introduced by Akamatsu first in the 1940s.

Akamatsu, K. (1943). "Shinkõkoku no sangyõ hatten no gankõ keitai [The Flying Geese Pattern of Industrial Development in Newly Industrializing Countries]." Ueda Teijirõ hakase kinen ronbunshû [Essays in Honor of Dr. Ueda Teijirõ] **4: Jinkõ oyobi Tõa keizai no kenkyû [Research on Population and the East Asian Economy]**: 565 - 577.
, Akamatsu, K. (1944). "Keizai shinchitsujo no keisei genri [Principles of Formation of New Economic Order]."

Figure 1: Akamatsu`s Original Figure



Akamatsu`s original figure of the flying geese pattern showing the intra-industry aspect of the theory across 4 different parts of the cotton industry (Akamatsu 1935, Akamatsu 1962). The horizontal line denotes time from about 1870 to the Second World War, while the vertical line denotes total value. The import curve starts the gaggle, followed by domestic production and lastly exports. We can see that the point, at which the country starts to export, is later for more capital intensive goods than for labor intensive ones: The difference between the cotton yarn industry and the machines and tools industry is especially visible.

Source: Akamatsu, K. (1962). "A Historical Pattern of Economic Growth in Developing Countries." The Developing Economies **1**: 3 - 25.

The intra-industry dynamic described by the figure is threefold: First we have a period where domestic demand induces manufactured goods to be imported from more developed countries abroad. This establishes a growth in demand which induces domestic production of the good. When this domestic industry is sufficiently developed and so domestic production exceeds domestic demand, the country starts exporting these goods. As production and exports increase over time, imports gradually decreases. These dynamics are due to demand linkages between consumers and producers both in the developing and the developed country, demand linkages between both countries in general, and the degree of complementarities in the countries respective industrial structures – characterized by phases of heterogeneous and homogeneous relations. Akamatsu here provides an explanation of emergence and development of different products and industries in a country, which is not solely based on changes in relative comparative advantage due to factor endowments, and therefore differs from the neoclassical view.

Although Akamatsu affirms trade as the main concept of introduction of new products and technology, he does not elaborate much on the mechanism itself. *Why* imports in phase one originally occurs are for example left unknown. The same goes for innovation and how technology is actually transferred from the exporting to the importing country. Akamatsu acknowledges this as important features, but innovation is exogenously incorporated, and the technology transfer is unexplained. The true reasons however, whether it is forced opening of trade or pure temptation in the first case, entrepreneurship or imitation in the latter, is of no crucial importance in light of the dynamics emphasized in the model. It is also worth noticing that the consumer demand Akamatsu describes are exogenously given in his framework, and are considered being static during the development after the domestic market has grown to trigger production. Demand for manufacturing goods from that point on is always there as a constant working force, leaving it to increasing production to induce exports.

What happens when competitiveness is lost and domestic production phased out in a given product, is also left in vagueness. To which extent the domestic market are taken over and served by the follower countries through imports are not elaborated up on (Schröppel and Mariko 2002). This is probably due to the fact that Akamatsu`s theory is following the development from a single country`s point of view. More specifically a development country`s point of view. The perspective in which one looks at the industrialization process is then clearly given. Since this dynamic framework is inspired by Hegelian[7] dialectics however, the same process is considered to be universal in the sense that any given economy being in a perpetual motion, tends to advance to higher stages of industrial development in the same manner (Korhonen 1994b, Shigehisa 2004). This underlying optimism and determinism of industrialization, with graduation and advancement through these three phases, is also observed in other offshoots of Hegelianism. *"In Akamatsu`s sense the historical development of the spirit of industrialism inevitably proceed through struggle and periods of stagnation towards increasingly higher levels of perfection." (Korhonen 1994b).* The three phases described appear almost as a universal law of motion.

The graduation from different industries creating the pattern, are characterized as the three-phase dynamic described in this section. First an *import substitution industrialization (SI),* and

[7] Hegel believed that the evolution of ideas occurs through a dialectical process. His work is based on the idealistic concept of a universal mind that through evolution seeks to arrive at the highest level of self-awareness and freedom. Offshoots from Hegelianism are amongst others Marxism.

filosofi.no (2000). "Georg W. F. Hegel." Retrieved 09.02, 2012, from http://www.filosofi.no/hegel.html.

, SEP (2010). "Georg Wilhelm Friedrich Hegel." Retrieved 09.02, 2012, from http://plato.stanford.edu/entries/hegel/.

then an *export promotion (EP)*, often called *export-led industrialization*. The discussion of SI versus EP is basically a discussion of the degree of an inward or outward looking economy. The SI-phase is of similar type as the *Import-substituting industrialization (ISI)* connected to the German Historical School and Friedrich List: A trade and economic policy that advocates the replacement of imports with domestic production, in an attempt to reduce foreign dependency through the existence of local production. The aim in flying geese, however, is to use imports to establish a domestic demand and a technology level capable of production, in order to move on to the next phase and start exporting. The aim is rather to achieve a *greater* international dependency. The EP-phase of export-led growth, famously characterizing East Asian growth, can then begin. Some countries are however seen to have begun the export-led phase straight away, skipping the import substitution phase. They have not aimed at saturating their own domestic markets, but rather relied on serving others`. The Import-Production-Export sequence is then truncated into a two stage Production-Export one (Shigehisa 2004).

One could then question whether these phases are actually a necessity for industrial development. The pattern is primarily predicting development patterns in the manufacturing industry, and it could be that the mechanisms at work are suitable only for this sector. South America `s development is connected to agriculture, and Indian development is highly connected to the emergence of service related industries, especially connected to the IT-sector. If the flying geese pattern is seen as a *necessity* within the described context, then the applicability of the theory on countries such as these must necessarily be little to none. This leads us over to more meta-theory related questions, and one can critically ask whether flying geese is really a theory, or mainly a description or taxonomy[8] of future development. To be less critical one could ask instead whether flying geese is describing a *general* development pattern, or if it is a theory of development in the manufacturing sector only.

The Inter-industry Aspect

The same dynamic described by the intra-industry aspect between imports, domestic production and exports within an industry, applies to the emergence of different industries in a country as well. The pattern here is a gradual upgrade from manufactured goods, mainly complete consumer goods, to incomplete manufactured goods requiring imports of raw

[8] Taxonomy is the science of classification according to a pre-determined system, with the resulting catalog used to provide a conceptual framework for discussion, analysis, or information retrieval.

materials and intermediate industries, and finally highly capital and technology intensive goods. Again, as discussed above, this gradual emergence of industries is explained by demand linkages. As domestic production of consumer goods increases, this creates a demand for an efficient production of the necessary inputs to the production of these goods. Capital goods such as machines and technology are then imported from abroad and put into production domestically, contributing to an upgrade of the given industry. Imported goods such as machinery that are not merely as they are creates a demand for intermediate industries, and increasing domestic demand for finished capital goods induces domestic production, and emergence of further new ones. This interplay of dynamic linkages is what Akamatsu calls *"domestic industrialization of the import industry"* (Akamatsu 1937, Akamatsu 1943, Akamatsu 1962). When reaching the capital intensive goods, the country has advanced its status as a country, joining the other developed countries at the top of the industrial hierarchy.

This domestic industrialization promotes the possibility of trade policy acting as a catalyzer for development. This is because the theory builds upon creation of domestic production capabilities for further advancement up the industrial ladder. In the linearized system described by the model, the faster the country reaches peak level of production, the faster they will advance. Policies such as "infant industry" protection in the follower country could help this process along, while protectionist measures such as export constraints in the leading country could do the opposite. It is exactly the presence of these types of complementarities that creates phases of economic heterogeneity and homogeneity, which drives economic development in the model. Akamatsu does not highly encourage nor discourage (for that matter), the use of such protectionist measures: He merely states that situations where the use of such measures could be a prevailing option, will arise. This could then lead to emergence of economic nationalism, which is often a byproduct of the struggle for economic independence. Protectionist measures could therefore be beneficial for the country if they are used correctly: When the native industry is vivid, and merely needs time to establish a large enough scale to compete. But if these measures are instead used to protect sinking industries that fails to develop efficiently, they will in the long run impoverish the economy rather than boost it (Korhonen 1994b). To know the difference between these two scenarios, so one could apply protectionist measures appropriately at an early stage, is not necessarily easy or possible. Akamatsu thus states that in the long run it would probably be more beneficial to not use such nationalistic measures, and simply let the imports destroy the inefficient industries.

This implies a "creative destruction" in line with Schumpeterian growth theory[9], again showing Akamatsu`s ties to the German Historical School.

The International Aspect

By swopping industries with different degrees of capital intensity, with different countries at different degrees of development and industrialization, Akamatsu reaches the last aspect of the flying geese theory: The international aspect.

> *"... countries of the world form a wild-geese-flying order from the advanced countries ... to the less-advanced countries..." (Akamatsu 1962).*

The example he uses, and the example that has become the most common illustration of the theory, is the East Asian countries as shown in Figure 2. Here Japan plays the role of the leader goose while the original NIEs creates the first tier and the ASEAN4[10] the second. We then have the latecomers and the latest comers, as Akamatsu calls them. These ladder country groups are in newer versions China and the "new ASEAN" countries: Vietnam, Lao PDR, Myanmar and Cambodia. The former ASEAN4 advanced to become the "new NIEs" when the original ones advanced up to the Japanese level, joining Japan at the top of the industrial ladder.

Emphasizing that this development pattern are seen as a general pattern, not exclusively designed for East Asia, Akamatsu points out that there are several industrial ladders and flying geese patterns in the world. He says that: *"...the wild geese order of industrial development from the advanced to the less-advanced countries is not a one-series row, but is divided into several wild-geese-flying rows, one following another. There is a wild-geese-flying group with America taking the lead, and a Western European group with England and Germany taking the lead, as well as a comparatively small group with Japan taking the lead" (Akamatsu 1962).* It is evident in the above quote, as well as in the rest of Akamatsu`s early work, that he did not consider Japan to be a true leader in a flying geese sense (Korhonen 1994b). This holds even long after the war.

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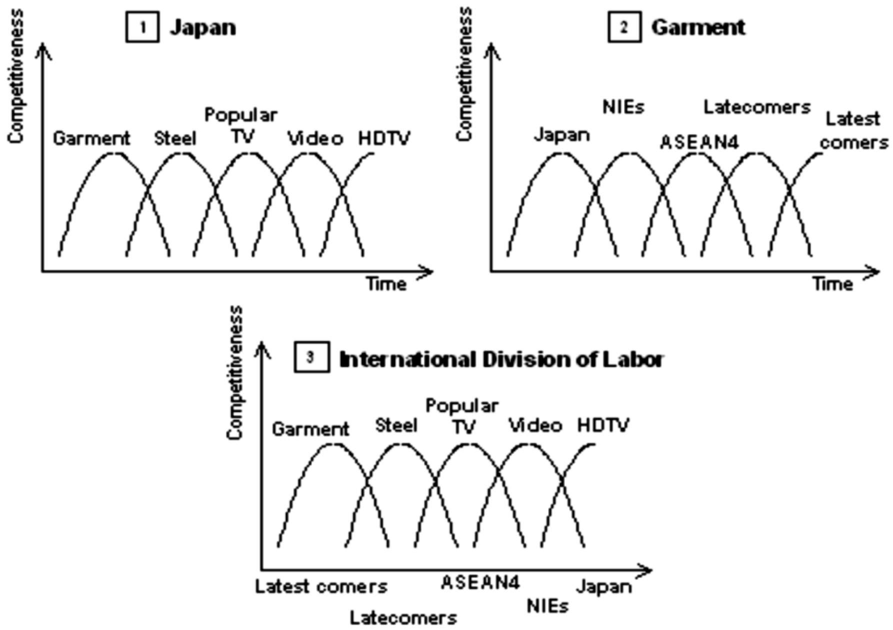
[9] Joseph Shumpeter was a central economist within the German Historical School. His theories of "creative destruction" and firm level growth are well known in the discipline of growth economics.

[10] ASEAN4 indicates 4 of the 5 founding ASEAN-countries: Malaysia, Indonesia, Singapore, Thailand and the Philippines (Singapore is categorized as one of the NIEs).

Figure 2: Saburo Okita`s Figures of Flying Geese



The 3 dimensions of the flying geese model: (1) the intra-industry, (2) the inter-industry and (3) the international, here illustrated with the classical countries and goods used in the literature. The illustration is made for and used by Saburõ Õkita in his presentation held at the 4th Pacific Economic Cooperation Council Conference in Seoul, 1985, which was the theory`s introduction into "the world of politics". We can clearly see the sequential and cyclical order in all three dimensions. It is also evident that diversification in production is not incorporated in the theory, as we can see a pattern indicating that production of (at least) highly different goods is not possible. Goods at the far sides of the pattern will have very different "competitive treats", and will thus be produced by very different countries.

Source: Furuoa, F. (2005). "Japan and the "Flying Geese" Pattern of East Asian Integration." eastasia.at **14**(1).

Akamatsu attempted to make a model not only of economic development, but also a model describing long-term business cycles. Akamatsu wrote in his early days: *"…when a process of perfection has been concluded, immediately a new process begins. Reality moves eternally forward from conclusion to conclusion" (Akamatsu 1927).* Development is a forever continuous process, and the dynamics Akamatsu describes are considered the explanation of the chasing pattern that countries of the world create. It is the intermingling and linkages between both the countries in the geese-formation and the different rows of flying geese, which is described. The process will not necessarily happen the same way in all countries, and the time spent in each phase will vary, but as no time limit is given countries will sooner or later advance to higher levels. In this sense Akamatsu attempts to present a deterministic and positive framework for international development of industries, which again clearly shows Hegelian influence (Akamatsu 1927).

The International Division of Labor

Two concepts Akamatsu uses frequently in his more elaborated explanation of the demand linkages, that emphasizes the international division of labor aspect, are *homogenous* and *heterogeneous* economic structures. According to Akamatsu, the flying geese development path depicts a change from heterogeneization to homogenization, and back to what he calls a "high-degree heterogeneization" – with the possibility of reaching a "high-degree homogenization".

The linkages describing the international aspect of the model are first characterized by a process of heterogeneization. *"…the Western European economy and the Asian economy have heterogeneous characters deriving from different natural environments, ways of life, and cultures. Out of this heterogeneous economic relationship, as a matter of course, something of an international division of labor is formed. When heterogeneous specialties are produced in different environments international relations are formed therein and trade is commenced" (Akamatsu 1962).* By creating a complementary relationship where the products of one area become the objects of wants by the inhabitants in the other area, heterogeneization can accelerate industrialization. This is what happens in the beginning of the intra-industry phase where imports create an increased demand, which later leads to emergence of domestic production. Further along in this dimension when exports starts up and imports decrease, we get what Akamatsu calls a process of homogenization, in which substitutive and competitive relationships emerge. This is when we move over to the inter-industry phase where the developing countries advance to the industries of the developed ones. The countries will here compete for the same consumers until the developed country`s exports are phased out of the market. At the same time however, both countries develop relations to other countries that are of similar type, so that as your relations with the country "in front of you" is characterized by homogenization, your relation to "the country behind you" are characterized by heterogeneization etc.

As the same intra-industry process evolves the same way at this higher industrial level, we get a higher degree of heterogeneization. As we keep on moving up the industrial ladder, industry by industry, we reach increasingly higher levels of heterogeneization and homogenization.

This view of seeing the catching-up process automatically emphasizes the international division of labor aspect, and the importance of the inter-linkages between the economies of the world. It also acknowledges that the process of industrialization is not a harmonious development, but is characterized by phases of highly conflicting relationships. At a certain development level, the relations a country has with other countries will be shaped by whether their bilateral relations are characterized by homogenous or heterogeneous relationships. By considering Japan for example, under the original gaggle, their relationship with the first tier countries reflects this. South Korea and Taiwan with more broadly based economies engaged in more extensive two-way trade with Japan, creating a more rivalry based relation. South Korea especially imitated and replicated the Japanese development pattern closely with around 15 to 25 years lag (Kojima 2000b), leaving the country with very similar industrial structures[11]. Singapore and Hong Kong on the other hand, served primarily as production bases for exports to third-part countries such as the United States. They ran large trade deficits with Japan, and had a much more complementary industrial structure. The implication of this was as expected: South Korea and Taiwan had a much more sour relationship with Japan regarding its international trade relations[12] (Cronin 1992, Shigehisa 2004). These imbalances and the conflicting relations that may emerge as part of the process is barely emphasized in modern versions of flying geese, and in adaptations of the theory for use in politics.

2.1.2 Newer Formalized Versions: Kojima`s "Westernization"

In 1960[13], Kiyoshi Kojima, Akamatsu`s principal student, published the first and most extensive formalized version of the flying geese model. And with this he also started what is considered the "westernization" of the theory. As Akamatsu took the view point of the follower country, Kojima, living in a very different Japan, took the view point of a developed one. With this change he diverted the focus allowing FDI[14] to play a role in the flying geese dynamic, and allowing the focus to also include analytical interpretations at firm level[15].

[11] This situation invites a discussion of the role of intra-industry trade in countries trade structures. Especially since within Akamatsu`s framework, in the end all countries will have similar industrial structures as they have advanced up the same industrial ladder.

[12] These countries also have histories predicting difficult relationships with Japan, but this statement refers only to industry and trade aspects of the respective countries relations with each other.

[13] Originally published in 1959 in Japanese, but published in English in 1960. The formalization was further developed in later years.

[14] Foreign Direct Investments

[15] FDI is also discussed in Vernon`s product cycle theory.

These modifications introduced a new phase as seen in the dynamics, where declining production and exports are combined with increasing offshore production, and what he calls *"reverse imports"* from less developed countries (see Figure 3 on next page).

Kojima`s main contribution was that he incorporated the main aspects of flying geese into a neoclassical Heckscher-Ohlin framework. By focusing on relative comparative advantage due to factor proportions in countries respective stages of development, he managed to keep the dynamic country dimension, as opposed to the static one characterizing neoclassical theory. Kojima therefore conceives investment decisions to be based on *dynamic relative advantage* rather than *current* competitive advantage. *"…while H-O-S theorem is the best reference to the 'comparative' way of thinking, analysis of international investment must allow for dynamic effects and not be restricted to static framework of the H-O-S theorem" (Kojima 1978).* The model`s dynamics is due to factor accumulation and specialization in line with neoclassical theory, and therefore differs from Akamatsu`s emphasis on demand linkages.

In line with neoclassical theory, Kojima considered the factor inputs important and incorporated the mechanisms into the classical framework, although the interpretation of capital as a factor differed from the classical view. Kojima saw capital as "managerial resources", which in addition to physical capital, included human capital such as skills, knowledge and technology (Kojima 1978). He therefore indirectly incorporates microeconomic aspects into the classical factor proportions model (Schröppel and Mariko 2002), by including a firm level view on the input decision[16]. Kojima calls these firms *"multinational firms"*, reflecting their international spread of production.

With the westernization of flying geese, the policy implications also changed. From a theory implying moderate protectionism as trade policy, we get a version promoting free trade in line with general neoclassical theory. This is a natural consequence of the neoclassical framework, but it is also due to the fact that Kojima heavily marginalized the conflicting phase of homogenization emphasized by Akamatsu[17]. Kojima instead chose to focus entirely on the export and international trade aspect, as well as the role of FDI, and promoted what has

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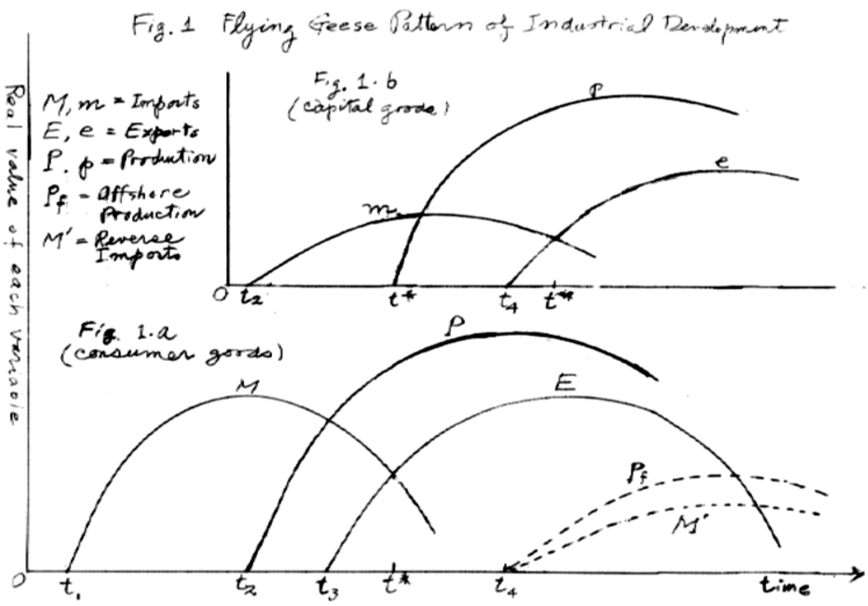
Vernon, R. (1966). "International Investment and International Trade in the Product Cycle." The Quarterly Journal of Economics **80**(2): 190 - 207.

[16] This is an indirect version of Vernon`s emphasis on firm level actions.
[17] This was also acknowledged by Vernon.

become known as *"export-led growth".* The conflicts that lies naturally in the phases of the original flying geese dynamic, has in general been marginalized and ignored in newer versions of the theory, thus fitting the modern market liberalistic view better.

Figure 3: Kojima`s "New" Figure of Flying Geese



Kojima`s extended version of the intra- and inter-industry aspect (Kojima 2000b). In this original drawing by Kojima, he illustrates the classical Import-Production-Export (M-P-E) relationship for consumer and capital goods, as well as a new aspect of offshore production and reverse import. In part a) of the figure we see that imports increase from t_1 to t_2, and at t_2 domestic production starts up. This induces the imports of capital goods as seen in part b) in order to supply the domestic production of consumer goods. When reaching t_3 the country starts exporting consumer goods, and at t*, imports are decreasing and exports increasing, resulting in balanced trade. At the same time production becomes equal to domestic demand reflecting a successful implementation of the catching-up process within the given industry. The industry is now able to turn from import substitution towards export-led growth. The dotted P_f and M` lines show the offshore production and the reverse import curve.

Source: Kojima, K. (2000b). "The 'Flying Geese' Model of Asian Economic Development: Origin, Theoretical Extensions, and Regional Policy Implications." Journal of Asian Economics **11**: 375 - 401.

Kojima does however emphasize the difference between what he calls *"American-type, anti-trade-oriented FDI"*, and *"Japanese-type, trade-oriented FDI"* (Kojima 1978). This is an extended element of the classic *Import-Production-Export* dynamic, as seen in Figure 3 above. The two dotted curves in part *a)* of the figure reflects the FDI-aspect of Kojima`s flying geese model. At point t^* in the figure, a lead country A, has graduated and reached the phase of post-catch-up. Exports of consumer goods are still increasing towards its peak level at t^4, before it declines because the country is losing comparative advantage in such labor-intensive industries, due to increased wages. A follower country B, then begins the production in this industry exploiting their lower wage costs relative to country A - *given* that country A makes FDI of the pro-trade type, by transferring capital, managerial skills and technology to country B. This transferring through FDI depends on individual firms` investment abilities in the lead country, reflecting Kojima`s incorporation of microeconomic level analysis through what he consistently calls *"multinational firms"*.

As the productivity of the leader country`s foreign production increases, the dotted line P_f starts to grow. This represents a comparative advantageous industry in the foreign country B, which firms in the leader country takes advantage of by investing in pro-trade FDI and increasing offshore production. The produced products are sold both in the offshore market in country B as well as in the home country A, through reverse imports (shown by the M`-curve). At the same time country A`s exports of their current domestic produced good, capital goods, increases (the e-curve in part *b)*). In this way FDI is undertaken from an investing country`s comparatively *disadvantageous* industry, making its offshore production in the follower country to achieve a stronger comparative advantage through technology and knowledge transferals. At the same time the leader country`s production and export of capital goods expands, enhancing their *current comparative advantage*, as the resources previously used in consumer goods production is allocated to the capital goods sector. As seen in Figure 3 the p- and e-curve in part *b)* increases as the P- and E-curve in part *a)*, representing the consumer goods industry, decreases. FDI in this manner thus augments comparative advantages in both the leader and the follower country which according to Kojima leads to: *"…expanded basis for trade and a reinforced productivity growth." (Kojima 2000b).* He then goes on to say that*: "As long as this type of FDI is promoted, an FG (Flying Geese) stimulus of industrialization is transmitted sequentially from a lead goose to follower geese, bringing about enlarged trade an co-prosperous economic growth."*[18].

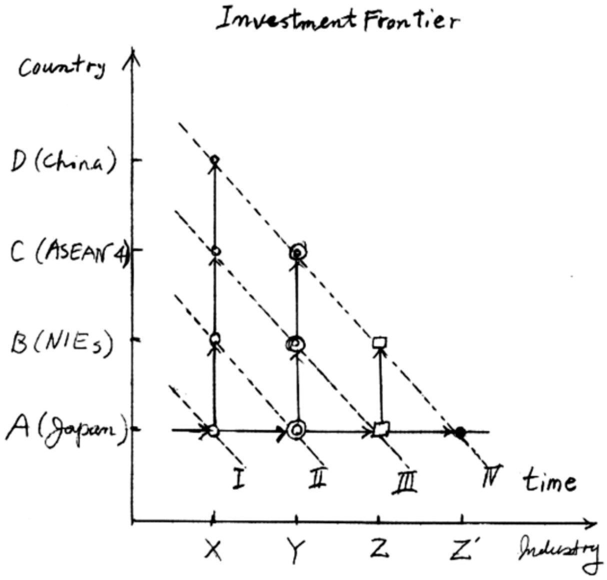
If investments are of the anti-trade type undertaken *against* the pattern of comparative advantages, one could expect a "hollowing out" of the home industry as the original exports and the domestic production of new industries, will decrease. The benefits for the follower country are also according to Kojima, dubious (Kojima 2000b), eliminating the common prosperity aspect seen in the case of pro-trade FDI. The "multinationals" will in this case

[18] He also emphasizes the possible spillover effects through FDI in a similar manner as economic geography models of growth and trade.

intrude the follower economies without helping the establishment of domestic production, hindering further development.

While Figure 3 and the above discussion clearly show that the model builds on the three dimensions in classical flying geese, Figure 4 illustrates Kojima`s additional aspect of pro-trade FDI much clearer. Kojima`s figure is drawn under two assumptions: *a)* The industrial structure of each economy is diversified an upgraded in a sequence from X to Y, to Z, and further to Z` over time, showed by the horizontal shifts. *b)* The flying geese pattern is transmitted through pro-trade FDI from the leader economy, down the hierarchy, according to decreasing stage of industrialization and per capita income over time. This geographical shift is shown vertically in the figure. The dotted lines indicate different points in time (Kojima 2000a, Kojima 2000b). As seen we can trace out all three dimensions of Akamatsus`s flying geese model, as well as Kojima`s FDI aspect: The horizontal relation illustrates the *intra-industry dimension*, the vertical relation illustrates the *international dimension*, or the international division of labor dimension, while the dotted lines illustrate the *intra-industry dimension* at different points in time. Figure 4 illustrates this dynamic with the classical countries in East Asia, showing Japan as the lead country with all its following geese.

Figure 4: Kojima`s Figure Incorporating FDI



Source: Kojima, K. (2000b). "The 'Flying Geese' Model of Asian Economic Development: Origin, Theoretical Extensions, and Regional Policy Implications." Journal of Asian Economics **11**: 375 - 401.

Kojima`s illustration of the three dimensions of Akamatsu`s theory, with emphasis on the FDI aspect of his extended version. The illustration is made with the classical geese countries in the standard order. Horizontally we have the intra-industry aspect, vertically the international aspect, and along the dotted lines we have the intra-industry aspect at different points in time. We can see how Japan upgrades its economy through advancing from X to Z` production, while engaging in pro-trade FDI inducing gradual economic development in the follower countries. From a given point and backwards along the dotted line, we can see the flows of FDI. At point III in time, where Japan is producing in the Z-industry, they are investing in the NIEs` Y-industry and the ASEAN4s` X-industry. The NIEs` are also investing in the ASEAN4s` X-industry, but they are at the same point receiving FDI from Japan in their Y-industry. In this manner all countries are tied together in their development process.

A point to be made is that the theory inhibits the philosophy that in each industrial cycle there is an appropriate time and place for "jumping off", meaning that there will always come a point at which it pays off to let others take over production (or at least provide the labor). This is embedded in the deterministic Historical School and Hegelian inspired foundation of the theory. Kojima has a strong focus on the future in the sense that multinationals should invest according to *prospective* comparative advantage: Reducing production in industries one are losing comparative advantage, and investing in industries one are expected to gain comparative advantage, while at the same time investing overseas in industries one are expecting *oversea countries* to gain comparative advantage in. This focus on expectations and predictions is stronger and more specific than Akamatsu`s, leaving Kojima`s model with a better foundation for analysis of future developments. Indeed Kojima predicted already in 1962 that East and Southeast Asia would become the economic success story of the world during the 1970s an onwards (Korhonen 1994b). The same goes for several other Japanese economists. Whether this had to do with the power of the framework, or just the fact that most economists were following the seemingly established consensus of continued rapid growth in this region, is though unknown (Korhonen 1994b). The common census was, however, mainly based on flying geese theory in different forms.

With Saburõ Õkita`s introduction of the model in Japanese politics in the mid-1950s, flying geese truly entered Japanese political, economic and theoretic discussions. Õkita, together with Kojima, became engaged advocates for the practical implications of the theory, which where then used to explain and validate Japan`s FDI in the region, as well as the common economic benefits this would lead to, including diminished conflicts, increased peace and better regional integration (Korhonen 1994b).

Kojima`s personal advocacy for East Asian integration is especially strong. His thoughts on this reflect his combined influence by Akamatsu and Swedish economist, Gunnar Myrdal. These economists differ in many aspects, but they share a common view when it comes to moderate nationalism and trade policy. Kojima incorporated the importance of national policy in his thoughts, but promoted free trade in line with neoclassical theory. He did however adopt Myrdal`s view on integration as a prerequisite for growth, trade and international integration (Korhonen 1994a, Korhonen 1994b). Myrdal suggests that developing countries should form their own groupings among themselves to further integrate and promote their own interests, to protect against exportation from the old industrialized countries. In his opinion the ideal solution for world economic development would be: *"…the formation of regional groups with effective protective walls against competition from the old industrialized nations."*(Myrdal 1964). Although Kojima advocated free trade, he still saw the benefits of promoting integration through economic cooperation, and became the initiator of many attempts and propositions promoting increased integration. In 1965 he proposed the creation of a Pacific Free Trade Area (PAFTA) among the US, Canada, Japan, Australia and New Zealand. Part of the proposition was also the creation of a parallel area consisting of the South East Asian nations, working in a tight cooperative relation to PAFTA. He later organized the first Pacific Trade and Development Conference (PAFTAD) in 1968, together with Õkita, and Foreing Minister in Japan at the time, Miki Takeo. This conference was successful and turned into a yearly arrangement, while the idea of PAFTA[19] never got realized. The Pacific Economic Cooperation Conference (PECC), however, saw the light of day in 1980, after

[19] As of February 27th 1981 there does however exist a "PAFTA", but this stands for "Pan Arab Free Trade Agreement".

initiative from Japanese Prime Minister Ohira Masayoshi, and the now Foreign Minister, Saburõ Õkita.

As illustrated in this section, the flying geese have had a huge influence on Japanese political and economic discourse, as well as the East Asian regions`. But the version of flying geese that was most influential was not Akamatsu`s original one, but rather Kojima`s westernized version. Both Õkita and Kojima, however, have been criticized in later years to overly focus on the international aspect of the model, neglecting the intra- and inter-industry dimensions. This also holds in general for all modernized versions (Korhonen 1994b, Schröppel and Mariko 2002) and the political use of it (Lin 2011). In a paper for the World Bank, Vice President Lin, uses flying geese theory to discuss and hypothesize about future world development and the rise of Africa and the "bottom billion". He, very positively, without a large emphasis on the conflicting aspects of the theory, proposes a very optimistic outlook on Africa`s development.

2.2 Product Cycle Theory

"Anyone who has sought to understand the shifts in international trade and international investment over the past twenty years has chafed from time to time under an acute sense of the inadequacy of the available analytical tools. While the comparative cost concept and other basic concepts have rarely failed to provide some help, they have usually carried the analyst only a very little way toward adequate understanding" (Vernon 1966).

This is the opening words in Raymond Vernon's 1966 article where he precedes to present his product cycle theory. Although different in many ways from Akamatsu`s flying geese theory presented over 30 years earlier, the theory uses the exact same three curves in its analysis, and is a theory attempting to describe similar types of industrial development. Vernon`s theory is however considerably more known in the western world[20].

One of the most obvious differences between the models is the perspective of the industrialization process. Whereas flying geese has the perspective of a development country, the ladder sees the process from the perspective of individual firms in an advanced country making decisions regarding its production facilities. When new products develops into what Vernon calls "mature products" and further reaches standardization, their production location

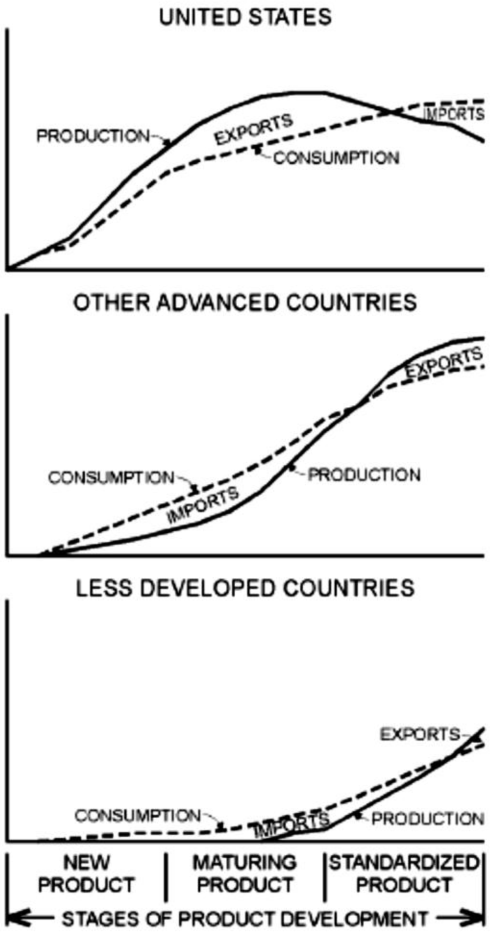
[20] A quick search on google scholar reveals that while 6990 have officially cited Vernon`s 1966 article, only 516 have cited Akamatsus 1962 English version of the paper. (search done june 20th 2012).

shifts from developed to less developed countries, tracing out similar patterns as in flying geese. This can be seen in Figure 5 (on next page), taken from Vernon`s original article.

While the patterns of development are similar, the economic process creating these patterns is different. In addition to the varying perspectives, a main difference in focus is that while flying geese has an explicit dynamic approach to industry development, the product cycle theory appears more static because no inter industry aspect is explicitly included. Akamatsu includes the aspect of sequential development of different industries in his basic model, while Vernon focuses on shifts in the production location of a given product, and follows the product throughout its life cycle, making product development a dynamic process. Product development is naturally static inn flying geese as innovation is considered exogenously given. This difference is probably due to the very different perspectives.

Akamatsu developed his theory with a historical look at Japan`s woolen industry, while Vernon looked at the division of labor between different locations in New York City (Korhonen 1994b, Shigehisa 2004). If one were to follow these respective perspectives, naturally the focus of the theories would differ. This also helps explain the different emphasis on innovation and technology. Akamatsu, taking the development country`s point of view, naturally focuses on the overall technological advancement of the economy while considering innovation exogenously given. Vernon, with the perspective of an advanced country, considers the technological level as exogenous and is focusing on the process of innovation at firm level.

Figure 5: Vernon`s Product Cycle Theory



Vernon`s Product Life Cycle (Vernon 1966). The figure is from the original article and shows the different stages of a product`s life cycle for countries at different levels of development. We see the sequential appearance of production and export, and it is clear that exports of the good is changing as time goes by, and comparative advantage changes due to changing production costs. The phenomenon that the most advanced country, which originally matures from the stages of production first will at a higher level of standardization experience "renewed imports", is also a feature in Kojima`s modification of Akamatsu`s theory. This can be seen in the figure over the United States furthest to the upper-right corner. An initial phase of imports as in flying geese does however not exist: The starting point is a situation with exports *already* in place.

Source: Vernon, R. (1966). "International Investment and International Trade in the Product Cycle." The Quarterly Journal of Economics **80**(2): 190 - 207.

Vernon`s focus on innovation can be compared to Akamatsu`s "heterogeneization" of the industry, in the sense that firms in advanced countries are differentiating their goods establishing a "renewed" opportunity to compete. In this manner Vernon has a constant country dimension, but with slightly changing industries as products evolves, while Akamatsu has a very dynamic country dimension, but an (almost) constant industry dimension as there is no innovation or upgrading within the independent industries considered. The element of "maturing products" and differentiation within industries is an element not mentioned or covered by Akamatsu. Another difference is Vernon`s dynamic view on consumption demand which is considered static by Akamatsu, as discussed earlier. This can be seen in Figure 5 above, as the dotted curves represent changes in consumption. We see that when consumption is lower than production we will have exports, and when the opposite is true, we have imports.

Despite some fundamental differences, both flying geese and product cycle theory give similar implications when it comes to trade policy and government intervention. Good arguments as to why protectionist trade policy would or should emerge are implied by both Akamatsu and Vernon. In flying geese it is connected to "infant industry" arguments and general protectionism, while it in product cycle theory is connected to protection from fierce competition that erodes away advantages forcing firms out of business.

2.3 Economic Geography

One of the newest branches within international economics is economic geography[21]: *"The location of economic activity in space"*. Traditional international economics neglects the fact that countries both occupy and exist in space by focusing merely on perfect markets and model countries as dimensionless points. Economic geography, by focusing on the geography of economic activity and location theory, manages to incorporate market imperfections such as transportation costs, increasing returns, monopolistic competition, demand and supply linkages, knowledge spillovers and labor market pooling.

The most striking feature of the geography of economic activity is agglomeration: Concentration of production and activity in space. Models within this branch thus see to explain the consequences of such clustering for industrial structures, development, production location, trade patterns and employment. A common approach is a core-periphery one which describes the tension between centrifugal and centripetal forces[22], which induces economic clustering and dispersion of industry. Krugman (1991), Krugman and Venables (1995) and Puga and Venables (1996), emphasizes forward and backward linkages as the main mechanism, while Lucas (2000) talks about "convergence clubs". The common feature is however the dynamic and sequential aspect these models inhibit as they are applied to "flying

[21] Until the 1990s economic geography received very little attention in mainstream economics.
[22] Broadly speaking *centripetal forces* are: desire for firms to locate near the largest market (*Backward linkages*) and the desire of consumers/workers to move to the region where goods are cheapest, and thus real wages are the highest (*Forward linkages*). *Centrifugal forces* are: The wish to serve the periphery with manufacturing goods.

Krugman, P. R. (1991). Geography and Trade, The MIT Press.
, Maurseth, P. B. (2011). Lecture 11: Economic Geography, University of Oslo.

geese style" development patterns. Puga and Venables (1996) say that *"…industrialization may spread in a series of waves from country to country."*, Krugman and Venables (1995) say that: *"convergence will not be uniform but will instead take the form of countries, in sequence, making relatively rapid transit from the "poor club" to the "rich club"."*.

2.3.1 Puga and Venables: The Spread of Industry

"During the last three decades industry has spread from Japan to several of its East Asian neighbors. In 1965 manufacturing absorbed nearly one of every four workers in Japan, against one in six in Taiwan, one in eight in the Philippines, or one in eleven in South Korea. Japanese manufacturing workers then earned over one and a half times as much as their Philippine colleagues, and three times as much as manufacturing workers in South Korea and Taiwan…" (Puga and Venables 1996).

Fascinated by the same miraculous East Asian development as Akamatsu and Kojima, Puga and Venables start their 1996 paper with this quote. They tell a story that are much more focused on how relative wages and employment shares in manufacturing changes within these countries, when pursuing to develop an alternative approach to the way industry spreads between countries, that differs from theories focusing on changes *within* each country, such as changes in comparative advantage, factor accumulation and investments. They suppose that all countries are similar in underlying structure, but that countries still have very different and not necessarily uniformly distributed, distributions of industry. Industrialization may then spread as a series of waves due to *"tension between agglomeration forces, which tend to hold industry in a few locations, and wage differences (or more generally factor considerations) which encourage the dispersion of industry." (Puga and Venables 1996).*

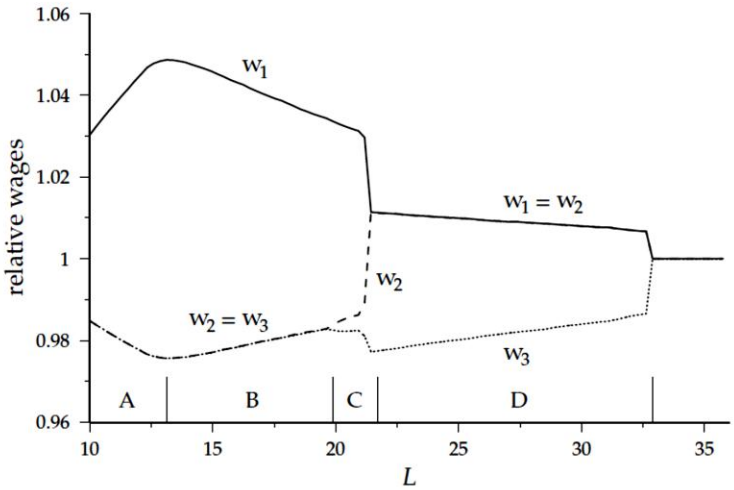
Their basic idea is a setup of countries with identical technology and endowments, but with different sectors. They then use a classical Dixit-Stiglitz approach with iceberg transportation costs and the manufacturing industry, being characterized by imperfect competition linked by input-output structures. This setup then creates, as is normal in this literature, a set of forward and backwards linkages pulling in opposite directions that are used to describe the dynamic changes in production and trade. *Forward linkages, or cost linkages,* exists because a lower price index reduces the cost of firms using this product as intermediates, which increases the producing firm`s sales and profits. *Backward linkages,* or *demand linkages,* exists because the presence of additional firms raises the labor demand and wage, and increases the purchasing power leading to increased sales and profitability for the producing firm[23].

Puga and Venables then set up a situation which yields similar development patterns as in Akamatsu`s theory, although different type of linkages are at works. In this setup all linkages (forward and backward) are considered to be similar across industries, but industries differ with regards to labor intensities. There are three countries (country 1 – country 3) whereas country 1 starts out with agglomeration of industry and the highest relative wage. This can be seen in Figure 6. Here the solid line represents country 1, the dashed line country 2 and the dotted line country 3. The vertical axis is the relative wage in each country (relative to the average of the three countries) and the horizontal axis measures the labor endowment of each country (efficiency units). The letters A – D indicates different phases in development.

They then study how exogenous changes in this setup changes the relative strengths of the forces for dispersion and agglomeration. Such relative changes will thus trigger spread of industry between countries. The exogenous changes used in the model are "economic growth", captured by assuming an exogenous increase in the labor endowment, measured in efficiency units, L. This increase is assumed to be the same at all locations, whereas the stock of land (in efficiency units) is assumed to be constant. An increase in "economic growth" in the model thus increases the share of manufacturing relative to agriculture. This *could* according to the authors be interpreted as *"growth in participation rates and as improvements in the educational attainments of the labor force"*. Such growth is documented to have played a role in the postwar growth of the Asian "tiger economies" (Young 1995). However, in this theory since quasi homothetic preferences is assumed for the representative consumer, Puga and Venables prefer to think of exogenous growth in the efficiency units of labor mainly as *"a process of technical change, raising the productivity of labor in both manufacturing and agriculture"*. Of course in reality technical change differ across both countries and sectors, but this is assumed since the growth in L is considered exogenous.

[23] Only the linkages are necessary to follow the evolution in industry presented by Puga and Venables. The formalities and technicalities of the model are not included due to the extent of the survey, and because no deeper more technical use of this framework will be pursued in the thesis.

Figure 6: Puga and Venable`s Relative Wage Dynamics



This shows the development in relative wages along the y-axis, and the labor intensity along the X-axis for three countries: country 1 (solid line), country 2 (dashed line) and country 3 (dotted line). The development is divided into phases A-D, each with different combinations of relative wage distribution amongst the countries. Country 1 starts out as the sole producer with a significantly higher relative wage (W_1), while country 2 and 3 starts out with the same relative wage ($W_2 = W_3$). As the labor intensity (L) increases wages starts to diverge as is seen across phase A, until a threshold is reached at beginning of phase B, when country 2 and 3 also start producing. At a certain level W_2 converges towards W_1, and becomes equal in value when entering phase D. W_3 suffers from country 2`s production expansion, and the wage decreases throughout phase C. In phase D however, W_3 starts converging towards W_1 and W_2, and finally becomes equal when exiting phase D.

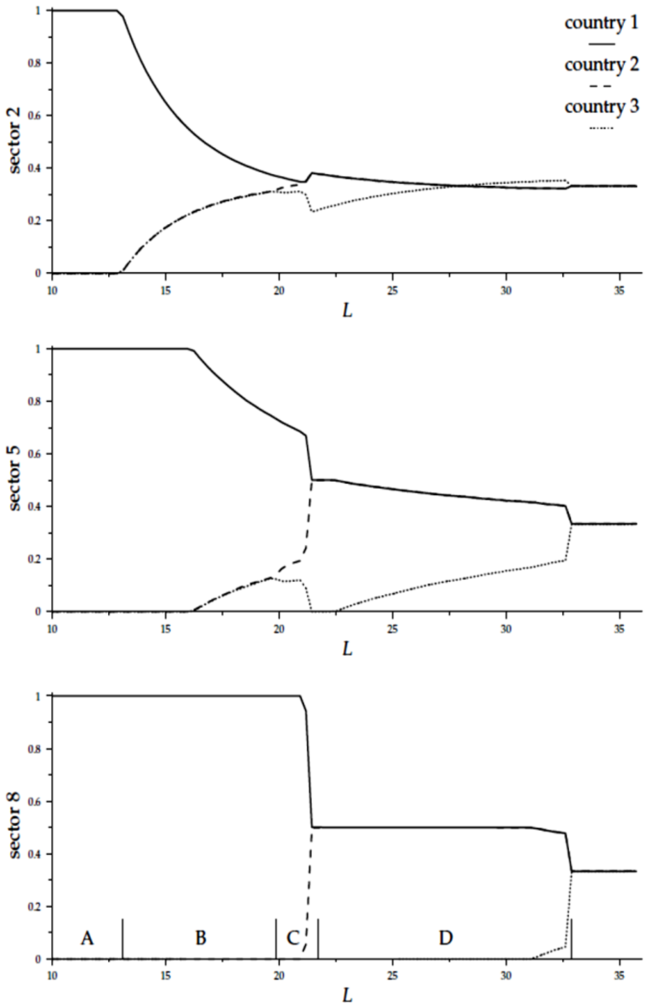
Source: Puga, D. and A. J. Venables (1996). "The Spread of Industry: spatial agglomeration in economic development." Centre for Economic Performance, Discussion Paper **279**

In phase A Country 1 starts with low labor intensity, L, and a high relative wage – and is thus the sole producer. As L increases, wages diverge, and when reaching a threshold point country 2 and 3 also start producing since production is turning profitable. As L keeps growing and we enter phase B, we get a reallocation in production with country 1 reducing production, and country 2 and 3 taking over because of their advantageously lower wages. In this phase these two countries have identical relative wages, and therefore identical industrial structures. This will change in the C-phase, as is seen clearly in the figure, when wages of the two countries diverge. At this point a critical mass of production is reached at which a relocation of firms from country 3 to country 2 raises profits of firms in country 2, and reduces profits of firms in country 3, due to linkages and externalities. Country 2 now undergoes a very fast industrialization as the country's firms reap the benefits of agglomeration. This economic success does however come at the expense of both country 1 and country 3, as is seen by these countries` falling relative wages. As this process continues we reach a phase D where wages in country 1 and country 2 have become identical. Country 2 have then in a flying geese manner "caught up" with country 1. Continued growth in labor endowment, however, increases the wage in country 3, thus narrowing the wage gap and moving wages towards the level of the other countries. Beyond some critical mass of production country 3 will further cross a threshold and start converging. Puga and Venables thus illustrate a different reasoning for the same unsurprising sequence of industrialization, also showed by Akamatsu, Kojima and Vernon.

In order to show how this development mechanism works with more sectors, Puga and Venables replicate the above figure in three different sectors of industry, representing different levels of labor-intensities. Sector 2 is highly labor-intensive, sector 5 is averagely intensive, and sector 8 is labor-*unintensive*. As seen in Figure 7 on next page, they trace out a pattern of change where labor intensive industry leads the spread of industrialization, and creates linkages attracting less labor-intensive activities, thereby moving up the industrial ladder towards more capital-intensive sectors. We can clearly see that country 1 is the first one to leave sector 2 and move into the less labor-intensive sector 5, and further along to sector 8. We also observe that the movements appear at a later point in time the less labor-intensive the sectors are. In sector 8 movements does not happen until phase C is reached, because only then is linkages strong enough.

Puga and Venables claim that their 1996-paper provides a *"radical way of thinking about the process of industrialization."*, and although looking at firm level linkages is a new way of thinking about the dynamic industrialization process, the broad pattern that their model predicts are very similar to Akamatsu`s 1930s articles of flying geese. Puga and Venables also argue that their model can explain the rapid "take-off" of the newly industrialized economies of East Asia, the same way flying geese is considered to explain this development. These economists all share a fascination with the East Asian miracle development, and their theories are throughout both papers linked to this phenomenon. Where Akamatsu talks about *"geese chasing each other on the sky"* and cyclical upgrading and shifts between industries and countries, Puga and Venables say that: *"Industrialization then commences in this country, and takes place at a rapid rate as forwards and backward linkages are created and a critical mass of industry attained. The process may then repeat itself, so industrialization takes the form of a sequence of waves, with industry spreading from country to country."*

Figure 7: Puga and Venable`s Model of the Spread of Industry



The inter- and intra-industry dynamics of economic development presented by Puga and Venables (1996). The figure shows the inter-industry development by looking at the share of employment in industries in different countries. The degree of labor endowments are decreasing from country 1 (the full line) to country 2 (the dashed line) to country 3 (the dotted line). The degree of labor-intensity in the sectors are also decreasing**,** staring with sector 2 (the very labor-intensive sector), to sector 5 (the averagely labor-intensive sector) and finally sector 8 (the non-labor-intensive sector). Labor intensity decreases from the top, and we see that the most labor intensive industry is the first one abandoned by country 1 (share of the industry falling from unity) and taken over by country 2 and 3. This reallocation starts later for the less labor intensive industries.

Source: Puga, D. and A. J. Venables (1996). "The Spread of Industry: spatial agglomeration in economic development." Centre for Economic Performance, Discussion Paper **279**

2.4 Comparison of Models: Differences in Implications

As seen throughout this survey, the literature is although fundamentally different, similar in many ways: Similar patterns of industrial transformation and formulations are found across theories. The specific dynamics and mechanisms at work are however important to understand, in order to see why the theories differ in the ways they do. Below is an attempt to summarize the main features in an overview table in order to make this understanding easier and more tractable.

Table 1: Comparisons of Models – Summary Table

	Flying Geese Theory		**Product Cycle Theory**	**Neoclassical Theory**	**The Economic Geography Approach**
	Akamatsu	**Kojima**	**Vernon**	**(Generally)**	**Puga & Venables**
Main Concept	Linkages at industry and country level	Factors of production at country level	Innovation of resources at firm level	Factors of production at country level	Linkages at firm and country level
Driving Force of Development	Demand	Supply	Supply	Supply	Supply and Demand
Country Development	Dynamic: *Changing comparative advantage through industrial upgrading*	Dynamic: *Changing comparative advantage through changes in factor proportions and specialization*	Static: *Technological and industrial level are static and exogenously given*	Static: *Technological and industrial level are static and exogenously given*	Dynamic: *Forward and backward linkages at firm level interacting and creating dynamics*
Product Development	Static: *No focus on product innovation*	Static: *No focus on product innovation*	Dynamic: *Innovation at firm level creates a dynamic product development path*	Static: *No focus on product innovation*	Static: *No focus on product innovation*
International Trade	Moderate protectionism	Free trade	Moderate protectionism	Free trade	Free trade

Summarizing major differences and similarities between the four different theoretic models discussed in the survey, and a broad category of theories labeled “neoclassical theories”. The main differences lie in dynamic versus static, and demand versus supply driven development.

Source: Made by the author.

3 Measuring Specialization and Competitiveness

When discussing and analyzing changes in industrial patterns, as is the case in the surveyed theories, we implicitly analyze changes in relative importance of sectors and the degree competitiveness in both production and trade. What we are interested in is how this specialization changes over time as countries get richer, but in order to empirically test data for this, a good measure of specialization and competitiveness is needed.

3.1.1 Relative Shares

The most common measure is simply calculating the relative shares of output, import or export. This is then done for each sector and each country, for a specifically chosen year. We thus have formally, with export as example: $C_{ij} = \frac{X_{ij}}{\sum_j Xij}$, which denotes the relative share of country i`s export in commodity market j to its own total exports, at a chosen year t (degree of specialization in j for country i for year t). Such relative importance has been calculated and analyzed using both production and trade data at many different levels of sector aggregation, and for many different countries and country groups. In some cases value added shares of total GDP is also used as measure. Since this is based more directly on production data, it seems like a better alternative than using relative production value.

As for import and exports, the relative shares are usually calculated using the standard equation above. This measure of relative importance however, is not necessarily the best measure to use. Relative shares do for example not include any “links” to the world market. Whether country i`s export share of commodity j is large or small in comparison to the world export of commodity j, is not incorporated in the formula in any way. This thus makes relative shares a less attractive measure if we want to reflect changes in the world market when comparing different countries. This is especially important to incorporate if we want to say something about countries competitiveness in sectors worldwide, and how this changes when countries get richer. Thus in this study a better measure should be used.

3.1.2 Revealed Comparative Advantage (RCA)

A measure of competitiveness is a country`s "*comparative advantage*", originally described by David Ricardio in his 1817 publication: *"On the Principles of Political Economy and Taxation"*. The expression refers to a country having an advantage in production of a good due to having the lowest alternative cost in producing that exact good[24]. Thus it is not the same as *absolute advantage*.

Because comparative advantage is theoretically defined in terms of autarky prices in determining the alternative costs, these true costs are impossible to actually observe. Thus real comparative advantage remains a theoretic concept. Balassa, however, argued in 1965, that the true pattern of comparative advantage could be calculated by using post-trade data. Even though he knew this were a second best approach, he argued under the philosophy that: *"One wonders, therefore, whether more could not be gained if, instead of enunciating general principles and trying to apply these to explain actual trade flows, one took the observed pattern of data as a point of departure.*" *(Balassa 1965)*. This index put forward by Balassa, known as the RCA index, is meant to *mimic* country`s real comparative advantages. The index seeks to identify whether a country has RCA in a sector or not, and does *not* seek to explain the true underlying *causes* for the existence of it. The logic behind the index is to evaluate comparative advantages on the basis of specialization in exports, visible by use of export data. This advantage is then relative to a reference group, usually the rest of the world, i.e. usually relative to the world total exports. Balassa says that the trade patterns emerging from this data (which is considered emerged under free trade conditions) will reflect country`s *underlying* comparative advantage. Thus, it reflects countries *underlying* competitiveness relative to the rest of the world.

The Revealed Comparative Advantage Index (RCA) for a given country i, and a given commodity j (at a given point in time t) is:

(1) $$RCA_{ij} = \frac{c_{ij}}{c_j}$$

[24] The original example was Portugal and England and their different advantages in producing land intensive wine, and labor intensive cloth.

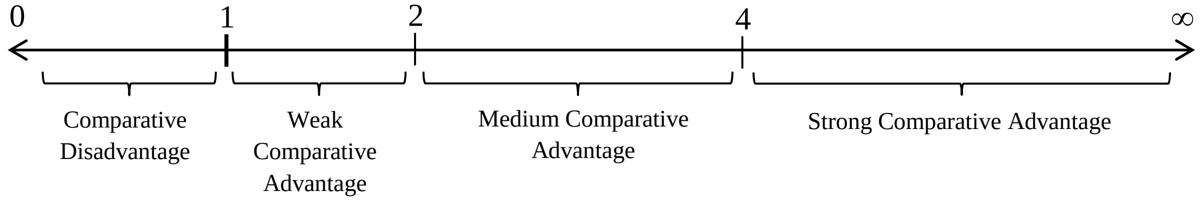
, where $C_{ij} = \frac{X_{ij}}{\sum_j Xij}$ denotes the relative share of country i`s export in commodity market j to its own total exports (degree of specialization in j for country i), and $C_j = \frac{\sum_i X_{ij}}{\sum_i \sum_j X_{ij}}$ denotes the relative share of world exports in commodity market j to the total world exports of all commodities (degree of specialization in j for the world). The index is unique for each country, commodity and year. The interpretation of the index is as following:

- $RCA_{ij} > 1$: Country i has RCA in commodity j
- $RCA_{ij} < 1$: Country i *do not* have RCA in commodity j
- $RCA_{ij} = 1$: Country i has "neutral" RCA in commodity j

The RCA index now enables us to check which countries have revealed comparative advantage in which commodities, it quantifies the degree of comparative advantage, and it makes it possible to create cross-country and cross-sector rankings. In sum, the index and its distribution enables us to conduct a thorough analysis of country`s patterns of trade.

Since the RCA index varies between 0 and ∞ with a "neutral" point at 1, the index is not balanced. A very small interval [0, 1) represents disadvantage, while an (in theory) unlimited interval (1, ∞] represents advantage. In order to make more sense of the interpretation of the index a division of the theoretical RCA range into four sub-groups, representing different strengths of revealed comparative advantage, is made. This grouping helps specify the *degree* of comparative advantage, making the index more meaningful in analysis of different industries and countries, *especially* when considering graphs showing the evolution of the index over time (Hinloopen and Marrewijk 2001):

Figure 8: The Range of the RCA Index



Four different groups of RCA are evident. Especially the three groups separating comparative advantage into Weak, Medium and Strong helps specify the index more. The groupings are done by Hinloopen and van Marrewijk.

Source: Hinloopen, J. and C. v. Marrewijk (2001). "On the empirical distribution of the Balassa index." Weltwirtshaftliches Archiv **137**: 1-35, but recreated by author.

Even with this improvement, however, the index is still *unbalanced*. This will not be critical when graphing and ranking countries, but with regards to regressions and econometrical analysis, this asymmetry in weighting *could* be inappropriate. A solution to this is thus creating a normalized index, such as **the Revealed Symmetric Comparative Advantage Index (RSCA)** (Dalum, Laursen et al. 1998, Laursen 1998):

(2) $RSCA_{ij} = \frac{RCA_{ij} - 1}{RCA_{ij} + 1}$

, where the values vary only in the interval [-1, 1], with 0 as the threshold between disadvantage and advantage, and:

- $RSCA_{ij} > 0$: Country i has RCA in commodity j
- $RSCA_{ij} < 0$: Country i *do not* have RCA in commodity j
- $RSCA_{ij} = 0$: Country i has "neutral" RCA in commodity j

Although this RSCA index solves the problem of asymmetry, the RCA and the RSCA indexes also inhibits other possible shortcomings. This has led to many alternative RCA measures, each answering to a specific weakness, but each one also inhibiting their own shortcomings (see e.g. (Donges and Riedel 1977, Bowen 1983, Proudman and Redding 1998)). Despite its identified shortcomings, however, Balassa`s original RCA index is undoubtedly the most commonly used index: *"…the RCA index continues to be the most widely accepted and widely used measure of international specialization and comparative advantage."(Sinanan and Hosein 2012).* The RCA index will therefore be used in the next chapter presenting descriptive evidence. Whether the RCA or the RSCA index should be used in the regressions in the main analysis, will be discussed and determined in Chapter 5 and 6.

4 Industrial Structure and Development: Descriptive Evidence

The data used is a panel data set (also called a longitudinal data set) created by Alessandro Nicita and Marcelo Olarreaga: *"Trade, Production and Protection 1976-2004"*[25]. The data set was published in 2006, and can be freely accessed and downloaded through the World Bank trade website. The main advantage with using this dataset is that the authors have merged data from different sources together in a common industry classification, corresponding to the 3-digit level ISIC Classification, Revision 2. All trade and production data is then *comparable.* The data is disaggregated into 28 manufacturing sectors covering industries at different levels of sophistication.

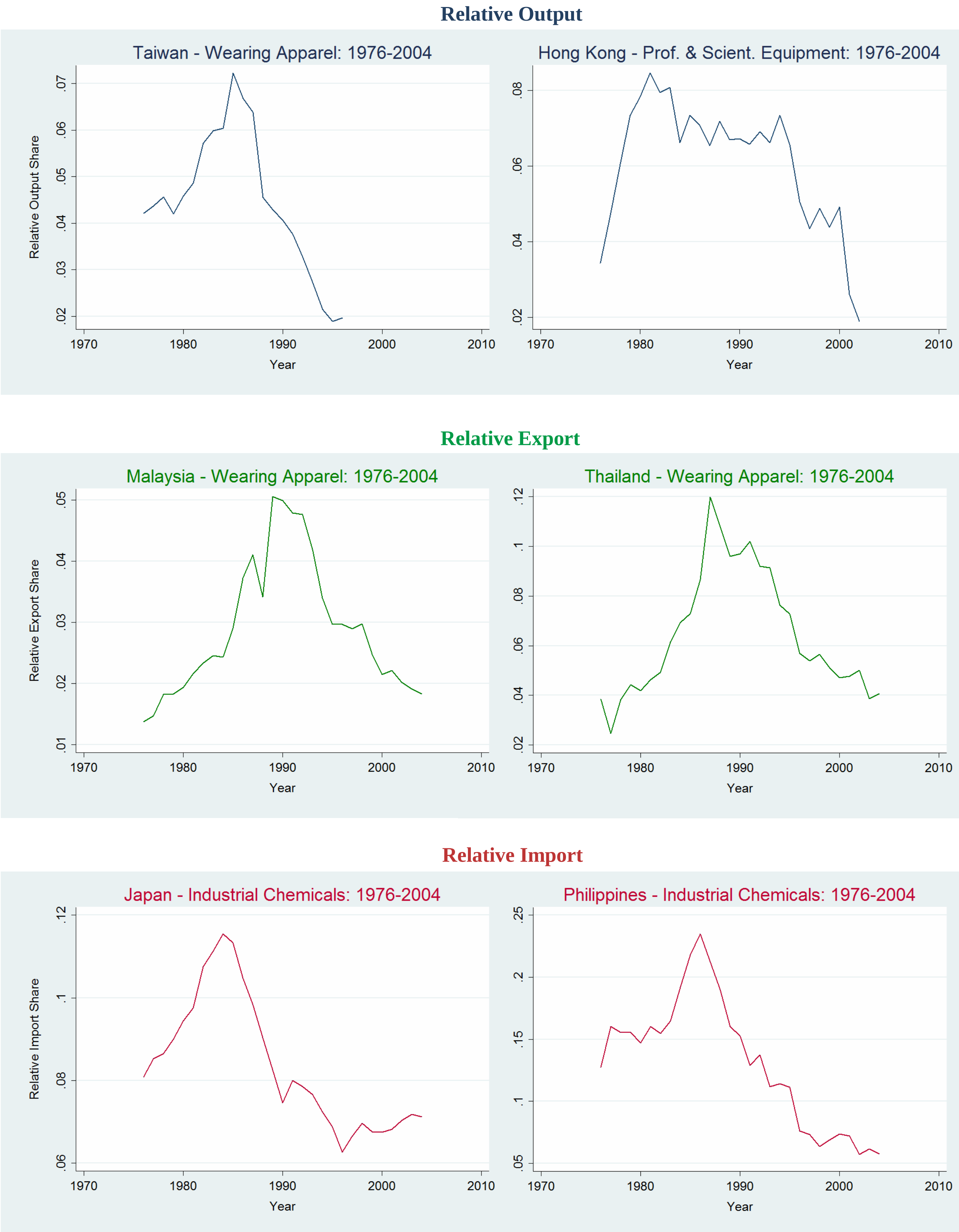
The calculations and graphics in this chapter are done in the software Stata. All figures are created by the author.

Relative Shares

As a first step in hunting for flying geese curves, the most common measure of specialization, relative share, is calculated and graphed for a selection of countries and sectors in Figure 9. This is done for both output, export and import data, and for sectors representing Low-Tech, Mid-Tech and High-Tech goods. From this figure we can confidently say that based on this brief graphical evidence, cyclical patterns clearly *seem* to exist. The relative importance of sectors definitely follows (at least in this selection of goods) a very cyclical pattern in line with flying geese.

[25] This is an update of their earlier version from 2001 covering the period 1976-1999. Besides the longer coverage in time series this update also inhibits general improvements such as increased country coverage, and an updated concordance table between the International Standard Industrial Classification (ISIC), Revision 2 and the Standard International Trade Classification (SITC), Revision 2.

Figure 9: Relative Shares for Output, Export and Import



The figures show the evolution of relative output, export and import for a selection of sectors and countries. Wearing Apparel (ISIC 322) is considered Low-Tech, Industrial Chemicals (ISIC 351) is considered Mid-Tech and Professional and Scientific Equipment (ISIC 385) is considered High-Tech.

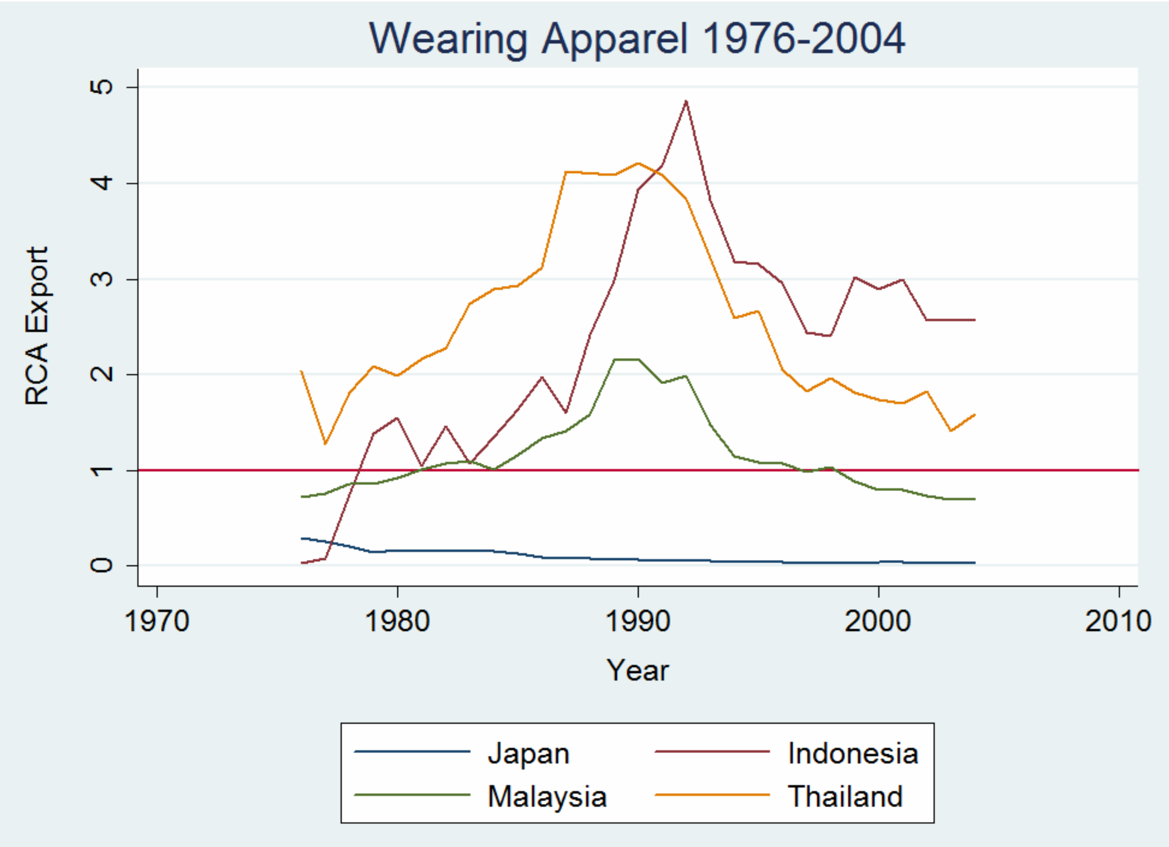
Source: Made by author

RCA Indexes

As discussed in Chapter 3, relative shares are not the best way of measuring specialization and competitiveness in light of this study. Therefore RCA, a much better measure in our case, is calculated and graphed. The focus here is on RCA for export data only. To investigate whether the evolution of RCA over time seems to follow flying geese patterns in different type of sectors, as well as across countries, three figures representing Low-Tech, Mid-Tech and High-Tech sectors are presented.

As is seen in the figure below, we see clear inverse U-curves. All countries in Figure 10 have this characteristic shape, except for Japan, which does not have RCA in Wearing Apparel at all within this time span.

Figure 10: RCA from 1976-2004, ISIC 322: Wearing Apparel

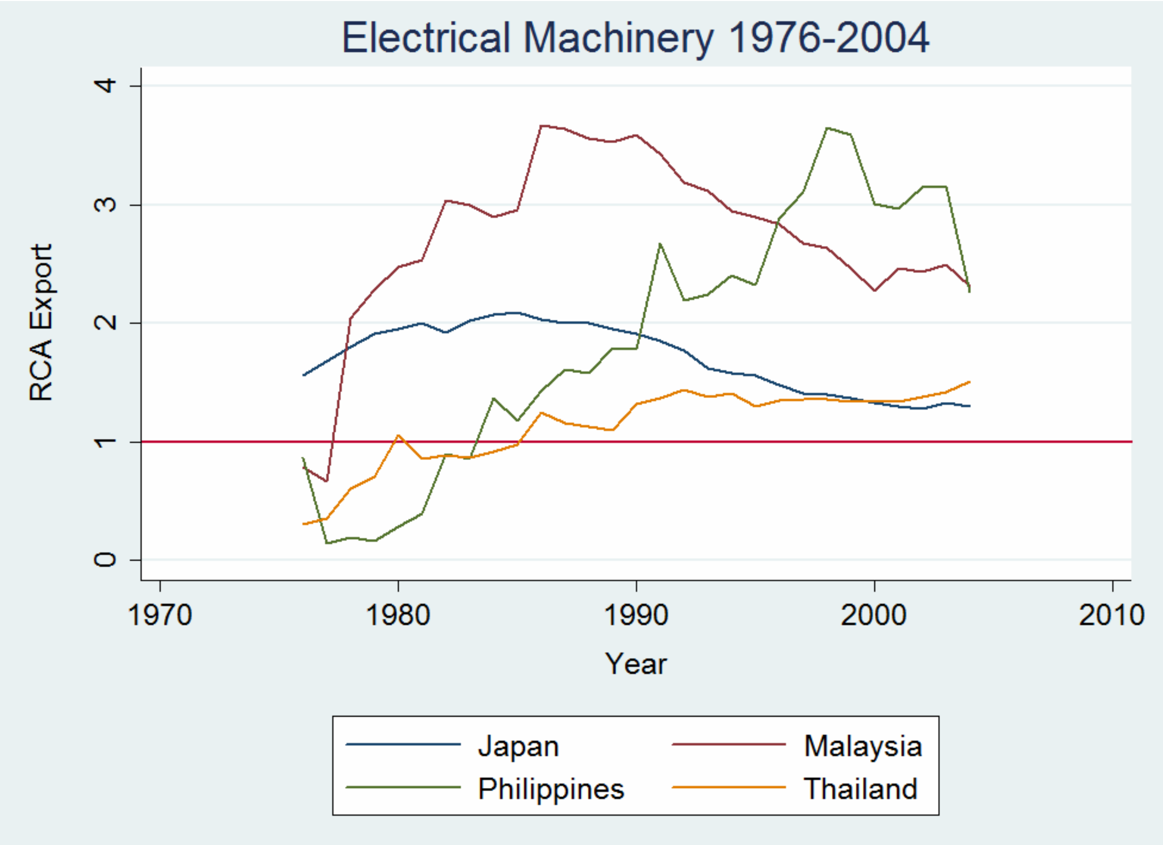


The figure gives an overview over RCA Export throughout the timespan 1976-2004 for the countries: Japan, Indonesia, Malaysia and Thailand, for ISIC 322 Wearing Apparel. This is a Low-Tech sector with regards to technology level needed in production.

Source: Made by author

Figure 11 is a similar figure showing the evolution of RCA within ISIC 382 Electrical Machinery. This is a Mid-Tech sector so the sophistication level in production is higher than in Wearing Apparel, which is a Low-Tech sector. The same clear patterns of inverse U`s are visible here as well, allthough a little less pronounced than in the Low-Tech case.

Figure 11: RCA from 1976-2004, ISIC 382: Electrical Machinery

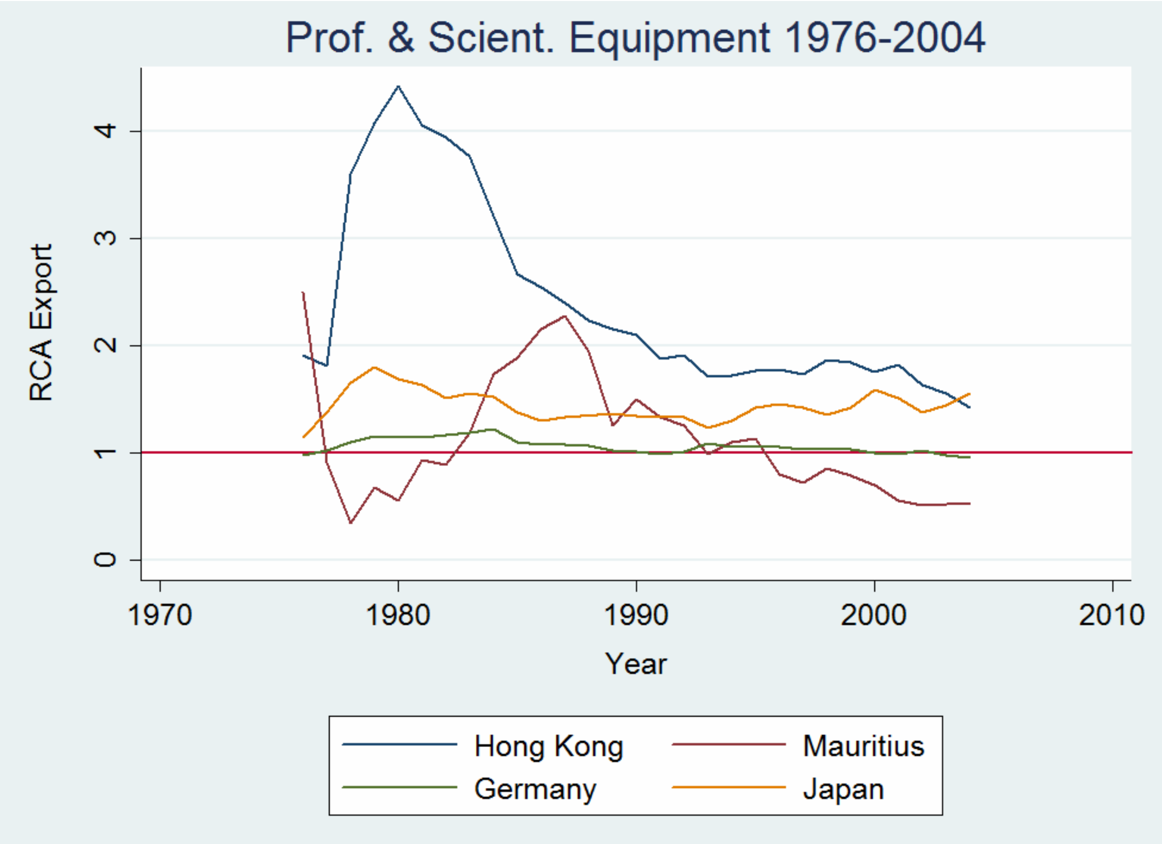


The figure gives an overview over RCA Export throughout the timespan 1976-2004 for the countries: Japan, Malaysia, Philippine and Thailand, for ISIC 382 Electrical Machinery. This is a Mid-Tech sector with regards to technology level needed in production, i.e. more technology is needed in production in this sector than in the Wearing Apparel sector.

Source: Made by author

The last sector presented is the High-Tech sector, ISIC 385 Professional & Scientific Equipment. This is the most advanced sector with regards to technology level in production. Again we see the same inverse U-shape as in the two previous sectors, although to an even lesser degree than in the Mid-Tech case. Hong Kong`s extreme dominance in this sector could however, also, somewhat distort the image.

Figure 12: RCA from 1976-2004, ISIC 385 Professional & Scientific Equipment



The figure gives an overview over RCA Export throughout the timespan 1976-2004 for the countries: Japan, Malaysia, Philippine and Thailand, for ISIC 385 Professional & Scientific Equipment. This is a High-Tech sector with regards to technology level needed in production, i.e. more technology is needed in production in this sector than in the Wearing Apparel sector and Electrical Machinery sector.

Source: Made by author

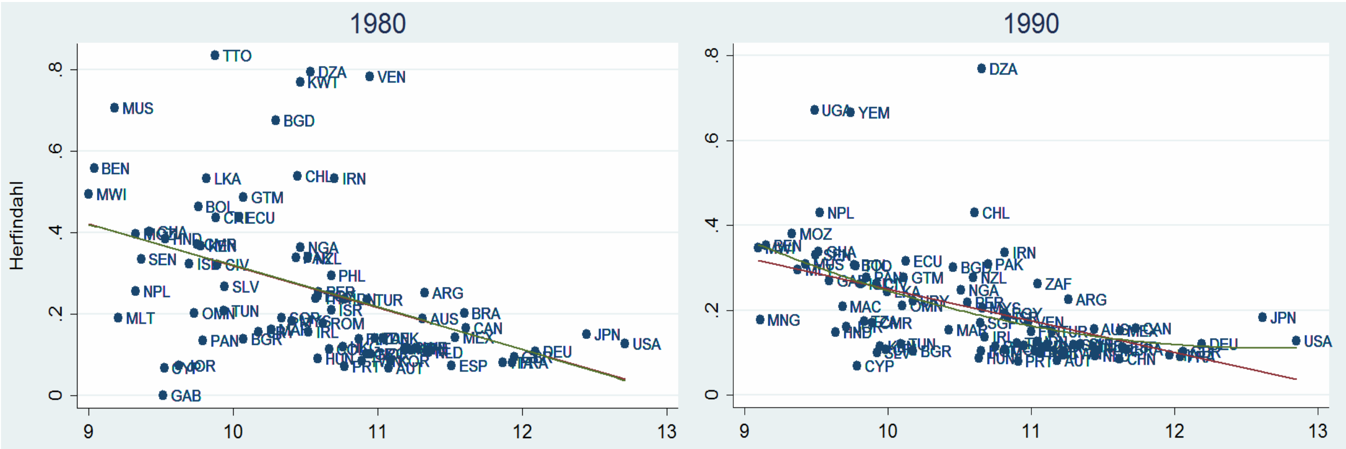
A remark based on these graphs is that there could be traces of a tendency for Low-Tech sectors to be more cyclical than especially the High-Tech sector. This "footlooseness" is thought to be more prevalent in sectors like textile, clothing, footwear etc. If this is true, then the countries having RCA in these sectors will change more over time, and could thus be more cyclical in nature. The reasons for this could be that Mid-Tech and High-Tech industries require more specific knowledge, and therefore have a more stable set of countries as producers and exporters. Another remark is that most of the countries presented in these figures are Asian countries, and we know that a lot of this region's recent growth in trade is in intermediaries and intra-industry trade between countries *within* Asia. This could possibly affect the figures presented. However, in general, there does seem to be evidence of flying geese curves for all type of sectors.

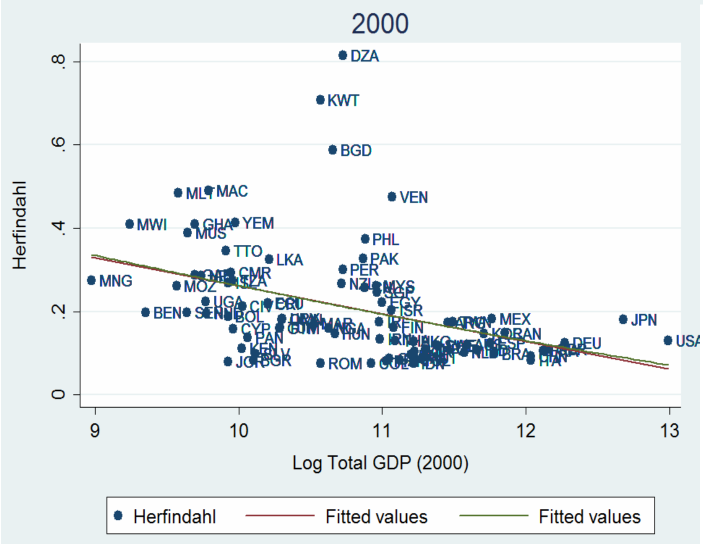
An issue not read off these figures, but found when graphing RCA`s, are the fact that some "early industrializers" like the USA, Germany and Japan show little sign of clear cyclicality. Many have stable (low) RCA in Mid-Tech sectors like Electrical Machinery and Machinery. This could of course be due to things like sector specific knowledge. However, it is in some cases shown that large countries with regards to economic size and population tend to have more diversified economies, so this could also be a reason. This would be reflected theoretically in lower RCA in most sectors, and if very prevalent, this could bias the RCA index. I will therefore use an index measuring the degree of concentration, to check if this seems to be a potential problem with the data used in this study.

Now if size matters, then a mechanism for it to influence the RCA index, is as said by having more diversified export structure. That means that if it is so that large countries are less concentrated, then a broader more even export share distribution will be the case. An index called Herfindahl (or Herfindahl-Hirshman) (Low, Olarreaga et al. 1998, Samen 2012) will be used to measure this. The index is given by: $H_{i,t} = \sum_j (c_{ij,t})^2$, where $(c_{ij,t})$ is the relative share of commodity j in country i`s total exports at time t, equal to $C_{ij,t} = \frac{x_{ij,t}}{\sum_j Xij,t}$. The index is then the sum of all squared relative export shares for all the commodities produced by the country at point t in time. The value of the index varies between 0 and 1, and the higher the value, the more concentrated the country`s export structure. The lower the value, the more diversified.

In Figure 13 we see a scatter plot of countries` Herfindahl index, on countries` log total GDP, for three years. As is clearly seen there is an almost linear negative relationship between the degree of specialization and economic size: The larger economic size, the more diversified – and the smaller economic size, the more specialized. The relations seem to dampen slightly when countries grow bigger.

Figure 13: Herfindahl – Log Total GDP, 1980, 1990 and 2000





This is three scatter plots placing all countries according to Herfindahl index value and log total GDP value. As can be seen, a decreasing linear relationship is evident for all three years: 1980, 1990 and 2000. This implies that the larger the countries are, economically speaking, the more diversified they are. And the smaller they are, the more specialized they are, i.e. the more dependent on only a few sectors.

Source: Made by author

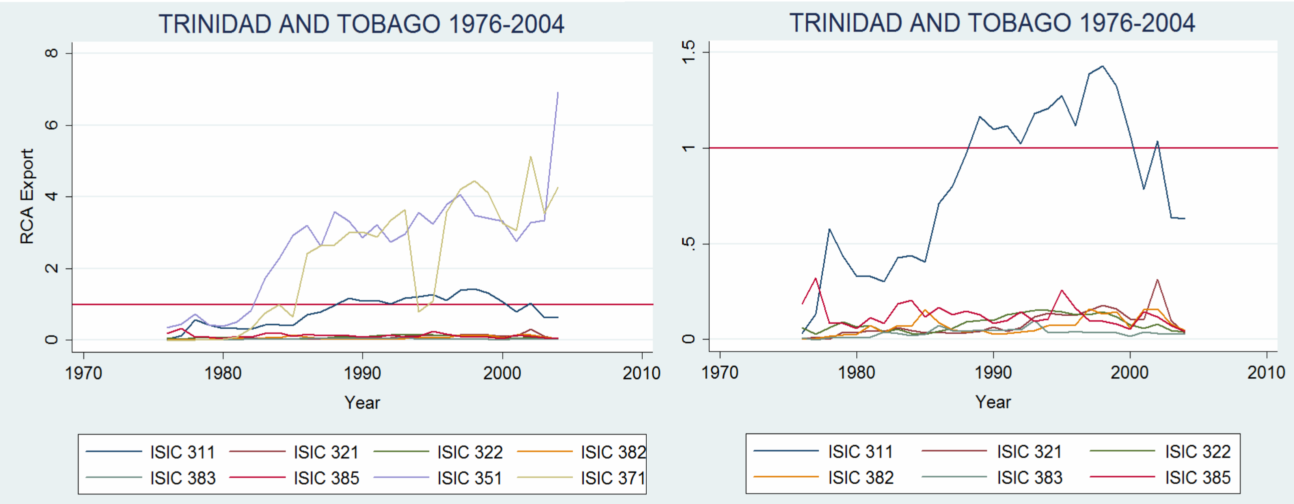
A diversified economy in the Herfindahl sense would mean more equal export shares of the goods exported, so that all the $C_{ij,t}$, and naturally the $(C_{ij,t})^2$, are similar in size. Such evenness in relative shares will also give more evenly sized RCA indexes, since no sector have a large share of any commodity`s export. If Herfindahl were large in value so that some sectors clearly dominated, then the RCA values would be more dispersed. As seen in Figure 13, we see that USA, Japan and Germany all are to the right lower corner, implying large economic size and low concentration. These countries are then assumed to have more narrow RCA distributions. This should however also imply that smaller countries (economically) with high Herfindahls, should have a greater dispersion in their RCAs.

Looking at the scatters above we see that for example Trinidad and Tobago (TTO) have concentrated exports. In Figure 14 their RCA distribution are graphed, and as seen from this, the dispersion is quite large. At the most they have an RCA of around 6 in ISIC 351 Industrial

Chemicals, and ISIC 371 Iron and Steel. If not considering these sectors, their RCA distribution reduces drastically. A representative of other Resource-Based and Low-, Mid- and High-Tech sectors are also included in these figures: ISIC 311 Food Products (Resource Based), ISIC 321 Textiles (Low-Tech), ISIC 322 Wearing Apparel (Low-Tech), ISIC 382 Machinery (Mid-Tech), ISIC 383 Electrical Machinery (Mid-Tech) and ISIC 385 Professional and Scientific Equipment (High-Tech).

Figure 14: RCA`s for Trinidad and Tobago, 1976-2004

ISIC 311, 321, 322, 382, 383, 385, 351 and 371



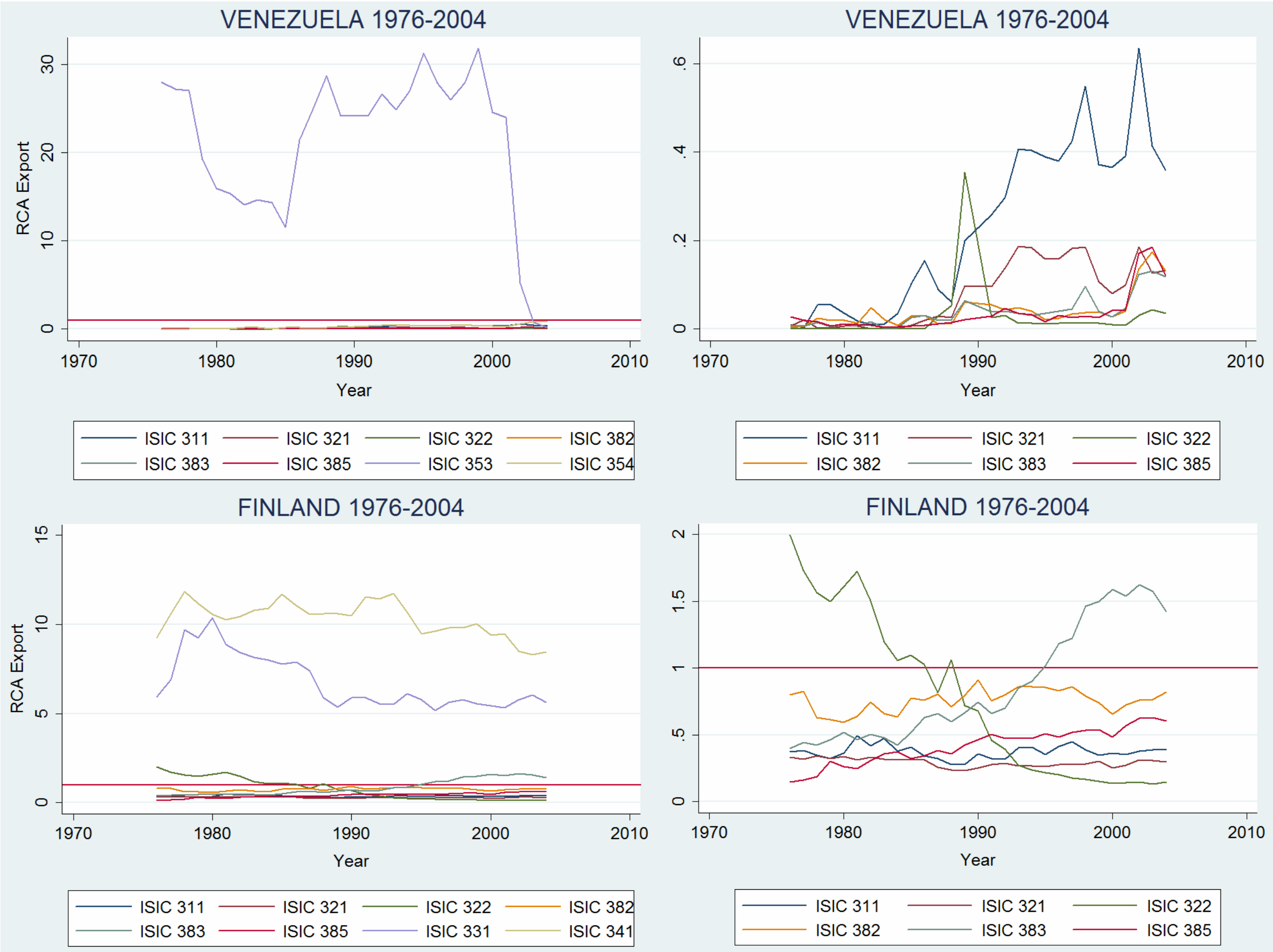
This shows the RCA distribution of different ISIC goods. The first graphs show all ISIC, the second line of graphs show the distribution when removing the country`s -specialization industry.

Source: Made by author

In the same way country size could affect industrial structure through diversification, natural resource production are sometimes shown to have a restricting effect. This could be because we observe that many small countries only export raw materials and natural resource related products. Or because that for the very poorest countries, such type of production might be the only thing they manage to export. These countries thus have very low diversification in their industrial structure. There is also reason to believe that industries heavily reliant on endowments and natural resources are less “footloose”, because they are closely tied to a specific geographical area. Theories of “the natural resource trap” and “Dutch-disease”, are examples of such thinking.

To check if such large dispersion in resource exports is existent in the data set of this study, similar graphs as above are generated for oil-exporting Venezuela, and for wood and forestry-exporting Finland. As seen in Figure 15, similar patterns as the ones with Trinidad and Tobago are found:

Figure 15: RCA`s for Natural Resource Exporters, 1976-2004
Venezuela and Finland



This shows the RCA distributions of different industries for oil-exporting Venezuela, and wood and forestry-exporting Finland. Clearly both countries` RCA distributions (as graphed here) are dominated by their specializing industry. Without these sectors, as is seen in the graphs to the right in the figure, they have much more stable and evenly distributed RCAs.

Source: Made by author

This indicates that resources and specialization in such, could possibly lead to bias in the RCA index. If this is the case then some measures has to be taken in order to clean the RCA from such bias. Therefore, I will formally check for the existence of such bias in the econometric analysis, and based on the results, discuss how to correct for it.

5 Methodology

5.1 Empirical Strategy

The main purpose of this study is hunting for the flying geese: Can we find a universal pattern of structural change, so that at a particular income level a country has a particular pattern of manufacturing production. And do these universal patterns have the characteristic inverse U-shape predicted by Akamatsu? And, if it is actually so that countries with low income levels export Low-Tech goods with little sophistication in production, whereas countries with high income levels export Mid- and High-Tech goods with high levels of sophistication, then does the point for which countries shift away from Low-Tech goods come at a lower GDP per capita level, than the turning point between Mid- and High-Tech goods (etc.)?

The study will use *Revealed Comparative Advantage* as the measure of competitiveness and specialization. The basic regression run is thus:

$$\mathbf{RCA} = \alpha_0 + \alpha_1 * \mathbf{gdp\_pcppp\_c2000} + \alpha_2 * \mathbf{Sqr\_gdp\_pcppp\_c2000} + \varepsilon$$

Separate regressions are run for the symmetric version of the index, RSCA, as part of testing for which measure to use. In order to test for inverse U`s at a sectorial level, one regression has to be run for each industry. This means that 28 independent regressions will be run for export, import and output. All regressions and tests are performed in the software Stata (SE version 10).

Some remarks in regards to Akamatsu`s U-curves is that the degree of "footloosness" varies between sectors. This could be due to technologies not being common knowledge, and therefore tied to specific countries or firms, or because production is based on natural resources and therefore tied to countries with such endowments. The ladder case is indicated by the empirical findings in last chapter. There is thus reason to believe that the curvature will vary between "slow moving" and "fast moving" sectors.

Another remark is that the curves could possibly be asymmetric in the sense that their curvature is skewed towards either higher or lower levels of income per capita. A reason for this could be the existence of certain technology thresholds, forcing countries to wait until reaching a specific income level before starting production. The curvature would then be skewed towards the higher GDP per capita levels. Skewness towards the lower part, with the curve falling over a large income interval as countries reduces production when reaching a certain threshold, is however not as intuitive. It is easier to imagine that curves would just keep on increasing. As indicated by Kojima, however, there is always a point at which it pays off to let others take over production of certain products (or at least provide the labor). That means that a country will *always,* at some point, start losing comparative advantage in sectors. Following this we would expect there to be a reduction in production and export for *all* sectors, as even rich countries loses their advantage with time. This would in general indicate a type of deindustrialization, as all manufacturing sectors will decline in importance – *even* the Mid- and High-Tech ones, and to a large degree the Resource-Based ones. If this is the case, then the evidence is generally in line with both Kojima and Akamatsu. Since this study is covering only the period from 1976-2004 (29 years) however, we could experience that some countries have already reached their falling part of the inverse U-curve , so these curves would only be decreasing, or that they have not yet reached their peak level, and thus the curve would be completely increasing[26].

A last remark is as discussed in Chapter 3, the possible measurement problems in regards to finding a good and unbiased measure of competitiveness and specialization. We found that empirical evidence suggests that the RCA could be biased by the relation between country size and diversification. Small countries measured as small economies, i.e. measured by the size of total GDP, seems to be more concentrated in production and exports, and they thus have a wider RCA distribution. The opposite goes for large economies. Along the same lines we also found that natural resource producers and exporters, seem too possibly be more specialized than others. This would indicate a wider RCA distribution in the same way as with the small economies.

To handle such issues, several different versions of the basic regression will be run in order to check the influence on the results in case of possible problems indicated in this section. The results from these regressions, and the main results, will be presented after the formal presentation of the econometric model and the empirical testing system.

[26] Japan`s curve in Figure 10 and Germany`s curve in Figure 12 could be examples of such happenings.

5.2 Econometric Model

Because the data set is a panel that have cross-sectional units *and* time series dimensions, the application of regression models are a bit more complex than for simple cross-sectional or time series data sets. Panel data analysis is however rising in popularity as it allows us to control for variables we cannot measure, like cultural factors, or variables that change over time but not across entities, such as national policies and international agreements. That is, panel data can possibly account for individual heterogeneity. The main drawbacks of a panel are however (possibly) many, and if not considered and accounted for, the results will turn out biased, inconsistent and inefficient. To avoid such problems and to find the most appropriate regression method to carry out the main analysis, I therefore preform 5 pre-tests checking for common panel data-problems. Depending on the results from these pre-tests, the regression method is chosen and run. A detailed description of the pre-tests can be found in Appendix 5 whereas a more intuitive discussion is given here[27].

The structure of the panel used in the thesis is as follows: The time-variable are the year span from 1976-2004 (t_{1976}, …, t_{2004}), and the panel variable are the ID connecting each country to each of the 28 ISIC sectors (ID=1=ARG_1=ARG311, … ,ID=29=BEN_1=BEN311, …). For example in the case of Exports, the dimension could be: (t_{1976}, $Export_{ARG1}$), which is the value of Argentina`s export in ISIC 311 (panel-dimension), and year 1976 (time-dimension). Regressions run on ISIC-level therefore consider *only* the Export values for the specific ISIC chosen, in this example ISIC 311. The GDP per capita variable changes according to the time-variable, but is of course different for each country (although the value does not vary between ISICs within the same country).

The first thing I test for is the need to add year-fixed effects (year-dummies) in the regressions to control for variables that are constant across entities, but evolve over time. If such time-fixed effects are added, then the regression model will return a different intercept for each year. These intercepts can then be thought of as year t`s effect on the dependent variable. The variation comes from the fact that omitted variable bias is being controlled for. In my case adding time-fixed effects would control for things constant across countries and sectors, but changing over time. This can be things like cultural values, type of political regime,

[27] The pre-testing structure are following Torres-Reyna`s Princeton lecture note on panel data analysis, but with additional tests known to account for more cases of panel data problems. Torres-Reyna, O. Panel Data Analysis - Fixed & Random Effects (using stata 10), Princeton University.

legislation etc. As usual to avoid the dummy-variable trap, one of the year-dummies or the intercept is being dropped from the regressions. This is done automatically and randomly by Stata in each case.

The second thing I test for is the existence of heteroskedasticity. If the error term in the regression is homoscedastic, then the variance of the conditional distribution given the independent variables is constant, and independent of changes in this variable. If the variance *depends* on the independent variable on the other hand, and thus changes as the independent variable changes, then the error term is heteroskedastic. In such cases, the regressions have to be run with robust standard errors correcting for this. In my case there would be heteroskedasticity if the variance of the RCA is dependent on the specific value of the GDP per capita variable. Heteroskedasticity is formally tested for, but it is in general considered smart to always assume heteroskedasticity, and thus always control for this by using the robust option.

The third pre-test is regarding autocorrelation (serial correlation) in the panel. This is a problem arising especially in panels with long time series (over 20-30 years), and it causes the standard errors of the coefficients to be smaller than they truly are, and thus yields higher R^2`s. The reason for this is that each independent variable is correlated with itself at a different point in time. This is due to omitted factors that are persistent over multiple years, and that are causing autocorrelation in the regression errors. This does not necessarily have to be the case, but in general as long as some omitted factors are autocorrelated, then the errors will be so as well. If GDP per capita at some point in time is correlated with GDP per capita at some other point in time, for the same country, then we would have autocorrelation. This is both highly likely, as well as it is considered smart to always assume this. Separate tests are however still performed.

The next thing tested for is the main issue with panel data, and the one that is the hardest to correct for: Existence of cross-sectional dependence. This is as with autocorrelation, mainly a problem with long time series. Assuming that disturbances of a panel model are cross-sectionally independent is as argued by amongst others, Hoechle, often highly inappropriate: *"Panel datasets are likely to exhibit complex patterns of mutual dependence between cross-sectional units (e.g. individuals or firms). Furthermore, because social norms and psychological behavior patterns typically enter panel regressions as unobservable common factors, complex forms of spatial and temporal dependence may even arise when cross-*

sectional units have been randomly and independently sample. In our case dependence in development between different countries and the countries` ISIC sectors, will yield cross-sectional dependence. Since this is a scenario quite believable, it is important to test for and control for such dependence. A set of tests following the structure in Hoechle`s Stata Journal article is therefore performed. If this implies cross-sectional dependence, then the proposed solution is carried out: Running the regressions with Driscoll-Kraay standard errors[28].

Lastly I test for the need to run regressions using fixed effects (fe), versus either random effects (re) or pooled regression/WLS. This is again done according to the method described by Hoechle. He proposes a new and improved testing method able to handle cross-sectional dependence, something that the regular Hausman-Test and the Wooldridge`s Hausman-Test are incapable of.

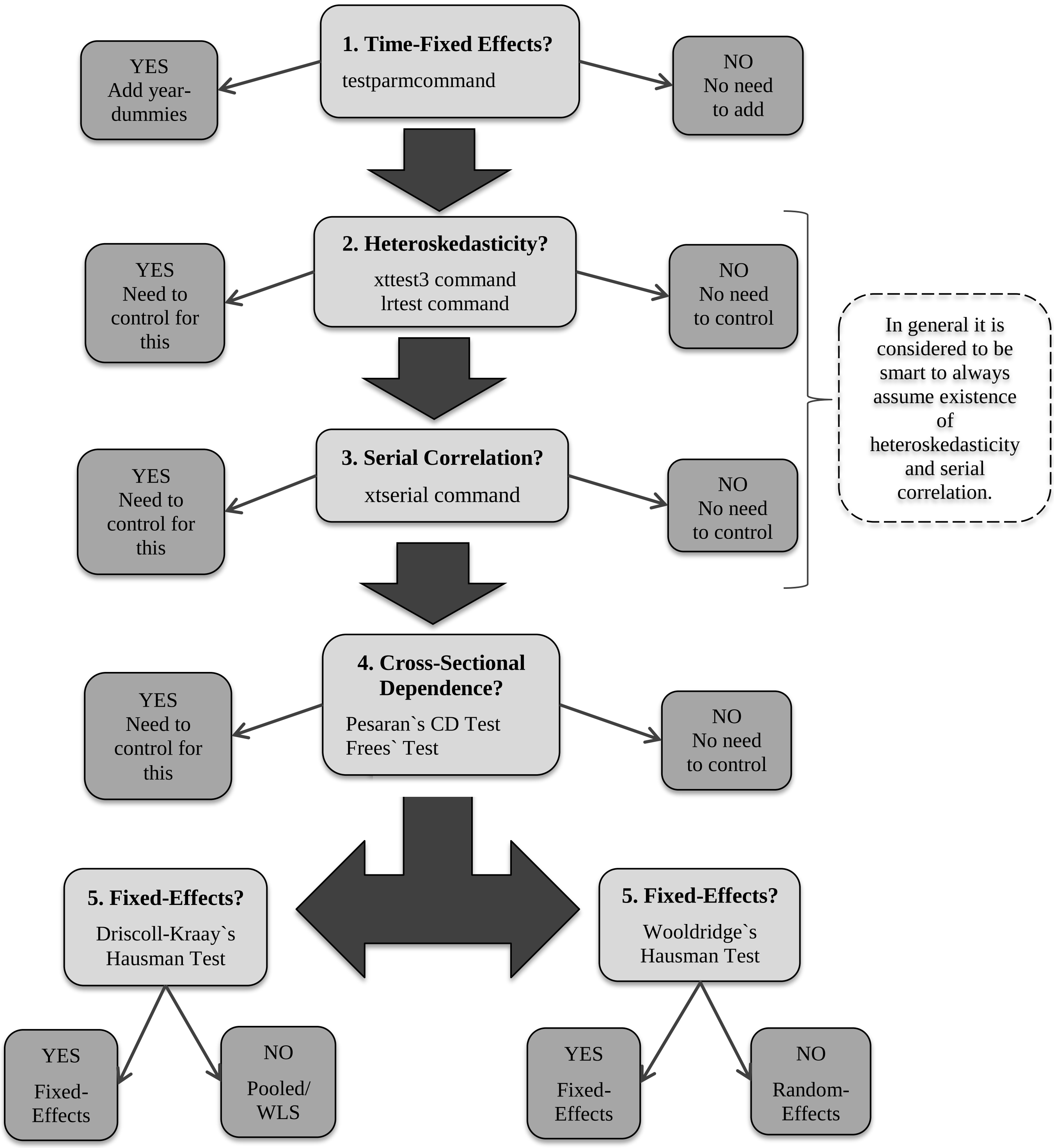
The standard OLS assumptions for multiple regressions are of course also considered: A conditional distribution of errors, given the regressors with a mean of zero, random variables (i.i.d.), no large outliers and no perfect multicollinerarity.

The formal structure of this pre-testing is illustrated in the figure below. The logic and the consequences of the different tests performed are easily seen by following the arrows.

All tests, calculations and regressions indicated in this chapter are performed in the software Stata. The results from this are presented in the next chapter together with graphs and figures, generated in Stata, Word and Excel. All is made by the author.

[28] This is done by using the stata command **xtscc**, programmed and presented by Hoechle. The stata command **xtcsd**, also presented in The Stata Journal are used to perform two different tests for cross-sectional dependence. Hoyos, R. E. D. and V. Sarafidis (2006). "Testing for cross-sectional dependence in panel-data models." The Stata Journal **6**(4): 482-496.

Figure 16: Overview over the Pre-Testing System - 5 Step Testing



This illustrates the structure of the pre-testing done to determine the regression method suitable for testing the data for U- and inverse U-relationships between RCA and GDP per capita.

Source: Made by author

Now based on the results from these tests, one of the following regressions will be run either with or without year-dummies according to pre-test results (example with RCA_Export as dependent variable):

1. xtreg **RCA_Export** gdp_pcppp_c2000 Sqr_gdp_pcpppc2000 (year_dum*), fe cluster(ccode_isic_id)
2. xtreg **RCA_Export** gdp_pcppp_c2000 Sqr_gdp_pcpppc2000 (year_dum*), re cluster(ccode_isic_id)
3. xtscc **RCA_Export** gdp_pcppp_c2000 Sqr_gdp_pcpppc2000 (year_dum*), fe lag(6)
4. xtscc **RCA_Export** gdp_pcppp_c2000 Sqr_gdp_pcpppc2000 (year_dum*), lag(6)

If running the regression with fixed-effects (fe), we assume that unobserved heterogeneity is correlated to some extent with the independent variables. Thus, all time invariant differences between entities are controlled for when using fixed regression (in the same manner as with time-fixed effects). The estimated coefficients of the fixed-effects regressions then cannot be biased because of omitted *time-invariant* variables. If running a random-effects (re) regression instead, then the variation across entities is assumed to be random an uncorrelated with the independent variables in the regression. In the case of random-effects, it is necessary to specify those individual characteristics that may (or may not) influence the dependent variable. This must be done by including control variables or using an instrument (Instrumental Variable Regression). This is thus more demanding with regards to the amount of data necessary.

The two above alternatives are tested for if there is no cross-sectional dependence, as illustrated in the above figure. *If* there is cross-sectional dependence, then the test being performed checks the need to run time-fixed effects regressions versus general pooled regression/Weighted Least Square Regression (WLS) (i.e. *not* fixed- versus random-effects). The results from this test will then be either to run the regressions with fixed-effects, thus controlling for all of the following: *heteroskedasticity, autocorrelation, cross-sectional dependence and need of fixed-effects,* or to run the regression as pooled/WLS, thus controlling for: *heteroskedasticity, autocorrelation and cross-sectional dependence*. When running the ladder one, the panel structure of the data is ignored, and there is assumed to be no unobserved individual heterogeneity between entities. This is thus the most restrictive regression model. If the test implies that this regression should be run, however, then the estimates will be *consistent*. This holds even if the regression were miss-specified as pooled when it should have been fixed (but then the estimators will be *inefficient*)[29]. The complete results of this pre-testing can be found in Table 1 –4 in Appendix 5. The Stata output from the testing are not included.

5.2.1 Regressions and After-Testing

After running the regressions indicted by the pre-tests described above, the following three criteria are checked to assure the existence of U`s or inverse U`s.

Significant gdp and gdp^2 Coefficients?

The first step is to check the sign and significance of the **GDP per capita** and **GDP per capita^2** coefficients. To confirm a U-shape the first coefficient has to be negative and the second positive. To confirm an inverse U, the first coefficient has to be positive and the second negative.

Maximum or Minimum Within the Range of GDP per Capita[30]?

The next step is to check whether the maximum or minimum implied by the regressions lies within the range of GDP per capita values. If this is the case, then a U- or inverse U-shape is usually confirmed. However, according to Mehlum and Lind (2007), these two steps alone are inadequate. The problem arises when the true relationship between RCA/RSCA and GDP per capita is convex or monotone, since a quadratic approximation then will erroneously yield an extreme point (and hence a U-shape or inverse U-shape)(ibid).

Significant Mehlum and Lind U-Test?

To account for this problem, Mehlum and Lind`s U-Test is also performed before concluding. This test secures that within the range of GDP values, the relationship between RCA/RSCA is decreasing for low values (high values) and increasing for high values (low values) if a U-shape (inverse U-shape) adequately can be concluded to exist. The null hypothesis for a U-shape is then that the relationship is increasing at the left side of the interval *and/or* is decreasing at the right side. This composite null hypothesis is based on an earlier general

[29] All regressions run with pooled/WLS regression are also run with fixed effects as a comparison. Many of them are significant, and for most of these the coefficients have the same sign. Based on the pre-testing however, the pooled/WLS option will be used if pre-test indicates so.
[30] This is in practice performed by using the **wherext** command in stata.

framework (Sasabuchi 1980)[31], and depends on the following decision*: Reject H_0 at the α level of confidence only if either H_0^L or H_0^H or both can be rejected at the α level of confidence*. H_0^L and H_0^H are the null hypotheses in the two one-sided tests:

H_0^L: coefficient larger than 0 for low values
H_0^H: coefficient smaller than 0 for large values

If both these tests jointly hold at the given level of significance, then a U- or inverse U-shape is concluded to exist, as long as the additional above criteria are also confirmed (Mehlum and Lind 2007). These criteria are checked for *all* individual regressions.

5.2.2 Description of Variables

The main variables used in the regressions are the RCA and the RSCA value for export, import and production, calculated after the formulas derived in Chapter 3. This is done for all countries, all years and all sectors. The GDP per capita variable from the dataset is used to calculate the squared and cubic GDP per capita values, and year-dummies for all 29 years (1976-2004), are also generated. In addition variables over economic size and dummies dividing the time span into different periods, are generated and used in alternative regressions, checking the basic equation's robustness to possible problems indicated in the descriptive evidence.

The GDP per capita values used are PPP in constant 2000 US Dollars i.e. GDP per capita values converted into 2000 US Dollar values, using purchasing power parity rates. This is done to obtain values that inhibits eliminated differences in price levels between countries, and thus permits cross-country comparisons[32]. A "2000 US PPP Dollar" then has the same purchasing power everywhere. Although GDP per capita measures in general have been

[31] More technical info on the Sasabuchi test and the Mehlum and Lind test can be found in the latter`s 2007 article. The test is performed in practice using the author`s **utest** command in Stata.
Mehlum, H. and J. T. Lind (2007). "With or Without U? - The appropriate test for a U shaped relationship." MPRA **4823**.

[32] In the simplest form PPP`s are relative prices, which show the ratio of prices in national currencies of the same good or service in different countries. A famous one-product index is "The Big Mac Currency Index" with "Big Mac PPP" as the conversion rate.

criticized for being incomplete measures of people's economic well-being, the lack of better measures leaves it as the (still) most used one (Schreyer and Koechlin 2002)[33].

Table 2: Overview over Variables

Variable Name	Description
RCA_Export	RCA for exports calculated per country, per ISIC, per year
RCA_ExportN	RCA for exports calculated per country, per ISIC, per year (RSCA)
RCA_Import	RCA for imports calculated per country, per ISIC, per year
RCA_ImportN	RCA for imports calculated per country, per ISIC, per year (RSCA)
RCA_Output	RCA for output calculated per country, per ISIC, per year
RCA_OutputN	RCA for output calculated per country, per ISIC, per year RSCA)
gdp_pcppp_c2000	GDP per capita PPP measured in 2000 US Dollars
Sqr_gdp_pcppp_c2000	The squared value of GDP per capita PPP measured in 2000 US Dollars
Cub_gdp_pcppp_c2000	The cubic value of GDP per capita PPP measured in 2000 US Dollars
gdp_c2000	Total GDP measured in 2000 US Dollars
Sqr_gdp_c2000	The squared value of total GDP measured in 2000 US Dollars
year_dum1 – year_dum29	One dummy variable per year with value equal to 1 if equal to that specific year, and value equal to 0 if otherwise (time period: 1976-2004)
timeperiod_dum1	Dummy specifying the time period 1976-1990
timeperiod_dum2	Dummy specifying the time period 1991-2004

Table showing the variables used in the different regressions.

Source: Made by author

[33] PPPs are considered by the World Bank as the best measure of standard of living, and are thus used in their calculations of poverty rates.

6 Empirical Results

6.1 Regression Results

As a first step, the basic regression equation is run with RCA and RSCA as dependent variable for exports only, i.e. with **RCA_Export** and **RCA_ExportN**. This is then used to see whether the normalized version of the index yields a better fit according to R^2 and level of significance. If this is the case, then only the normalized index will be used in the regressions for output and imports.

A reason for *why* the RSCA could show better fit than the RCA regressions is the possible bias induced by economic size and natural resources. To solve for such bias one could either add control variables to the right side of the regression, or alter the RCA index on the left hand side. Many papers searching for similar U and inverse-U patterns are adding variables to control for country size: either economic, geographical or population wise. Others are controlling for resource endowments, mostly indirectly (and some are controlling for both) through the use of proxies.

In the ladder strategy, the need to control for natural resources becomes less problematic since we are using RCA (or RSCA) as dependent variable, an index meant to *mimic* country`s real comparative advantages. Relative advantage in production and trade is due to individual differences in things like natural resources, large populations (easy access to labor) and a lot of capital. As differences in endowments could indeed influence the relation between dependent and independent variable in general, what is done here is to test for changes in RCA as income per capita grows, i.e. for changes *indirectly* in amongst other things: natural endowments. The need to control for such factors is therefore, given that one believes that RCA (or RSCA) is indeed reflecting comparative advantages, not crucial.

As for country "size", this is not as clearly controlled for through the RCA itself. A large dispersion in RCA caused by this, will thus give values acting as outliers in the regressions. This is especially the case since the RCA index is unbalanced and has an infinite interval for having RCA (and a very limited for the opposite). A way to control for such bias is then to use the RSCA as dependent variable instead of RCA. Since this index is symmetric around the neutral point (neutral RCA = 0), the bias from very large RCA values is minimized, although not completely removed. An alternative measure is to add control variables for economic size, such as total GDP in the basic regression.

In this study both these approaches are attempted. Firstly the basic equation is run with both RCA and RSCA as dependent variable. Then the basic equation with and without total GDP as control variable, is run, again both with RCA and RSCA as dependent variable. From this it was found that the effect of adding total GDP as a variable had a very small effect when using RSCA as dependent variable, whereas it had a noticeably larger effect in the RCA regressions[34]. Even with control variables in the RCA case, the basic regressions using RSCA shows a better fit: The largest improvement is undoubtedly when running the basic equation with RSCA instead of RCA in general. In only 5 cases do the RCA regressions show a higher R^2, and the RSCA regressions have more significant results. Since R^2 in some cases is more than twice as high, RSCA will thus be used to test the output and import data. The complete summarized results from these regressions are found in Appendix 6. Only the significant results will be presented throughout this chapter[35].

Another issue that could influence the regressions is time trends. When adding year-dummies variables that are constant across entities, but evolve over time, are controlled for. The regression model will return a different intercept for each year reflecting year t`s effect on the RSCA index. If this is enough to control for overall increasing technology level and the effect this has on the regression results, are however unclear. If a general increase in technology or sophistication level happened across all industries and countries, then one could imagine this causing the peak level of GDP per capita to change. If at one point the GDP per capita turning point in an industry is 10 000 US Dollars, but due to increased technology needed in the sector it increases to 15 000 US Dollars, then the peak at the inverse U (if existent), will be moved. Now if this is happening to a large degree, then running the regressions for all years would force the peak at an averaging level, possibly giving misleading results.

[34] The result from this is not added in the Appendix. Only the difference between the basic regression using RCA and RSCA is presented here.

[35] Other control variables such as tariffs or quotas could have an improving effect if added in the regressions. Such phenomena could decrease the opportunity to move production around, since all industries would become less “footloose”. This is however not included in the regressions performed in this study, since the data for this in the data set used, is incomplete. Adding such variables could then *possibly* change or reduce the strength of the results. The hypothesis is that adding it would decrease the sharpness of the curves.

As a way to check the importance of such problems, the regressions are run including timespan-dummies, separating the timespan into two different periods: One for 1976-1990 and one for 1991-2004. The turning points for the regressions with significant inverse U`s are surprisingly stable between these periods. For some sectors there is no inverse U-pattern for the first period, but only for the second one – *however* the turning point in the second period is similar to the one in the overall regression. This is the case for especially oil related products and transport equipment. Although a more thorough test of this could be performed, by for example adding interactive terms, this will be left for further research. As for now, the study will consider the "timespan-dummy approach" as enough to conclude that at least to some extent, the problem are being solved by the inclusion of year-dummies.

On the next page is an overview table over the significant results for export, import and output regressions, using the RSCA as dependent variable. More specific results such as R^2 and coefficient values for each of the regressions can be found in Appendix 6. As is clear from the last row in Table 4, there are much more significant results based on the export data. Here a total of 23 regressions came out with significant coefficients, whereas 19 of them with proof of inverse U`s. The turning points also show a considerable variation in GDP per capita level, from around 10 000 US Dollars (2000)[36] in the case of Leather Products, to around 30 000 US Dollars in the case of the Transport Equipment. As the industries vary drastically with regards to technology level, this is obviously as assumed.

A similar spread in maxima is also evident in the import and output regressions.

[36] By (2000) I mean that the Dollars are expressed in fixed prices at the 2000-Dollar level.

Table 3: List over Significant U and Inverse U Regressions

	RSCA Output					**RSCA Imports**					**RSCA Exports**				
ISIC	**∩**	**U**	**gdp^2**	**U-Test**	**Max/Min**	**∩**	**U**	**gdp^2**	**U-Test**	**Max/Min**	**∩**	**U**	**gdp^2**	**U-Test**	**Max/Min**
311	X		**	**	Max 13 332.03							X	***	**	Min 23 522.28
314		X	***	***	Min 19 385.45	X		***	***	Max 18 139.6	X		***	***	Max 15 303.42
321						X		***	***	Max 9 347.678		X	***	*	Min 29 584.96
322											X		***	***	Max 10 615.74
323		X	***	***	Min 25 647.15	X		***	***	Max 18 370.54	X		***	***	Max 9 979.51
324											X		***	***	Max 13 390.72
331												X	***	***	Min 17 637.46
332	X		***	***	Max 17 824.54						X		***	***	Max 20 106.71
341						X		***	***	Max 14 882.15	X		***	***	Max 24 907.58
342	X		***	**	Max 25 530.22	X		***	***	Max 14 915.67	X		***	**	Max 28 301.28
351	X		***	***	Max 17 405.98						X		***	***	Max 22 645.93
352							X	***	***	Min 26 088.64					
353	X		***	***	Max 16 183.68		X	***	***	Min 19 725.47	X		***	***	Max 8 287.888
354	X		***	***	Max 17 025.9	X		***	***	Max 16 130.01					
355		X	***	***	Min 23 422.56						X		***	***	Max 17 183.86
356						X		***	**	Max 25 416.24	X		***	***	Max 22 049.42
361	X		***	**	Max 15 695.9	X		***	*	Max 30 149.66	X		***	***	Max 15 088.3
362	X		***	***	Max 17 094.17	X		***	***	Max 17 615.1	X		***	***	Max 18 574.25
369											X		***	***	Max 14 983.06
371											X		***	***	Max 19 122.54
372	X		**	*	Max 24 460.1	X		***	***	Max 28 375.68					
381	X		***	***	Max 16 674.93						X		***	***	Max 27 338.87
382	X		***	***	Max 23 072.39	X		***	**	Max 17 211.29	X		***	***	Max 22 151.55
383						X		***	***	Max 18 603.12	X		***	***	Max 23 163.14
384	X		***	***	Max 16 343.3						X		***	**	Max 29 391.83
385												X	***	***	Min 17 804.09
SUM	**12 inverse U`s** (and 3 U`s)					**12 inverse U`s** (and 2 U`s)					**19 inverse U`s** (and 4 U`s)				

*Significant at a 10 % level **Significant at a 5 % level ***Significant at a 1 % level

"gdp^2" indicates significant coefficients for both linear and quadratic terms**. "U-Test"** indicates significant results on Mehlum and Lind`s test. **Max/Min** are expressed in 2000 US Dollar terms.

NOTE! RSCA indicates the variables: **RCA_OutpuN**, **RCA_ImportN** and **RCA_ExportN**

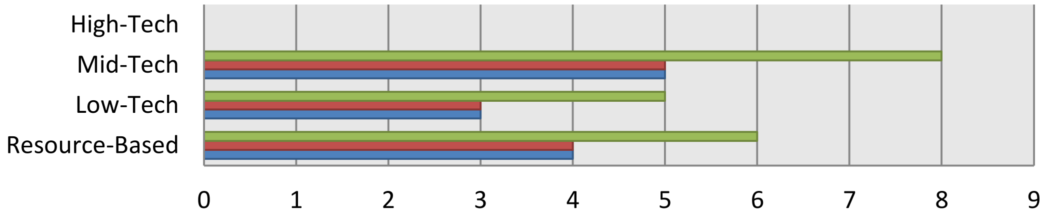
*Specific coefficient values are shown in Appendix 6 Table 3

Summary over the significant results for all normalized RCA values: output, import and export.

Source: Made by author

It is clear that type of industry indeed has something to say for at what GDP per capita level the RSCA starts decreasing, i.e. for determining the dynamics in RSCA as GDP per capita rises. All broad implications from the structural change theories can thus be said to have been confirmed. An important conclusion not expected in advance, is that the Low-Tech industries that were *assumed* to be more cyclical, clearly is *not*: Inverse-U`s are surprisingly more prevalent in the Mid-Tech industries. This holds for all tree variables as seen in Figure 17 below:

Figure 17: Number of inverse-U`s According to Type of Sector



	Resource-Based	Low-Tech	Mid-Tech	High-Tech
Inverse U`s: Export	6	5	8	0
Inverse U`s: Import	4	3	5	0
Inverse U`s: Output	4	3	5	0

This shows the distribution of significant inverse-U relationships detected.

Source: Made by author

An important specification in regards to the results in Table 3 and Figure 17, is in what income-group or income level specification the turning point is in. As the GDP per capita measure used in this study are *purchasing power parity adjusted*, the regular World Bank group division (based on unadjusted GDP per capita) is not applicable. Therefore the 4 group division used by Schreyer and Koechlin (2002) will be used:

Table 4: Income-Groups

Income Group	**GDP per capita PPP US Dollars (2000)**
Low-Income	0 - 10.750
Low Middle-Income	10.751 – 21.500
High Middle-Income	21.501 – 25.800
High-Income	25.801 - ∞

These groupings are originally based on 1999 US Dollars in the article, but are considered here as well. The boundaries are calculated based on the OECD 30 average (all OECD countries at the time) equal to **21.500** US Dollars. See more specific overview in Appendix 7.

Source: Schreyer, P. and F. Koechlin (2002). "Purchasing power parities - measurement and uses." OECD Statistics Brief **3**.

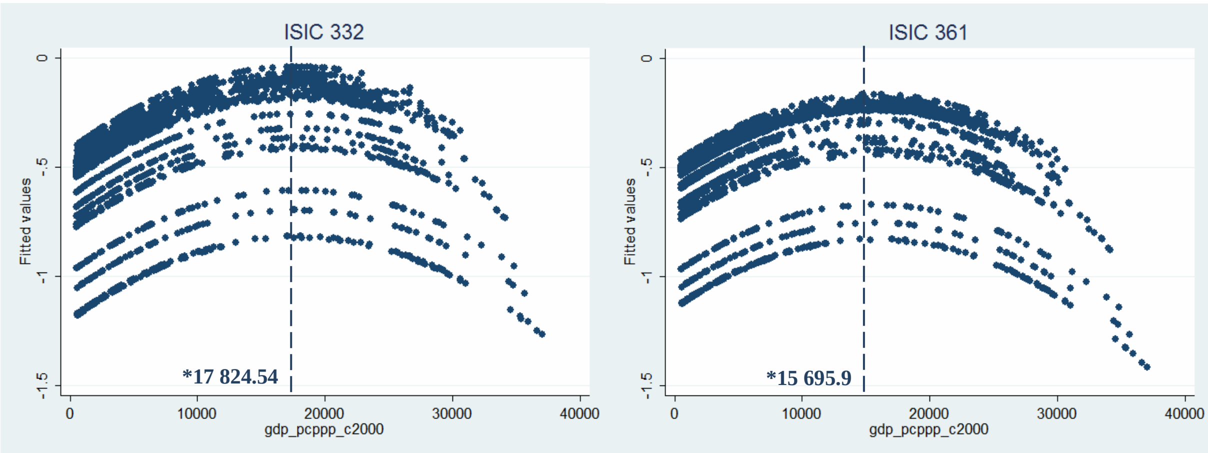
From this we can conclude that the result in Table 3 indicates that most turning points happen at a GDP per capita level characterizing Low Middle- and High Middle-Income countries. This holds in general for output, import and export results.

6.1.1 Trends in Output Data

From Table 4 it is clear that out of the 28 regressions, 12 can significantly be concluded to have inverse U`s. These 12 sectors include representatives for all type of goods except High-Tech ones. As the most interesting in regards to the research question (in addition to the existence of these U`s), is the difference in turning point between Low-Tech and Mid-Tech sectors, scatter plots with examples of these two will be presented[37]. In Figure 18 the predicted values for Furniture (332) , and Pottery China Earthenware (361), is plotted against GDP per capita (gdp_pcppp_c2000). The dotted lines represent the maxima for each plot, and the GDP per capita value is the starred-one.

As is seen below, the value for both turning points are below 21 500 US Dollars (2000). More specifically, these sectors have a shift in production at a GDP per capita value characteristic for Low Middle-Income countries.

Figure 18: RCA Output 1976-2004: Low-Tech Industries *ISIC 322 and 361*



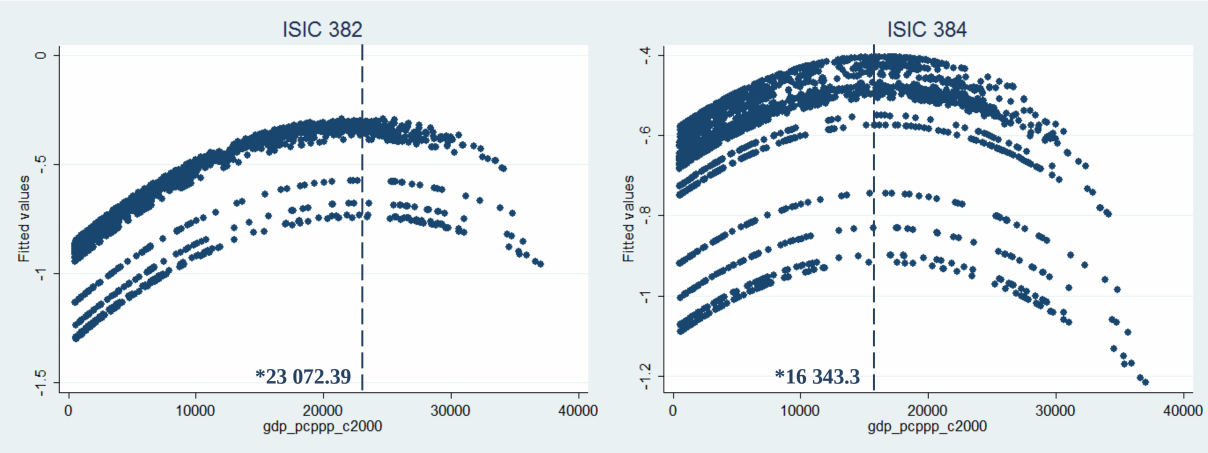
This shows the predicted values from the regressions for the Low-Tech sectors: Furniture (332) and Pottery China Earthenware (361).

Source: Made by author

[37] A complete set of figures over all significant regressions can be found in Appendix 6.

Below is the same type of figures for ISIC 382 Machinery and ISIC 384 Transport Equipment. The turning point for Machinery is above 21 500 US Dollars (2000) i.e. placing the shift in the value range of the High Middle-Income countries, whereas ISIC 384 have a turning point similar to the Low-Tech sectors above. The main point here is however that a clear cyclicality in terms of inverse U`s is existent for all four sectors – *also* in the Mid-Tech sectors. These results are thus supporting the idea of deindustrialization. Not only Pottery Earthenware is decreasing at a certain income level, so are the production of Machinery and Transport Equipment.

Figure 19: RCA Output 1976-2004: Mid-Tech Industries *ISIC 382 and 384*



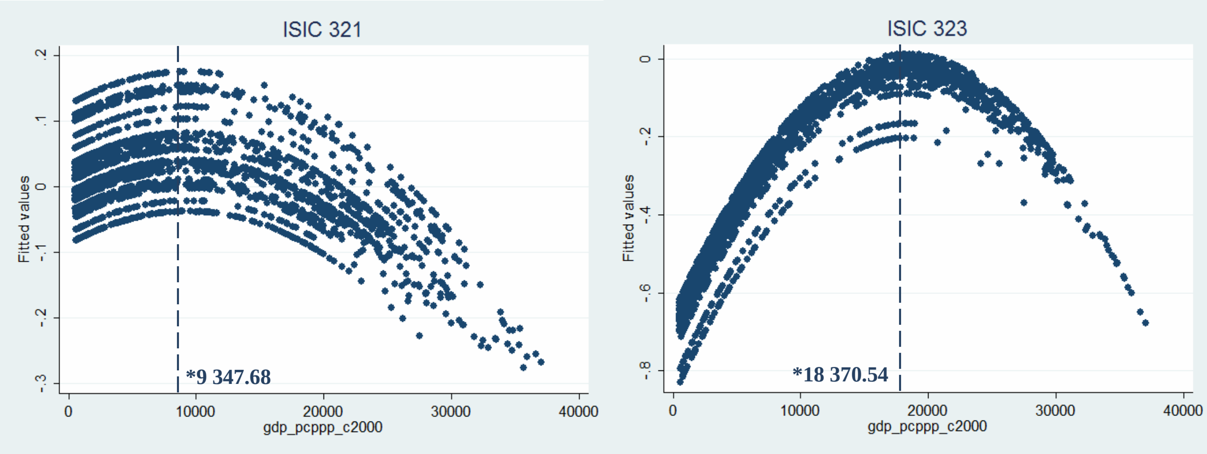
This shows the predicted values from the regressions for the Mid-Tech sectors: Machinery (382) and Transport Equipment (384).

Source: Made by author

6.1.2 Trends in Import Data

Figure 20 is showing the predicted values for ISIC 321 Textiles and ISIC 323 Leather Products. Clear inverse U`s can be seen, and the turning point for Textiles especially, is at a relatively low GDP per capita level. Both turning points are thus happening at income levels characterizing countries in the two lowest income groups.

Figure 20: RCA Import 1976-2004: Low-Tech Industries *ISIC 321 and 323*

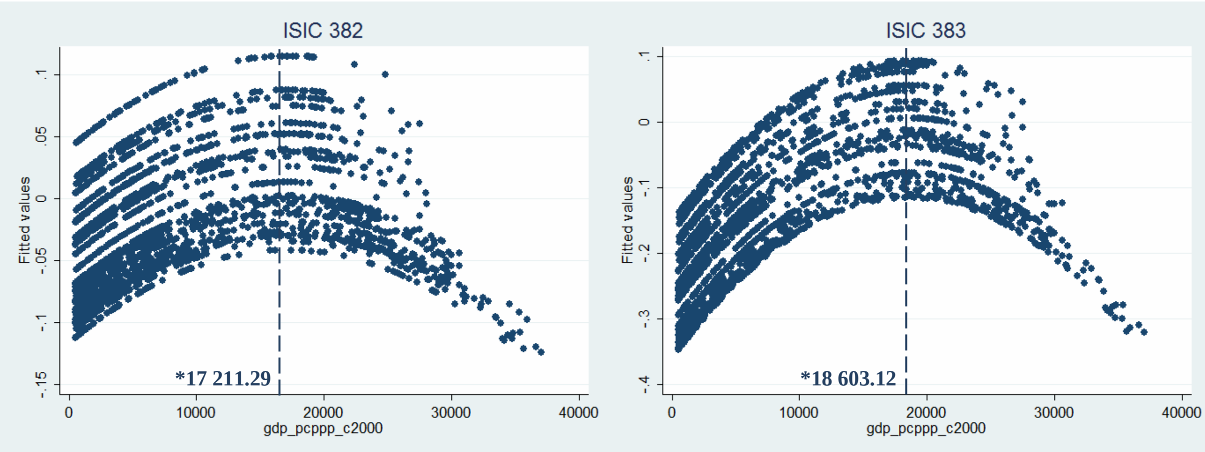


This shows the predicted values from the regressions for the Low-Tech sectors: Textiles (321) and Leather Products (323).

Source: Made by author

Looking at the figures for the Mid-Tech industries below, for ISIC 382 Machinery and ISIC 383 Electrical Machinery, both has a shift in RCA at around 18 000 Dollars. This is in line with GDP values of Low Middle-Income countries.

Figure 21: Import 1976-2004: Mid-Tech Industries *ISIC 382 and 383*



This shows the predicted values from the regressions for the Mid-Tech sectors: Machinery (382) and Electrical Machinery (383).

Source: Made by author

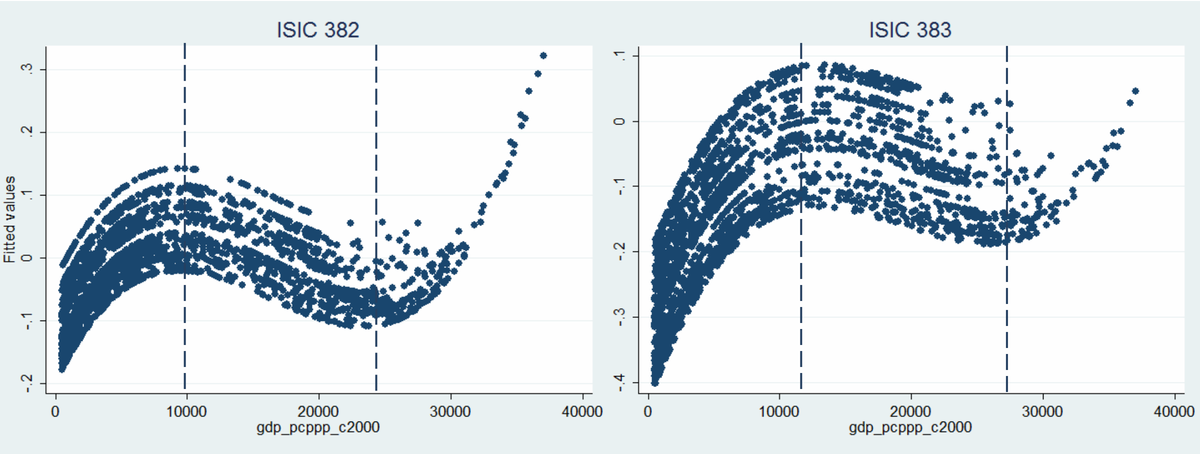
We again see that for both the Low-Tech and the Mid-Tech sectors the characteristic flying geese pattern is very visible. Clear turning points can be found, and we have phases characterized by first growing then decreasing comparative advantages in imports.

Now a possible reason for why the import regressions are showing evidence of less inverse U`s than the export regressions, could in line with the idea of deindustrialization, be that the curves instead are shaped as N`s. The pattern would thus be increasing RSCA up until a point, then a decreasing phase, before yet another change in patterns as RSCA starts increasing again. This last increase is then due to the fact that some countries, mainly the richest ones, have decreased their importance in these sectors, and thus have to import the goods *again*. That the effect of such changes in patterns is visible first in the import data, is actually in line with original flying geese theory.

To check for this, cubic terms for GDP per capita is added in the regression equations. The regressions are run in the same way as the quadratic ones, starting with the pre-testing to help find the suitable regression method. This is done for output and export data in addition to the import data, which is the one of main interest. The result from this were that in the case of output and export, almost no N`s were found. But in the case of imports, a total of 12 N`s were found. Out of these, 3 sectors with significant proof of N`s had no significant proof of inverse U`s, and 10 out of the 12 sectors showed an higher R^2 for the cubic regressions than the quadratic ones. Some of these differences were not very large, but others showed a clear difference. The significant results from the import cubic regressions can be found in Appendix 6.

The two sectors showing the largest improvement with cubic regressions compared to inverse U`s, are ISIC 382 Machinery and ISIC 383 Electrical Machinery. The predicted value plots for these sectors are shown in Figure 22:

Figure 22: Import Cubic Regressions 1976-2004: Mid-Tech Industries *ISIC 382 and 383*

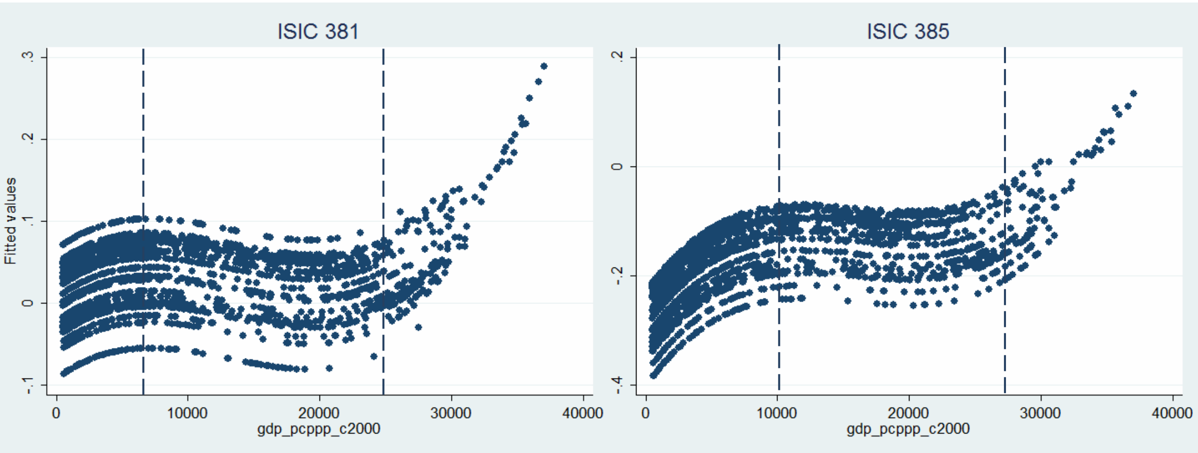


This shows the predicted values from the regressions for the Mid-Tech sectors: Machinery (382) and Electrical Machinery (383).

Source: Made by author

For the sectors Fabricated Metal Products (381) and Professional and Scientific Equipment (385), there is no evidence of inverse U`s. When including cubic terms however, coefficients indicting N`s are found significant. The predicted values are seen below:

Figure 23: Import Cubic Regressions 1976-2004: Mid-Tech Industries *ISIC 381 and 385*



This shows the predicted values from the regressions for the Mid-Tech sectors: Fabricated Metal Products (381) and Professional and Scientific Equipment (385).

Source: Made by author

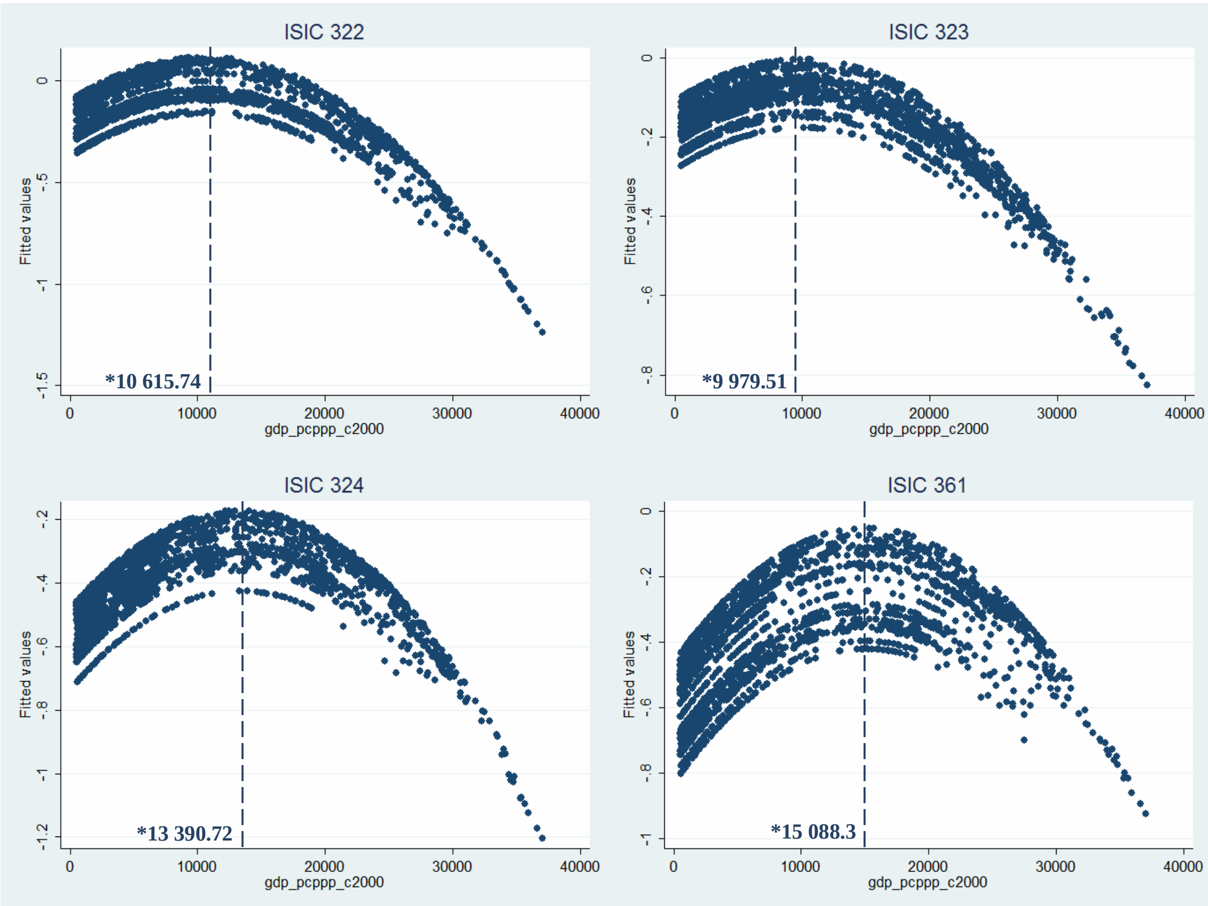
It should in regards to these graphs be noted that adding higher polynomials in the regressions will in general give more significant results since allowing for more and more peaks, it becomes easier to fit most plots of observations. However, adding cubic terms cannot be considered to be a very large addition. It should however be kept in mind.

6.1.3 Trends in Export Data

For the export sector a total of 19 regressions can be concluded to show inverse U-relationships between RSCA and GDP per capita. This is 7 sectors more than for both the output and import regressions, and is in general a very high number. As the theories of industrial transformation focuses mainly on export data – and because the RSCA/RCA index originally is based on export data as a mean to mimic underlying comparative advantages, this is not unexpected.

Below is a figure showing the predicted values for the four Low-Tech sectors: Wearing Apparel (322), Leather Products (323), Footwear (324) and Pottery China Earthenware (361). In general all these sectors have a low turning point in line with expectations, as well as clear inverse U-patterns. All turning point are below 16 000 US Dollars (2000).

Figure 24: RCA Export 1976-2004: Low-Tech Industries *ISIC 322, 323, 324 and 361*

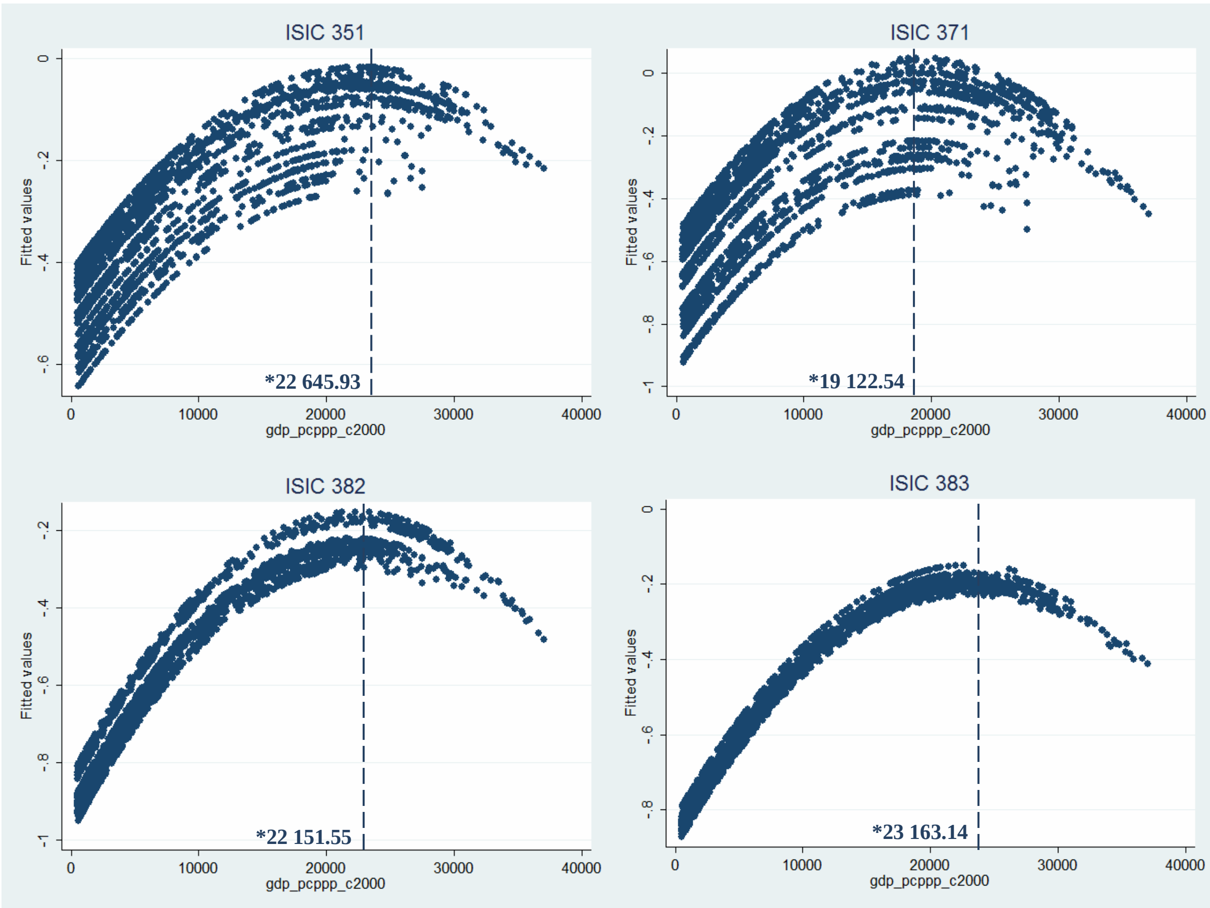


This shows the predicted values from the regressions for these 4 Low-Tech Sectors: Wearing Apparel (322), Leather Products (323), Footwear (324) and Pottery China Earthenware (361).

Source: Made by author

As for the Mid-Tech Industries, Figure 25 shows that the turning point for these industries in general appears at a higher GDP per capita level than for the Low-Tech industries. All sectors have turning points of above 20 000 US Dollars (2000). This is again, as expected for this type of goods with a higher sophistication level. The general pattern of clear inverse U-shapes are also here existent, again supporting the idea about possible deindustrialization.

Figure 25: RCA Export 1976-2004: Mid-Tech Industries *ISIC 351, 371, 382 and 383*

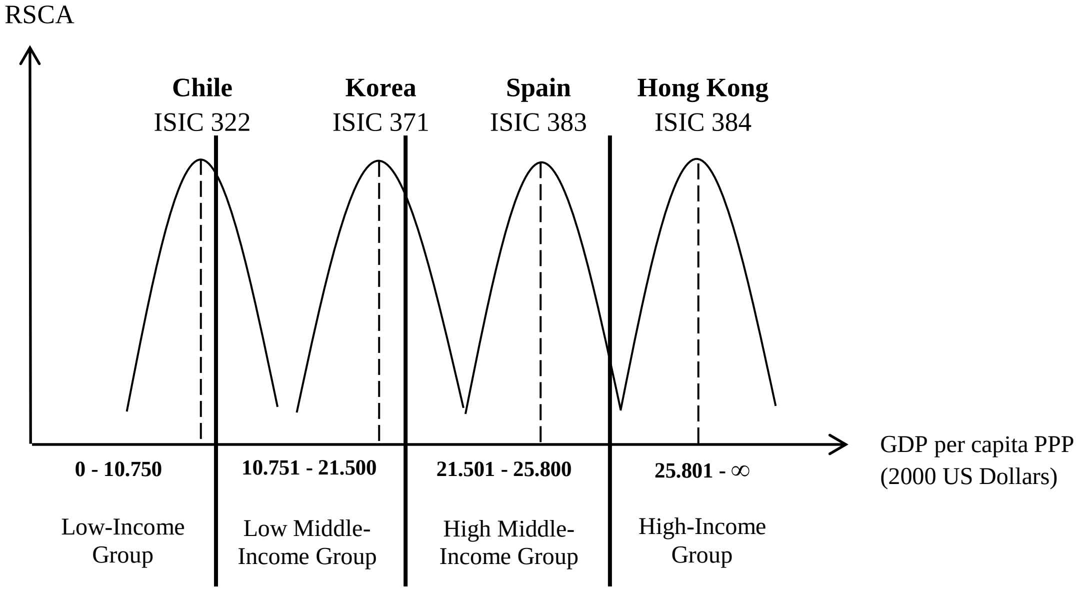


This shows the predicted values from the regressions for these 4 Mid-Tech Sectors: Industrial Chemicals (351), Iron and Steel (371), Machinery (382) and Electrical Machinery (383).

Source: Made by author

Another remark is that we see a clear difference between the Low-Tech sectors having turning points within the range of the Low-Income and Low Middle-Income countries, whereas for the Mid-Tech Sectors this is happening at GDP per capita values characterizing High Middle-Income countries. This is also in line with expectations. In Figure 26 the spread of industry in connection with GDP per capita level, is illustrated in a very stylized manner similar to Okita`s figures (Figure 2 in this thesis). The year 2004 is used as an example, and countries with a GDP per capita value equal to the turning points found in the regressions, are stated as examples. This is done to show what type of countries these GDP values are actually "representing". The industrial hierarchy in 2004 (based on data and regressions from this study) is thus similar to one with Chile, Korea, Spain and Hong Kong as producers. This is as seen in the figure below:

Figure 26: Country-Examples with 2004 GDP per Capita Values



This shows the turning points from the regressions for (from left to right): Wearing Apparel (322), Iron and Steel (371), Electrical Machinery (383) and Transport Equipment (384), according to Income-Groups. Based on GDP per capita values from 2004, Chile, Korea, Spain and Hong Kong, represent the type of country characterized by the GDP per capita turning point in these 4 industries.

Source: Made by author

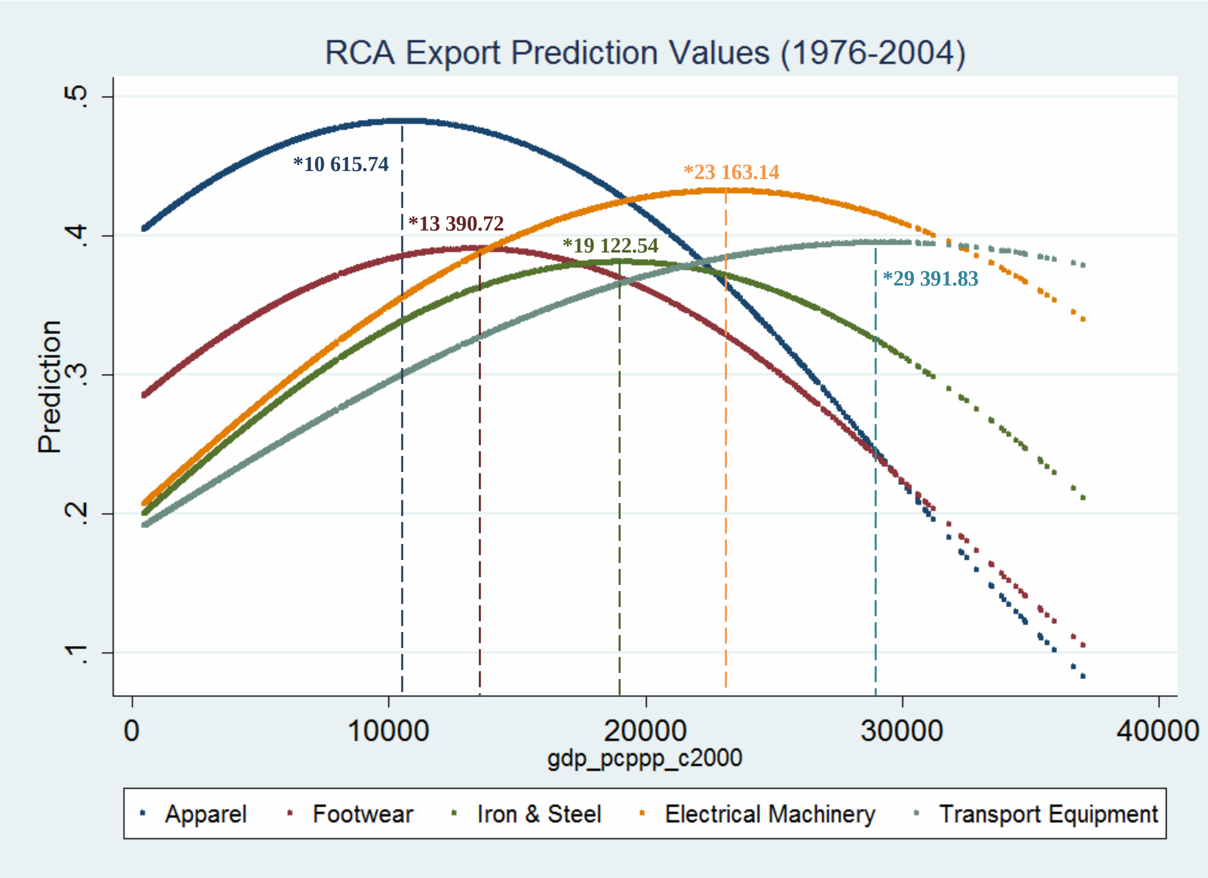
Flying Geese Patterns

Clearly, based on the results presented in this chapter, and seen especially well in the predicted value plots[38], Kojima was correct: There *seems* to be a point for all countries in all industries, at which it pays off to start decreasing the importance of that particular sector. Comparative advantage is thus seemingly as stated by Koijma, very dynamic, so that everybody will start losing their initial advantages. Broad implications from theories of structural change, and especially flying geese theory, can then be said to have been shown.

[38] A colleague at NUPI, Bakhrom Mananov, called these plots *"Splashing Water Graphs"*, which I in light of Akamatsu`s "flying geese curves", find very fitting and in the same spirit. Thank you for the fun suggestion.

Below is a figure plotting predicted values from different sectors, based on export regressions, trying to imitate the classical flying geese pattern (similar to the stylized figure above). We see the Low-Tech sectors Apparel and Footwear reaching their peaks first, before the Mid-Tech sectors gradually does the same, as GDP per capita keeps on increasing. The different turning points have values representing all types of income-groups (see Table 4).

Figure 27: Flying Geese Pattern – Predicted Values



This shows the predicted values forming a flying geese pattern. It is clear that the Low-Tech sectors: Apparel and Footwear, experiences a shift in RCA at earlier levels of GDP per capita than the Mid-Tech sectors: Iron & Steel, Electrical Machinery and Transport Equipment.

Source: Made by author

6.2 Deindustrialization and the Service Industries

The main trend seen from the empirical evidence and the econometrical analysis is the clear cyclicality in *all* type of sectors, irrespective of technology level and degree of sophistication. The flying geese were found as expected in the Low-Tech sectors, but they were found in the more technology intensive sectors *too* - and surprisingly to a *larger* extent. Thus sectors we would have thought to be less "footloose" actually turned out to be *more*. This is an important finding because technology barriers, knowledge specificity and other aspects of production and trade tying sectors to specific locations, seems to work less restrictively than assumed. Also these sectors will in a flying geese sense, or as emphasized by Kojima: Have dynamic comparative advantage as a main feature leading manufacturing to move around. And thus leading countries to move their way up the industrial hierarchy, following Akamatsu`s view of world industrial development. What Akakmatsu is not discussing however, is the rise of services, and what will happened after "all" counties actually reaches "graduation" i.e. catches up with the developed countries. This is to some extent due to Akamatsu`s holistic and verbal approach, but it is also due to the fact that his theory was written in the 1930`s – way before the rise of the service sectors.

The findings of reduced comparative advantage in *all* manufacturing sectors as GDP per capita grows, is as mentioned earlier, in line with the idea of deindustrialization: The phenomenon of decreasing share or relative importance of industry. As industry is a broad term, it is important to point out that the focus in this study has been on changes *between* different manufacturing industries. When this study is finding a decrease in comparative advantages, this study is thus saying more than just the classical statement of *"decreasing secondary sector and increasing tertiary sector"*.

The authors behind the theories of structural change surveyed in this thesis also considered what would happen to industry as the tertiary sector emerged. Even econometric studies were conducted by some of these economists (see e.g. (Chenery 1960, Chenery and Syrquin 1975). It is however in later years that the phenomenon of deindustrialization has been formally established in the literature (Rowthorn and Ramaswamy 1997, Rowthorn and Coutts 2004, Palma 2008, Tregenna 2009). A question is thus whether similar universal patterns of cyclicality are found in the service industries too? Already now are studies showing evidence of much more diversity in development within this sector. There is a large difference between services like haircuts and restaurant meals with no possibility of full cyclicality, and financial services and telecommunications that are fully tradable services. The ladder might experience cyclicality. However, more research is needed.

A recent study by World Bank economist, Ejaz Ghani, presented at a conference in 2011, found large differences in the evolution of service sectors in China, USA and India`s economy. He actually runs the same basic quadratic regressions as is done in this study, but between share of service industries and GDP per capita, in addition to share of manufacturing. Although the regressions are run only with these countries` statistics, he finds an overall inverse U in the same way that is found in this study (although it is in our study found at a more detailed sector level). As for the service sector, no evidence of inverse U was found in 1991 or in 2005. The quadratic coefficient changes to negative in the 2005-regression, but the linear term is insignificant for both years (Ghani 2011).

The main message Ghani presents is the common worldwide rise of the service industry, and the rise of India through the specialization in services at the expense of the manufacturing industry. He argues that this shows that manufacturing is *not* the only way to grow, and that India`s development offers hope to latecomer countries seeking to grow. He proposes a type of *"service led growth"* in the same manner as the "export led growth", famously characterizing the miracle growth in East Asia. He argues that the latecomers do not need to wait for their turn in the manufacturing cycle, but can skip this and move directly into the hierarchy of the service sectors. Whether this is actually possible is up to future development to answer. Based on the results in this study however, it can be concluded that since generally speaking "all" countries follow the similar inverse U-pattern of development, both in agriculture and manufacturing, there is reason to believe that both these phases are in some way essential to development.

Another point, is the fact that the richest countries are the ones to move out of manufacturing, and thus over to more service related sectors. And this study emphasizes that this "move" actually seems very universal. The latecomers skipping manufacturing, thus competes with the most advanced countries of the world when directly entering this sector. Whether this is hopeful or more like doomsday could be discussed. Take India for example, which has had a huge increasing importance in the service sector, without having the same income increase and deindustrialization as rich countries such as the US and Germany. And take China, a country heavily engaged in manufacturing. Undoubtedly China has done better. Now, this is of course not proof that service sector growth is an impossible way to fast development. What can be stated, however, is that universal patterns of development points to a general importance in progress of industry. And that these patterns are in this study found to be much more universal and prevalent than thought. History tells us that almost no country has developed and moved up to “high income status” without a large increase in both manufacturing production and trade.

A remark to the idea of general development patterns in this sense is the case of China and India. These countries are huge in geographic size, population size and economy. And as illustrated by Ghani`s research, these countries` economies do act particularly. These giants are equivalent to many medium and large sized countries, and whether they should be treated as one entity or several smaller ones divided after provincial borders, is unknown. China`s recent development is described as: *“...a huge bird flying side by side with the various layers of flying geese at various levels of industrial production.”*, and: *“In some areas China is competing or can potentially compete with Japan and the NIEs. On the other hand, China is also providing the downstream labor intensive products in competition with the ASEAN4.”(Chan 1993).* This implies that China could potentially capture the entire value chain, thus competing at all levels in the industrial hierarchy. Hong Kong has a GDP per capita (PPP) of over 45 000 US Dollars, Shanghai of above 22 000. This is equivalent to Singapore and Saudi Arabia`s GDP per capita. On the other end of the scale we find Guanxi with GDP per capita (PPP) similar to Swaziland of barely 5000 Dollars, and Gansu with GDP barely reaching 4000 (economist 2011). Similar differences within India are also evident (economist 2011). Studies performing similar analysis as is done in this study, but at a provincial level in the case of both India and China, would thus be of great importance. The problem of adequate statistics to actually perform these studies, however, is a prevailing one.

7 Conclusion

In this study, which looked at 28 manufacturing industries for 86 countries over the years 1976-2004, evidence of very cyclical and universal development patterns were found. Thus the main research question: ”*Is there a universal pattern of structural change, so that at a particular income level, a country has a particular pattern of manufacturing production?”*, can be said to have been answered. More specifically, the hunt for the existence of inverse U-patterns in the spirit of Akamatsu`s flying geese, can be considered a success. Contrary to beliefs, all types of sectors, independent of technology level, knowledge requirements and degree of sophistication, showed evidence of inverse U`s. The relation between (revealed) comparative advantage and GDP per capita, seem to follow very similar patterns in the majority of countries and sectors. This holds for output, import and export data. The confirmation of these types of patterns is thus the main contribution of this study, since a surprisingly low number of rigorous cross-country studies covering a large set of countries have been performed.

These results are implied by Akamatsu and Kojima in flying geese theory, and some other theories of structural change. Since the research was undertaken with a particular focus on flying geese with the aim of increasing the knowledge of it, the results also highlights the need for better knowledge of unknown theories in general. Even though Akamatsu`s theory is more verbal and holistic than for example Puga and Venables “spread of industry model”, and lacks the application of mathematical equations and algebra, important implications and answers can be lost if we ignore such contributions. The world is indeed holistic, and full of general patterns despite of major differences. Forgetting these similarities and only focusing on very specific aspects of the economy or society, could give a too narrow picture. Although general patterns say little about policy or specific causal effects, it does show important universal relations.

An important consequence of the world`s industrial upgrading, is a historic shift in location of production, particularly from developed to developing countries. During the last 30 years developing countries have rapidly increased their share of the global market. Some Asian countries, mainly Japan, South Korea, Hong Kong, Taiwan and Singapore, experienced the fastest industrialization process yet seen, as they rapidly managed to achieve sustained growth and moved credibly towards high-income status. During the last decade we also saw other emerging countries beginning to take off, the latest including enormously populated countries such as China, India and Brazil. But with this rapid catch-up there is an increasing inequality between countries who manage to catch up, and those who simply do not. The diverging patterns among world economies today are vast and growing. Many middle-income countries, especially in Latin-America, still strives for industrial advancement after years of stagnated development, and most of Africa still remains marginalized and trapped in the low-income low-growth category. Identifying similarities can help discover crucial phases in development that are needed in order to advance, and with the evidence indicating universal development patterns, further implications can be made.

The presence of cyclicality also for advanced sectors is related to the phenomenon of deindustrialization. However, in addition to just confirming the classical view of *"decreasing secondary sector and increasing tertiary sector"*, something is said about the changes *between* different manufacturing industries. The inter-industry development is characterized by the very same inverse-U patterns envisioned by Akamatsu as early as in 1932. Another contribution made by the thesis is the discussion and reconsidering of how industrial specialization should be appropriately measured in order to avoid potential bias. The study especially considers relative shares as an inadequate measure, if one is interested in making analysis incorporating relative importance in the world as a whole. The RCA and the further adjusted measure, RSCA, is thus used to perform the econometric analysis.

With regards to future implications, it is already acknowledged that the stylized development pattern for the rise and fall of agriculture seems well described by theories, and proved by empirical studies. With this study`s evidence of the inverse U-patterns, the same seems to be the case in the manufacturing sector. The going debate on structural change (see e.g. (Melitz 2003)) however, is focusing more and more on firm heterogeneity, i.e. change *within* sectors. And the empirical literature has convincingly shown that firms are indeed heterogeneous, and may differ in scale, skills and technology. As this study has focused on the sector approach, to what extent there *also* exists structural change within sectors, is a hypothesis not tested. What the study can say, however, is that sectors still matter: *"What you make matters, and what it is most appropriate for you to make, will change over time as income grows".* Seemingly, there is indeed an industrial hierarchy.

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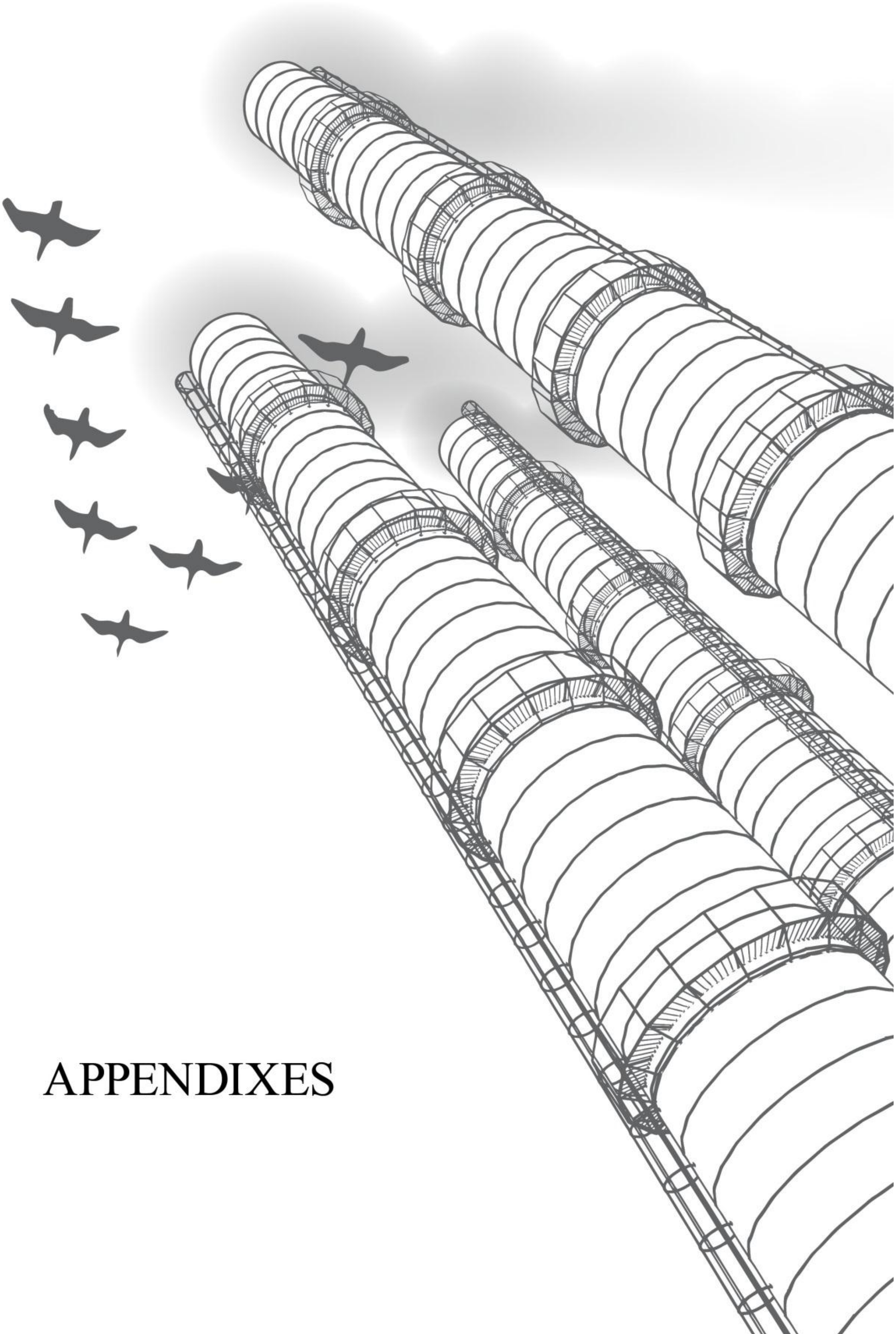


APPENDIXES

Illustration made by my sister, Charlotte Soon Kvebek.

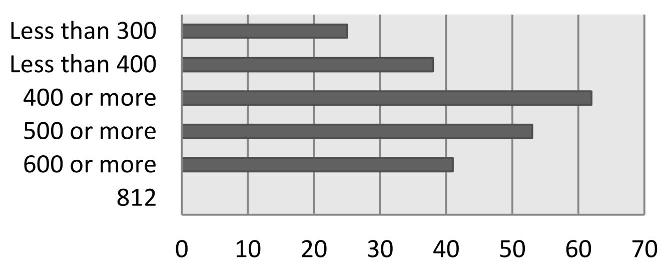
Appendix 1: Data Coverage and Discussion of General Shortcomings

Production Data

The source of this data is the United Nations Industrial Development Organization (UNIDO). The data used are compiled and published early in their International Yearbook of Industrial Statistics, using the 3-digit ISIC Classification, Revision 2[39].

When it comes to data coverage, this part of the dataset is limited both in regards to time and countries. This is due to the fact that some countries, in particular developing countries, report statistics only sporadically. The data reported are also often in a different format than earlier – or than the standard. Although UNIDO makes great efforts to standardize the reporting of data to make it comparable, these issues are still visible in the dataset. Now given a complete coverage of all 28 sectors for all years 1976-2004, each country would have 812 observations. Unfortunately, no countries in this dataset have all observations. Below is a table showing a more detailed picture of the data coverage. As seen only 41 countries have 600 or more observations, while 38 countries have less than 400. This means that around 38 % of countries have less than approximately 50 % of all observations.

A1- Figure 1: Production Data Coverage



	812	600 or more	500 or more	400 or more	Less than 400	Less than 300
Number of Countries	0	41	53	62	38	25

This is an overview over the number of countries and their total amount of observations. As is clear from the figure, no countries have full coverage, and 25 countries have less than 37 % of observations. 62 countries however, have more than approximately 50 % coverage.

Source: Made by author

[39] The trade data is then the data transformed to fit the common classification, whereas the production data is used as it is.

Trade Data

The source of this data is the COMTRADE database kept by the United Nations Statistic Division. The data is originally provided after the SITC Classification, Revision 2, and converted to ISIC Revision 2 Classification, with help of a concordance table. The import and export data is on both country and time coverage, very complete, and the missing observations are mostly among developing countries. In order to fill these missing observations a set of mirrored data are provided. Such data uses partner data instead, and calculates the country`s exports based on all other countries` imports *from* the country, and the country`s imports based on all other countries exports *to* the country. Mirrored data is then an indirect way of calculating export and import values, and increases total coverage, since many developed countries have detailed data on all their bilateral trade relations. It is however important to remember that this is *indirectly* reported data, and some caution should possibly be made. Below is an overview over total observations counted both by total export and import value, *and* total *mirrored* export and import value. All values are given in 1000 US Dollars except number of observations.

A1- Table 1: Trade Data Coverage – Mirrored and Normal Values

	Number of Observations	Median	Mean	Standard Deviation	Min	Max
Total Export Value	56 923	47 055,94	1 371 085	6 341 342	0	193 000 000
Total Mirrored Export Value	74 173	21 350,16	1 075 963	5 611 332	0	193 000 000
Difference in Observations	*14 250*					
Correlation	*0,9796*					
Total Import Value	56 923	121 002,7	1 364 384	5 873 890	0	229 000 000
Total Mirrored Import Value	74 173	70 110,08	1 073 748	5 177 759	0	229 000 000
Difference in Observations	*14 250*					
Correlation	*0,9924*					

This table is showing the differences between the mirrored and the basic trade data. The mirrored data have consistently lower values than the basic data. The difference in total observations and the correlation between basic and mirrored values are also shown.

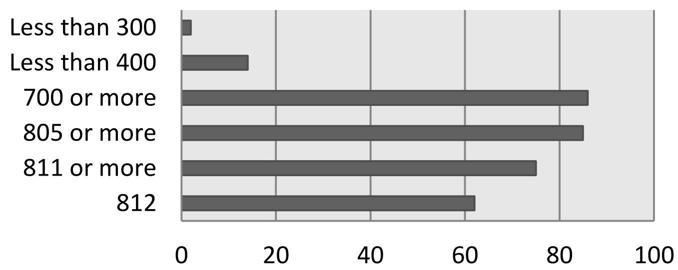
Source: Made by author

Now the mirrored data have 14 250 observations more than the basic trade data. Given a complete coverage of 812 observations per country, and 100 countries, this would yield a total of 81 200 observations. From the table above we can see that if we use the basic data our coverage would be around 70 %[40], whereas with mirrored data the coverage would be around 90 %[41]. From this it is seems natural to use the mirrored data.

But the mirrored data is an indirect measure so we should consider the basic trade data of "primary order", since it is reported directly as exports or imports by the countries themselves. An approach is then to use the mirrored data *only* in the cases where the basic data have missing values. This will thus give coverage similar to using mirrored data only, but we will have approximately 77 %[42] "primary data", while only the remaining is mirrored values. This is the approach used in the thesis (the argumentation for it goes as above).

As seen in the table, the mirrored values are lower in value than their counterparts. The mean value of exports are around 300 000 lower for the mirrored value than the basic value. The same goes for the import data. The correlation between the series are however very good, with values of 0,9796 and 0,9924 – which is extremely close to 1 (perfectly correlated). The time series therefore seems quite similar with regards to development, and the choice of merging these data in replacing the missing values seems to outweigh the loss in consistency coming from using two different series.

A1- Figure 2: Trade Data Coverage – Merged Data



	812	811 or more	805 or more	700 or more	Less than 400	Less than 300
Number of Countries	62	75	85	86	14	2

This is an overview over the number of countries and their total amount of observations. 62 countries have full coverage, and a total of 86 countries have 86 % or more. Only 2 countries have trade data with less than 37 % coverage. As seen in A1 -Figure 1 above, a total of 25 countries had less than 37 % coverage of production data. Trade data clearly has a much better coverage.

Source: Made by author

[40] (56 923 / 81 200) * 100 % ≈ 70,10 %
[41] (74 173 / 81 200) * 100 % ≈ 91,35 %
[42] (56 923 / 74 173) * 100 % ≈ 76,74 %

GDP Data

The GDP data is mainly directly from the World Bank`s World Development Indicators, with some additional data collected by the authors from other World Bank sources. The data is provided in a separate file, but with identical structure both in regards to country code abbreviations, timespan and structure.

The data covers four different variables: Total GDP and PPP adjusted GDP per capita, measured in both current US dollars and 2000 US dollars. The country coverage is broader than in the main dataset for production and trade, and data for 231 countries are available, although with varying degree of completeness in regards to time series. With 29 years and 231 countries, a complete coverage would yield 6699 observations. Such completeness is non-existing but the coverage is still good.

A1 – Table 2: GDP Data Coverage

	Number of Observations	**% of complete coverage (6699 observations)**
GDP Current US Dollars	5333	79,61 %
GDP PPP 2000 US Dollars	4938	80,95 %
GDP per capita Current US Dollars	5423	73,71 %
GDP PPP per capita 2000 US Dollars	4938	73,71 %

This is a table over number of observations available in the GDP dataset.

Source: Made by author

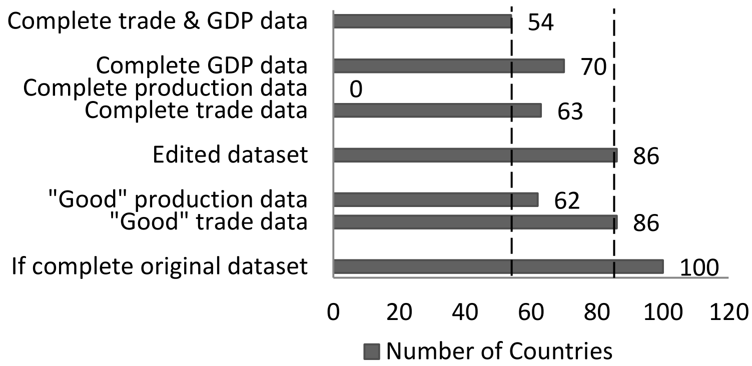
The Specific Data Used in the Thesis

The starting point is the 100 countries in the main dataset. But as discussed, we have 14 countries with less than 400 observations in the trade dataset and 38 countries with less than 400 observations in the production dataset. Less than 400 observations will be less than 49 % of what a complete set of observations would yield. A question is then what to do with the countries having "good" trade data but "bad" production data. If the 38 countries with "bad" production data should be completely removed from the data set, then the countries would reduce to 62. But 24 out of these countries would still have adequate trade statistics. Since especially export data is very important in answering the thesis` research questions, I choose to keep all countries as long as they have "good" trade data[43].

[43] Out of the 14 countries excluded, however, all of them also have bad production data.

The actual data used in the analysis then covers 86 countries with examples from all parts of the world. A complete list over these is found in Appendix 2. All these are also covered by the additional GDP data, but a few countries only have observations for some years. Mostly though, the GDP data is complete and the same categorization of "bad" data applies here (observations less than 400). Below is an overview of the improved coverage attained by excluding the 14 countries discussed. Among these 86 countries, 54 of them have a complete set of observations with regards to trade and GDP. That means that in light of the trade analysis 63%[44] of countries have complete coverage. No country has perfect coverage of production data.

A1 - Figure 3: Overview over the Data Set



An overview of the improvements in the edited dataset. Complete data will yield 812 observations per country, and "good" data means observations of 400 or more. As is seen, 86 countries have "Good" production and trade data, while 54 coutries have complete trade and GDP data.

Source: Made by author

General Shortcomings

In the article by Nicita and Olarreaga published with the dataset, they have a section discussing special considerations. The most important one is the fact that the dataset is an unbalanced panel. As I have discussed in this chapter, there is a large amount of missing values in the original dataset, so that use of for example country or industry averages, *may* not be very meaningful. This is because they might correspond to different time periods or different countries at different times. A choice here is then needed to be made by the user: Should countries with bad data be excluded, should additional supplementary data be found and added, or should one try to interpolate missing data. As is evident from the above discussion, in this study, countries with a lot of missing values ("bad" data) were excluded. This mainly because most of the countries with missing data have shorter but still continuous

[44] 54/86 * 100 ≈ 62,79 %

data, so that interpolating is difficult, and because collecting new data and then transforming it into the same classifications, is a lot of work. The ladder method would also require that data from different sources would be necessary, since Nicita and Olarreaga already exhausted the sources used in the original dataset. All though the panel is unbalanced, this does not necessarily imply less value with regards to the results. Most panels are indeed always unbalanced and there are ways to take this into account when running regressions.

Another issue is the use of mirrored data with regards to the differences in calculation method between imports and exports. In theory export data is recorded as free on board (FOB) while import data is recorded by cost, insurance and freight (CIF). Export and import values are then not exactly the same, and we should expect the ratio between exports and imports (FOB/CIF-ratio) to be larger than one[45]. This is because one should expect some types of costs to be added during transportation, so that a part of the import value reflects such costs instead of the pure import value. The mirrored values will therefore differ since they are calculated with use of numbers constructed by different methods. Problems such as these are especially important to keep in mind when using bilateral trade and protection data. The data used in the thesis is however not as exposed to the same type of high measurement errors.

One should also mention that when it comes to total values and the variables used in the thesis, around one percent of observations have a total value of exports larger than the sum of production plus imports. This could be due to several things, for example discrepancies in production end export year, misallocation of goods with regards to ISIC groupings, and incomplete reporting of data. Measurement errors should therefore be considered as a concern[46], although not a large one, since it only applies to around one percent of observations. A last remark is that some countries could have misleading data due to country characteristics such as country size, natural resources, and the fact that they act as entrepôts or shipping hubs.

[45] A common calculation method used by the IMF for many years, is the use of the factor 1,1 as a mean to construct mirrored import en export values. The value of constructed imports will then be 10 % higher than the value of observed exports, whereas the constructed export value will be 10 % lower than the observed import value. Although this is an approximating method, it is a common way to solve the issue.

[46] Some other caveats are also discussed in the paper, but these are connected to protection and bilateral trade. This can be read in part *V* of the Nicita and Olarreaga paper.

Appendix 2: List of all Countries

A2 – Table 1: Country Overview

County Name	Code
Argentina	ARG
Australia	AUS
Austria	AUT
Benin	BEN
Bangladesh	BGD
Bulgaria	BGR
Bolivia	BOL
Brazil	BRA
Canada	CAN
Switzerland	CHE
Chile	CHL
China	CHN
Cote D'Ivoire	CIV
Cameroon	CMR
Colombia	COL
Costa Rica	CRI
Cyprus	CYP
Germany (76-90 West)	DEU
Denmark	DNK
Algeria	DZA
Ecuador	ECU
Egypt	EGY
Spain	ESP
Finland	FIN
France	FRA
Gabon	GAB
United Kingdom	GBR
Ghana	GHA
Greece	GRC
Guatemala	GTM
Hong Kong	HKG
Honduras	HND
Hungary	HUN
Indonesia	IDN
India	IND
Ireland	IRL
Iran	IRN
Iceland	ISL
Israel	ISR
Italy	ITA
Jordan	JOR
Japan	JPN
Kenya	KEN
Korea	KOR
Kuwait	KWT
Sri Lanka	LKA
Macau	MAC
Morocco	MAR
Mexico	MEX
Malta	MLT
Myanmar	MMR
Mongolia	MNG
Mozambique	MOZ
Mauritius	MUS
Malawi	MWI
Malaysia	MYS
Nigeria	NGA
Netherlands	NLD
Norway	NOR
Nepal	NPL
New Zealand	NZL
Oman	OMN
Pakistan	PAK
Panama	PAN
Peru	PER
Philippines	PHL
Poland	POL
Portugal	PRT
Qatar	QAT
Romania	ROM
Senegal	SEN
Singapore	SGP
El Salvador	SLV
Sweden	SWE
Thailand	THA
Trinidad and Tobago	TTO
Tunisia	TUN
Turkey	TUR
Taiwan	TWN
Tanzania	TZA
Uganda	UGA
Uruguay	URY
United States	USA
Venezuela	VEN
Yemen	YEM
South Africa	ZAF

Source: Made by author

Appendix 3: Additional on the Size and Dynamics of RCA

Size of RCA

Based on equation (1) we can see that there are two major determinants when it comes to the size of RCA, and that it is their relative relation that matters for the size of the index:

(1) $RCA_{ij} = \frac{C_{ij}}{C_j} = \frac{A}{B}$

As both A and B can take on low or high values, the RCA equation depicts four different scenarios. In these we clearly see what the implication would be on the size of RCA. Of course "normal" values, neither particularly small nor large relative shares, are also possible, but these four scenarios give a good overview over the magnitude of RCA with different A or B values. We can see that extreme values of the index, either very large or very small, are due to an asymmetric relation in relative importance between the country of interest and the world. More equal sizes in relative importance on the other hand, produce "normally sized" RCAs. Whether RCA is above or below 1 is not argued for in the table, but will of course depend on the sizes of both A and B.

A3 – Figure 1: "2 by 2" Scenario Table over RCA Outcomes

	High A	**Low A**
High B	SCENARIO 1 – "High A – High B": Relative importance of this good is high for both the specific country's exports, and for the world`s exports. The RCA will therefore be: RCA = High A/High B = "Normal RCA" **EX:** RCA = 0,4/0,2 = 2	SCENARIO 2 – "Low A – High B": Relative importance of this good is low for the specific country's exports, and high for the world`s exports. The RCA will therefore be: RCA = Low A/High B = "Very Tiny RCA" **EX:** RCA = 0,02/0,2 = 0,1
Low B	SCENARIO 3 – "High A – Low B": Relative importance of this good is high for the specific country's exports, and low for the world`s exports. The RCA will therefore be: RCA = High A/Low B = "Very High RCA" **EX:** RCA = 0,4/0,02 = 20	SCENARIO 4 – "Low A – Low B": Relative importance of this good is low for both the specific country's exports, and for the world`s exports. The RCA will therefore be: RCA = Low A/low B = "Normal RCA" **EX:** RCA = 0,02/0,02 = 1

This two-by-two table shows the different scenarios between high and low levels of relative export shares and their implication for the size of RCA.

Source: Made by author

Dynamics of RCA

When it comes to dynamic changes in the RCA index, it is the evolution of A and B that matters. If neither A nor B changes at all, then there is no reason for the RCA to change: RCA at point t_1 would be equal to RCA at point t_2. If A grows more than B, RCA will increase, whereas the opposite holds if B grows more than A. This is because RCA at point t_1 and t_2 will have different values. Using the difference in these RCA indexes one gets from subtraction, will however, as argued by Cai et al., give a *potentially* misleading result. They identify a weakness in the RCA index when it comes to identification of RCA *variation* over time, in cases where the changes are disproportional between t_1 and t_2. When such changes are the case, it is generally not possible to keep the RCA constant in all other markets (that the country is also trading in), so that the variations in a country`s RCAs could *possibly* reflect things other than changes in comparative advantage: They *could* reflect disproportionate changes between markets and market shares[47]. Because of this they propose a new index, RCAV, in their FAO[48] paper: *"Assessment of comparative advantage in aquaculture"*, which could be used when suspecting that the RCA variation could be misleading (Cai, Leung et al. 2009). Their index is based on calculating a benchmark RCA for cases where there is no real change, and then to use this benchmark to measure the variation between periods in situations where there is indeed a structural change. Possible problems with disproportional changes will thus be eliminated.

Algebraically the original RCA-Index can be written as follows:

(2) $RCA_{ij} = \frac{S_{ij}}{S_i}$

, where $S_{ij} = \frac{X_{ij}}{\sum_i Xij}$ denotes country i`s export share in commodity market j, and $S_i = \frac{\sum_j X_{ij}}{\sum_i \sum_j X_{ij}}$ denotes the share of country i`s total exports in the total world export market. It is clear that

[47] From Cai et al. we have the EX: Uruguay had RCA in catfish of values 55,48 in 1990-94 and 35,78 in 1995-99, which indicates a decrease comparative advantage. But Uruguay`s specialization has actually increased from 69 % in 1990-94 to 77% in 1995-99. With a β-value of 0,5615, the RCAV index is positive and has the value 4,65 – properly reflecting the gain in comparative advantage Cai, J., et al. (2009). Assessment of comparative advantage in aquaculture. FAO. Rome. **528**.

[48] Food and Agriculture Organization of the United Nations

(1) is equivalent to (2), and is just another way to write the expression[49]. According to (2) RCA_{ij} compares country i`s share in export market of commodity j, to country i`s share in the total export market, or generally speaking to market k. The interpretation is the same as with equation (1), with 1 as the threshold between advantage and disadvantage.

In order to derive the RCAV index, we need to take time, t, directly into account. Two points in time will therefore be denoted t and (t+1) (generally speaking t+n). From equation (2) above we get:

(3) $$RCA_{ij,t} = \frac{s_{ij,t}}{s_{ik,t}}$$

From (3) we see that if market share ratios remain the same during the period from t to (t+1), then there will be no change in the country`s RCA patterns, i.e.

(4) $$\frac{\tilde{s}_{ij,(t+1)}}{\tilde{s}_{ik,(t+1)}} = \frac{s_{ij,t}}{s_{ik,t}}, \forall j, k$$

, where $\tilde{S}_{ij,(t+1)}$ represents what country i`s export share in commodity market j *would have been* under constant RCA, i.e. under no comparative advantage variation between periods. According to (3) this constant behavior will be the case when market share ratios grow at the same rate, i.e.

(5) $$\forall j, \frac{\tilde{s}_{ij,(t+1)}}{s_{ij,t}} = \alpha$$

, where α is a positive constant indicating the growth rate of both relative shares.

Now given that country i experiences no variation in RCA between time t and (t+1), its export of commodity j will be equal to:

(6) $$\tilde{E}_{ij,(t+1)} = \tilde{S}_{ij,(t+1)} * E_{j,(t+1)}$$

[49] $RCA_{ij,t} = \frac{s_{ij,t}}{s_{ik,t}} = \frac{(X_{ij}/\sum_i Xij)}{(\sum_j X_{ij}/\sum_i \sum_j Xij)} = \frac{\left(\frac{X_{ij}}{\sum_i Xij}\right) * \frac{1}{\sum_j X_{ij}}}{(\sum_j X_{ij}/\sum_i \sum_j Xij) * \frac{1}{\sum_j X_{ij}}} = \frac{\left(\frac{X_{ij}}{\sum_j Xij}\right) * \frac{1}{\sum_i X_{ij}}}{1/\sum_i \sum_j Xij} = \frac{\left(\frac{X_{ij}}{\sum_j Xij}\right) * \frac{1}{\sum_i X_{ij}} * \sum_i Xij}{1/\sum_i \sum_j Xij * \sum_i Xij} = \frac{X_{ij}/\sum_j Xij}{\sum_i Xij/\sum_i \sum_j Xij} = \frac{c_{ij,t}}{c_{ik,t}}$

, where $\tilde{E}_{ij,(t+1)}$ represents total export of commodity j at time (t+1) for country i, equivalent to X_{ij} from (1) above. From (5) we see that (6) can be expressed as:

(7) $$\tilde{E}_{ij,(t+1)} = \alpha * S_{ij,t} * E_{j,(t+1)}$$

Since $X_{ij,t} = E_{ij,t}$, then we can write: $\tilde{C}_{ij,(t+1)} = \frac{\tilde{E}_{ij,(t+1)}}{\sum_{j_k} \tilde{E}_{ij_k,(t+1)}}$, which substituted in (7) gives:

(8) $$\tilde{C}_{ij,(t+1)} = \frac{S_{ij,t} * E_{j,(t+1)}}{\sum_{j_k} S_{ij_k,t} * E_{j_k,(t+1)}}$$

With actual total exports being equal to $X_{i,(t+1)} = E_{i,(t+1)}$, country i`s benchmark for constant RCA in commodity j will be:

$\tilde{E}_{ij,(t+1)} = \tilde{C}_{ij,(t+1)} * E_{i,(t+1)}$, which substituted in equation (8) gives:

(9) $$\tilde{E}_{ij,(t+1)} = \frac{S_{ij,t} * E_{j,(t+1)} * E_{i,(t+1)}}{\sum_{j_k} S_{ij_k,t} * E_{j_k,(t+1)}} = \frac{(1+g_j)\, C_{ij,t} * E_{i,(t+1)}}{\sum_{j_k} C_{ij_k,t} * (1+g_{j_k})}$$

Since $\tilde{E}_{ij,(t+1)}$ represent country i`s export of commodity j under constant RCA, the deviation of its actual export of commodity j from this constant benchmark, will reflect the country`s variation in RCA between period t and (t+1). The RCAV index is therefore defined as:

(10) $$RCAV_{ij} = \frac{E_{ij,(t+1)} / E_{i,(t+1)}}{E_{j,(t+1)} / E_{(t+1)}} - \frac{\tilde{E}_{ij,(t+1)} / E_{i,(t+1)}}{E_{j,(t+1)} / E_{(t+1)}} = RCA_{ij,(t+1)} - \beta * RCA_{ij,t}$$

, where $\beta = \frac{1+g}{1+\sum_j C_{ij,t} * g_j}$

, g_j is equal to $(E_{j,(t+1)} - E_{j,t})/E_{j,t}$, representing the growth rate of world exports of commodity j between time t and (t+1)

, and g is equal to $(E_{i,(t+1)} - E_t)/E_t$, representing the growth rate of total world exports of all commodities.

The interpretation of the RCAV index is then:

- $RCAV_{ij} > 0$: Country i has *increased* its RCA in commodity j
- $RCAV_{ij} < 0$: Country i has *decreased* its RCA in commodity j

, and the greater the value of the index, the stronger the gain or loss in RCA.

Since $\sum_j C_{j,t} * g_j = g$, with $C_{j,t} = E_{j,t}/E_t$, β would be unity only when C_{ij} is identical to C_j for all commodity markets j, which according to equation (1) gives $RCA_{ij,t} = 1$ for all commodities. Countries with similar export patterns as the world average will then have β-values close to unity, while countries with specializations very different than the world average, can have β-values substantially different than unity.

From (10) we have that: $RCAV_{ij} = RCA_{ij,(t+1)} - \beta * RCA_{ij,t}$, where β is as above. We recognize that (4) implies that $\widetilde{RCA}_{ij,(t+1)} = \frac{\tilde{S}_{ij,(t+1)}}{S_{ik,(t+1)}}$, which according to (5) is equivalent to $\widetilde{RCA}_{ij,(t+1)} = \beta * RCA_{ij,t}$. We thus have that:

(11) $RCAV_{ij} = RCA_{ij,(t+1)} - \beta * RCA_{ij,t}$

$$= RCA_{ij,(t+1)} - \widetilde{RCA}_{ij,(t+1)} = RCA_{ij,(t+1)} - \frac{\tilde{S}_{ij,(t+1)}}{S_{ik,(t+1)}}.$$

From (3) we have that $RCA_{ij,(t+1)} = \frac{S_{ij,(t+1)}}{S_{ik,(t+1)}}$, which inserted in (11) gives:

(12) $RCAV_{ij} = \frac{S_{ij,(t+1)}}{S_{ik,(t+1)}} - \frac{\tilde{S}_{ij,(t+1)}}{S_{ik,(t+1)}} = \frac{S_{ij,(t+1)} - \tilde{S}_{ij,(t+1)}}{S_{ik,(t+1)}}$. From this we see that the RCAV index actually measures country i`s structural variation in market j ($S_{ij,(t+1)} - \tilde{S}_{ij,(t+1)}$), *normalized* by the country`s world market share. This normalization is done after the same reasoning as with the RSCA-Index: To better facilitate cross-country comparisons. This index does however reflect *change* in RCA, not RCA at a given moment in time such as the original RCA and the RSCA index. A direct substitution of the RCA and RSCA index is thus not straight forward.

Appendix 4: Overview over All Sectors

A4 – Table 1: Overview - ISIC Sectors and Technology Classifications

ISIC	ISIC Name	Good Classification
311	Food products	Resource-Based
313	Beverages	Resource-Based
314	Tobacco	Resource-Based
321	Textiles	Low-Tech
322	Wearing apparel except footwear	Low-Tech
323	Leather products	Low-Tech
324	Footwear except rubber or plastic	Low-Tech
331	Wood products except furniture	Resource-Based
332	Furniture except metal	Low-Tech
341	Paper and products	Resource-Based
342	Printing and publishing	Mid-Tech
351	Industrial chemicals	Mid-Tech
352	Other chemicals	Mid-Tech
353	Petroleum refineries	Resource-Based
354	Miscellaneous petroleum and coal products	Resource-Based
355	Rubber products	Resource-Based
356	Plastic products	Mid-Tech
361	Pottery china earthenware	Low-Tech
362	Glass and products	Resource-Based
369	Other non-metallic mineral products	Resource-Based
371	Iron and steel	Mid-Tech
372	Non-ferrous metals	Mid-Tech
381	Fabricated metal products	Low-Tech
382	Machinery except electrical	Mid-Tech
383	Machinery electrical	Mid-Tech
384	Transport equipment	Mid-Tech
385	Professional and scientific equipment	High-Tech
390	Other manufactured products	Low-Tech

Source: Made by author

Appendix 5: Complete Description and Results from the Pre-Testing System

The complete description of the pre-testing and the specific hypotheses tested in each step are provided here. Complete summary tables over the results for each of the dependent variables applied in the thesis are also available. The tests showed, as an example, are the ones performed with **RCA_ExportN** as dependent variable for ISIC 323.

Step 1: Testing for the Need to add Time-Fixed Effects

. *H0: no time-fixed effects necessary*
. *H1: time-fixed effects needed*
. *(Prob > F) > 0,05 --> Failed to reject H0 --> no time-fixed effects needed!*
. *(Prob > F) < 0,05 --> Rejects H0 --> need to add time-fixed effects!*

. *Regular Standars Errors - FE*
. qui xtreg RCA_ExportN gdp_pcppp_c2000 Sqr_gdp_pcppp_c2000 year_dum* if isic==323, fe
. testparm year_dum*

. *Regular Standars Errors - RE*
. qui xtreg RCA_ExportN gdp_pcppp_c2000 Sqr_gdp_pcppp_c2000 year_dum* if isic==323, re
. testparm year_dum*

. *Driscoll-Kraay Standard Errors - FE*
. qui xtscc RCA_ExportN gdp_pcppp_c2000 Sqr_gdp_pcppp_c2000 year_dum* if isic==323, fe lag(6)
. testparm year_dum*

. ***Driscoll-Kraay Standard Errors - POOLED***
. qui xtscc RCA_ExportN gdp_pcppp_c2000 Sqr_gdp_pcppp_c2000 year_dum* if isic==323, lag(6)
. testparm year_dum*

Step 2: Testing for Existence of Heteroskedasticity

. *H0: homoskedasticity*
. *H1: heteroskedasticity*
. *(Prob > chi2) > 0,05 --> Failed to reject H0 --> homoskedasticity present!*
. *(Prob > chi2) < 0,05 --> Rejects H0 --> heteroskedasticity present!*

. *With year-dummies*
. qui xtreg RCA_ExportN gdp_pcppp_c2000 Sqr_gdp_pcppp_c2000 year_dum* if isic==323, fe

. xttest3

. *No year-dummies*
. qui xtreg RCA_ExportN gdp_pcppp_c2000 Sqr_gdp_pcppp_c2000 if isic==323, fe

. xttest3

PANEL LEVEL HETEROSKEDASTICITY TEST
H0: homoskedasticity
H1: heteroskedasticity
(Prob > chi2) > 0,05 --> Failed to reject H0 --> homoskedasticity present!
(Prob > chi2) < 0,05 --> Rejects H0 --> heteroskedasticity present!

With year-dummies
xtgls RCA_ExportN gdp_pcppp_c2000 Sqr_gdp_pcppp_c2000 year_dum* if isic==382, igls panels(heteroskedastic)
estimates store hetero1
xtgls RCA_ExportN gdp_pcppp_c2000 Sqr_gdp_pcppp_c2000 year_dum* if isic==382, igls
local df=e(N_g)-1
lrtest hetero1 . , df(`df')

No year-dummeis
xtgls RCA_ExportN gdp_pcppp_c2000 Sqr_gdp_pcppp_c2000 if isic==382, igls panels(heteroskedastic)
estimates store hetero2
xtgls RCA_ExportN gdp_pcppp_c2000 Sqr_gdp_pcppp_c2000 if isic==382, igls
local df=e(N_g)-1
lrtest hetero2 . , df(`df')0

Step 3: Testing for Serial-Correlation

. *H0: no serial correlation*
. *H1: serial correlation exists*
. *(Prob > F) > 0,05 --> Failed to reject H0 --> no serial correlation!*
. *(Prob > F) < 0,05 --> Rejects H0 --> serial correlation exists!*

. *With year-dummies*
. xtserial RCA_ExportN gdp_pcppp_c2000 Sqr_gdp_pcppp_c2000 year_dum* if isic==323

. *No year-dummies*
. xtserial RCA_ExportN gdp_pcppp_c2000 Sqr_gdp_pcppp_c2000 if isic==323

Step 4: Testing for Cross-Sectional Dependence

. *Pesaran Test*
. *H0: no cross-sectional dependence*
. *H1: cross-sectional dependence exists!*
. *(Pr) > 0,05 --> Failed to reject H0 --> no cross-sectional dependence!*
. *(Pr) < 0,05 --> Rejects H0 --> cross-sectional dependence exists!*

. *For fixed-effects*
. qui xtreg RCA_ExportN gdp_pcppp_c2000 Sqr_gdp_pcppp_c2000 if isic==323, fe

. xtcsd, pesaran abs

. *For random-effects*
. qui xtreg RCA_ExportN gdp_pcppp_c2000 Sqr_gdp_pcppp_c2000 if isic==323, re

. xtcsd, pesaran abs

. *For fixed-effects with year-dummies*
. qui xtreg RCA_ExportN gdp_pcppp_c2000 Sqr_gdp_pcppp_c2000 year_dum* if isic==323, fe

. xtcsd, pesaran abs

. *For random-effects with year-dummies*
. qui xtreg RCA_ExportN gdp_pcppp_c2000 Sqr_gdp_pcppp_c2000 year_dum* if isic==323, re

. xtcsd, pesaran abs

. *Frees Test*
. *H0: no cross-sectional dependence*
. *H1: cross-sectional dependence exists!*
. *Frees statistic > critical value --> Rejects H0 --> cross-sectional dependence exists!*
. *Frees statistic < critical value --> Failed to reject H0 --> NO cross-sectional dependence!*

. *For fixed-effects*
. qui xtreg RCA_ExportN gdp_pcppp_c2000 Sqr_gdp_pcppp_c2000 if isic==323, fe

. xtcsd, frees abs

. *For random-effects*
. qui xtreg RCA_ExportN gdp_pcppp_c2000 Sqr_gdp_pcppp_c2000 if isic==323, re

. xtcsd, frees abs

. *For fixed-effects year-dummies *
. qui xtreg RCA_ExportN gdp_pcppp_c2000 Sqr_gdp_pcppp_c2000 year_dum* if isic==323, fe

. xtcsd, frees abs

. *For random-effects year-dummies *
. qui xtreg RCA_ExportN gdp_pcppp_c2000 Sqr_gdp_pcppp_c2000 year_dum* if isic==323, re

. xtcsd, frees abs

Step 5: Testing for Use of Fixed-Effects

. *1. Regular Hausman Test (xtreg)*
. *H0: random effects*
. *H1: fixed effects*
. *(Prob > chi2) > 0,05 --> Failed to reject H0 --> random effects!*
. *(Prob > chi2) < 0,05 --> Rejects H0 --> fixed effects!*
. *THIS TEST IS NOT VALID IF THERE IS CROSS-SECTIONAL DEPENDENCE*
. qui xtreg RCA_ExportN gdp_pcppp_c2000 Sqr_gdp_pcppp_c2000 if isic==323, fe

. estimates store fixed

. qui xtreg RCA_ExportN gdp_pcppp_c2000 Sqr_gdp_pcppp_c2000 if isic==323, re

. estimates store random

. hausman fixed random

. hausman fixed random, sigmamore

. *2. Wooldridge Robust Hausman Test*
. *H0: random effects*
. *H1: fixed effects*
. *(Prob > F) > 0,05 --> Failed to reject H0 --> random effects!*
. *(Prob > F) < 0,05 --> Rejects H0 --> fixed effects!*
.*BETTER, BUT STILL NOT VALID IF THERE IS CROSS-SECTIONAL DEPENDENCE*
. qui xtreg RCA_ExportN gdp_pcppp_c2000 Sqr_gdp_pcppp_c2000 if isic==323, re

. scalar lambda_hat = 1 - sqrt(e(sigma_e)^2/(e(g_avg)*e(sigma_u)^2+e(sigma_e)^2))

. gen in_sample = e(sample)

. sort ccode_isic_id year

. qui foreach var of varlist RCA_ExportN gdp_pcppp_c2000 Sqr_gdp_pcppp_c2000 {

. reg RCA_ExportN_re gdp_pcppp_c2000_re Sqr_gdp_pcppp_c2000_re gdp_pcppp_c2000_fe Sqr_gdp_pcppp_c2000_fe if in_sample, cluster(ccode_i
> sic_id)

. test gdp_pcppp_c2000_fe Sqr_gdp_pcppp_c2000_fe

. *3. Driscoll-Kraay Hausman Test*
. *VALID IF THERE IS CROSS-SECTIONAL DEPENDENCE*
. *H0: random effects/pooled OLS consistent*
. *H1: fixed effects*
. *(Prob > F) > 0,05 --> Failed to reject H0 --> pooled OLS is consistent!*
. *(Prob > F) < 0,05 --> Rejects H0 --> fixed effects!*
. xtscc RCA_ExportN_re gdp_pcppp_c2000_re Sqr_gdp_pcppp_c2000_re gdp_pcppp_c2000_fe Sqr_gdp_pcppp_c2000_fe if in_sample, lag(6)

. test gdp_pcppp_c2000_fe Sqr_gdp_pcppp_c2000_fe

A5 – Table 1: Summary **RCA_Export** - Pre-Tests and Implied Regressions

ISIC	Method	Year-Fixed Effects	Robust Standard Errors	Auto-correlation	Cross-sectional dependence	Fixed Effects	Random Effects	Pooled/ WLS
311	xtscc	x	x	x	x			x
313	xtscc	x	x	x	x			x
314	xtscc	x	x	x	x			x
321	xtscc	x	x	x	x			x
322	xtscc	x	x	x	x			x
323	xtscc	x	x	x	x			x
324	xtscc	x	x	x	x			x
331	xtscc	x	x	x	x			x
332	xtscc	x	x	x	x			x
341	xtscc	x	x	x	x			x
342	xtscc	x	x	x	x			x
351	xtscc	x	x	x	x			x
352	xtscc	x	x	x	x			x
353	xtscc	x	x	x	x			x
354	xtscc	x	x		x			x
355	xtscc	x	x	x	x			x
356	xtscc	x	x	x	x			x
361	xtscc	x	x	x	x			x
362	xtscc	x	x	x	x			x
369	xtscc	x	x	x	x			x
371	xtscc	x	x	x	x			x
372	xtscc	x	x	x	x			x
381	xtscc	x	x		x			x
382	xtscc	x	x	x	x	x		
383	xtscc	x	x	x	x			x
384	xtscc	x	x	x	x			x
385	xtscc	x	x	x	x	x		
390	xtscc	x	x	x	x			x

Source: Made by author

A5– Table 2: Summary **RCA_ExportN** - Pre-Tests and Implied Regressions

ISIC	Method	Year-Fixed Effects	Robust Standard Errors	Auto-correlation	Cross-sectional dependence	Fixed Effects	Random Effects	Pooled/ WLS
311	xtscc	x	x	x				x
313	xtscc	x	x	x	x	x		
314	xtscc	x	x	x	x	x		
321	xtscc	x	x	x	x			x
322	xtscc	x	x	x	x			x
323	xtscc	x	x	x	x			x
324	xtscc	x	x	x	x			x
331	xtscc	x	x	x	x			x
332	xtscc	x	x	x	x			x
341	xtscc	x	x	x	x			x
342	xtscc	x	x	x	x			x
351	xtscc	x	x	x	x			x
352	xtscc	x	x	x	x			x
353	xtscc	x	x	x	x			x
354	xtscc	x	x	x	x			x
355	xtscc	x	x	x	x			x
356	xtscc	x	x	x	x			x
361	xtscc	x	x	x	x			x
362	xtscc	x	x	x	x			x
369	xtscc	x	x	x	x			x
371	xtscc	x	x	x	x			x
372	xtscc	x	x	x	x			x
381	xtscc	x	x	x	x			x
382	xtscc	x	x	x	x	x		
383	xtscc	x	x	x	x			x
384	xtscc	x	x	x	x			x
385	xtscc	x	x	x	x	x		
390	xtscc	x	x	x	x			x

Source: Made by author

A5 – Table 3: Summary **RCA_OutputN -** Pre-Tests and Implied Regressions

ISIC	Method	Year-Fixed Effects	Robust Standard Errors	Auto-correlation	Cross-sectional dependence	Fixed Effects	Random Effects	Pooled/ WLS
311	xtscc	x	x	x	x			x
313	xtscc	x	x	x	x	x		
314	xtscc	x	x	x	x	x		
321	xtscc	x	x	x	x			x
322	xtscc	x	x	x	x	x		
323	xtscc	x	x	x	x	x		
324	xtscc	x	x	x	x	x		
331	xtscc	x	x	x	x	x		
332	xtscc	x	x	x	x	x		
341	xtscc	x	x	x	x	x		
342	xtscc	x	x	x	x			x
351	xtscc	x	x	x	x	x		
352	xtscc	x	x	x	x			x
353	xtscc	x	x	x	x			x
354	xtscc	x	x	x	x			x
355	xtscc	x	x	x	x	x		
356	xtscc	x	x	x	x	x		
361	xtscc	x	x	x	x			x
362	xtscc	x	x	x	x			x
369	xtscc	x	x	x	x	x		
371	xtscc	x	x	x	x	x		
372	xtscc	x	x	x	x			x
381	xtscc	x	x	x	x	x		
382	xtscc	x	x	x	x			x
383	xtscc	x	x	x	x	x		
384	xtscc	x	x	x	x	x		
385	xtscc	x	x	x	x			x
390	xtscc	x	x	x	x	x		

Source: Made by author

A5 – Table 4: Summary **RCA_ImportN -** Pre-Tests and Implied Regressions

ISIC	Method	Year-Fixed Effects	Robust Standard Errors	Auto-correlation	Cross-sectional dependence	Fixed Effects	Random Effects	Pooled/ WLS
311	xtscc	x	x	x	x			x
313	xtscc	x	x	x	x			x
314	xtscc	x	x	x	x			x
321	xtscc	x	x	x	x			x
322	xtscc	x	x	x	x			x
323	xtscc	x	x	x	x			x
324	xtscc	x	x	x	x			x
331	xtscc	x	x	x	x			x
332	xtscc	x	x	x	x			x
341	xtscc	x	x	x	x			x
342	xtscc	x	x	x	x	x		
351	xtscc	x	x	x	x			x
352	xtscc	x	x	x	x	x		
353	xtscc	x	x	x	x			x
354	xtscc	x	x	x	x			x
355	xtscc	x	x	x	x			x
356	xtscc	x	x	x	x			x
361	xtscc	x	x	x	x			x
362	xtscc	x	x	x	x			x
369	xtscc	x	x	x	x			x
371	xtscc	x	x	x	x			x
372	xtscc	x	x	x	x			x
381	xtscc	x	x	x	x			x
382	xtscc	x	x	x	x			x
383	xtscc	x	x	x	x			x
384	xtscc	x	x	x	x			x
385	xtscc	x	x	x	x	x		
390	xtscc	x	x	x	x			x

Source: Made by author

Appendix 6: Complete Regression Results

The complete summary tables over the different regressions run are presented here as additional material to the tables presented within the text.

A6 – Table 1: Summary - **RCA_Export** and **RCA_ExportN**

RCA_Export (Regular = R)							RCA_ExportN (Normalized = N)							
ISIC	∩	∪	gdp^2	U-Test	Max/Min	R^2	ISIC	∩	∪	gdp^2	U-Test	Max/Min	R^2	**Best fit?**
311		x	***	***	Min 24 139.27	0.1005	311		x	***	**	Min 23 522.28	0.1306	**N**
313	x		***	***	Max 15 665.58	0.0575	313		x					**R**
314	x		**	**	Max 13 371.83	0.0191	314	x		***	***	Max 15 303.42	0.1037	**N**
321		x	***	***	Min 20 317.28	0.1139	321		x	***	*	Min 29 584.96	0.0477	**R**
322	x			*	Max 7 182.334	0.0454	322	x		***	***	Max 10 615.74	0.0702	**N**
323		x					323	x		***	***	Max 9 979.51	0.0312	**N**
324	x		***	***	Max 13 142.46	0.0449	324	x		***	***	Max 13 390.72	0.0507	**N**
331		x	***	**	Min 22 375.84	0.0399	331		x	***	***	Min 17 637.46	0.0197	**R**
332	x		***	***	Max 18 575.92	0.0416	332	x		***	***	Max 20 106.71	0.1185	**N**
341	x		***	***	Max 25 854.23	0.1013	341	x		***	***	Max 24 907.58	0.1938	**N**
342	x		**	*	Max 21 854.11	0.0283	342	x		***	**	Max 28 301.28	0.1986	**N**
351	x						351	x		***	***	Max 22 645.93	0.1199	**N**
352		x	**	**	Min 6 853.589	0.0851	352							**R**
353							353	x		***	***	Max 8 287.888	0.0361	**N**
354		x					354							-
355	x		***	***	Max 14 865.01	0.0535	355	x		***	***	Max 17 183.86	0.1561	**N**
356	x		**	**	Max 19 806.07	0.0435	356	x		***	***	Max 22 049.42	0.1563	**N**
361	x		***	***	Max 11 352.04	0.0442	361	x		***	***	Max 15 088.3	0.0949	**N**
362	x		***	***	Max 15 949.49	0.0515	362	x		***	***	Max 18 574.25	0.1508	**N**
369	x		**	**	Max 10 142.24	0.0200	369	x		***	***	Max 14 983.06	0.0773	**N**
371	x		***	***	Max 15 281.76	0.0442	371	x		***	***	Max 19 122.54	0.1800	**N**
372		x	***	***	Min 17 683.26	0.0249	372		x					**R**
381	x		***		Max 30 768.84	0.1273	381	x		***	***	Max 27 338.87	0.2358	**N**
382	x		***	***	Max 22 721.1	0.1642	382	x		***	***	Max 22 151.55	0.1780	**N**
383	x		***	***	Max 19 266.84	0.1073	383	x		***	***	Max 23 163.14	0.2599	**N**
384	x		***	***	Max 29 000.47	0.1743	384	x		***	**	Max 29 391.83	0.2650	**N**
385		x	***	***	Min 21 726.92	0.0379	385		x	***	***	Min 17 804.09	0.0401	**N**
390							390							-

NOT SIGNIFICANT *Significant at a 10 % level**Significant at a 5 % level***Significant at a 1 % level

In the far right column is an overview over which of the two regressions represents the best fit according to highest R^2.

Source: Made by author

A6 – Table 2: Summary - **RCA_OutputN**, **RCA_ImportN** and **RCA_ExportN**

RCA_OutputN						**RCA_ImportN**						**RCA_ExportN**					
ISIC	∩	U	gdp^2	U-Test	Max/Min	ISIC	∩	U	gdp^2	U-Test	Max/Min	ISIC	∩	U	gdp^2	U-Test	Max/Min
311	x		**	**	Max 13 332.03	311		x	***		Min 33 014.36	311		x	***	**	Min 23 522.28
313		x		*	Min 24 253.22	313						313		x			
314		**x**	*****	*****	**Min 19 385.45**	**314**	**x**		*****	*****	**Max 18 139.6**	**314**	**x**		*****	*****	**Max 15 303.42**
321		x				321	x		***	***	Max 9 347.678	321		x	***	*	Min 29 584.96
322		x				322	x					322	x		***	***	Max 10 615.74
323		**x**	*****	*****	**Min 25 647.15**	**323**	**x**		*****	*****	**Max 18 370.54**	**323**	**x**		*****	*****	**Max 9 979.51**
324		x				324	x					324	x		***	***	Max 13 390.72
331		x				331	x		***		Max 33 357.07	331		x	***	***	Min 17 637.46
332	x		***	***	Max 17 824.54	332						332	x		***	***	Max 20 106.71
341	x					341	x		***	***	Max 14 882.15	341	x		***	***	Max 24 907.58
342	**x**		*****	****	**Max 25 530.22**	**342**	**x**		*****	*****	**Max 14 915.67**	**342**	**x**		*****	****	**Max 28 301.28**
351	x		***	***	Max 17 405.98	351						351	x		***	***	Max 22 645.93
352	x					352		x	***	***	Min 26 088.64	352					
353	**x**		*****	*****	**Max 16 183.68**	**353**		**x**	*****	*****	**Min 19 725.47**	**353**	**x**		*****	*****	**Max 8 287.888**
354	x		***	***	Max 17 025.9	354	x		***	***	Max 16 130.01	354					
355		x	***	***	Min 23 422.56	355		x	**		Min 22 046.05	355	x		***	***	Max 17 183.86
356						356	x		***	**	Max 25 416.24	356	x		***	***	Max 22 049.42
361	**x**		*****	****	**Max 15 695.9**	**361**	**x**		*****	***	**Max 30 149.66**	**361**	**x**		*****	*****	**Max 15 088.3**
362	**x**		*****	*****	**Max 17 094.17**	**362**	**x**		*****	*****	**Max 17 615.1**	**362**	**x**		*****	*****	**Max 18 574.25**
369		x	***		Min 25 104.38	369		x				369	x		***	***	Max 14 983.06
371	x					371	x					371	x		***	***	Max 19 122.54
372	x		**	*	Max 24 460.1	372	x		***	***	Max 28 375.68	372		x			
381	x		***	***	Max 16 674.93	381		x				381	x		***	***	Max 27 338.87
382	**x**		*****	*****	**Max 23 072.39**	**382**	**x**		*****	****	**Max 17 211.29**	**382**	**x**		*****	*****	**Max 22 151.55**
383	x					383	x		***	***	Max 18 603.12	383	x		***	***	Max 23 163.14
384	x		***	***	Max 16 343.3	384		x				384	x		***	**	Max 29 391.83
385	x		**		Max 32 345.5	385		x		*	Min 10 490.18	385		x	***	***	Min 17 804.09
390	x					390	x		***		Max 35 516.16	390					

NOT SIGNIFICANT *Significant at a 10 % level**Significant at a 5 % level***Significant at a 1 % level

*The framed and bolded rows are the ISIC`s where a significant U or inverse U-relation is found for all three variables.

gdp^2 here refers to whether both criteria for an inverse U or a U relation is satisfied, i.e. whether both the gdp_pcppp_c2000 and the Sqr_gdp_pcppp_c2000 coefficients are significant. **U-Test** refers to whether Mehlum and Lind`s test turns out significant in addition.

Source: Made by author

A6 – Table 3: Summary Coefficients - **RCA_OutputN**, **RCA_ImportN** and **RCA_ExportN**

RCA_OutputN				**RCA_ImportN**				**RCA_ExportN**			
ISIC	gdp_pcppp_c2000	Sqr_gdp_pcppp _c2000	U-Test	ISIC	gdp_pcppp_c2000	Sqr_gdp_pcppp _c2000	U-Test	ISIC	gdp_pcppp_c2000	Sqr_gdp_pcppp _c2000	U-Test
311	0.0000135**	-5.05e-10**	**	311	-0.0000187***	2.83e-10***		311	-0.0000464***	9.89e-10***	**
313	-0.000216	4.46e-10*	*	313	5.38e-06	2.60e-10		313	-0.0001829**	3.30e-09	
314	-0.0000594***	1.53e-09***	***	314	0.0000431***	-1.19e-09***	***	314	0.0000454***	-1.48e-09***	***
321	-0.0000128*	2.46e-10		321	0.0000107***	-5.75e-10***	***	321	-0.000153	-8.21e-11	*
322	-0.000031	2.42e-10		322	0.0000339***	-1.64e-10		322	0.0000406***	-1.91e-09***	***
323	-0.0000118***	9.38e-10***	***	323	0.0000725***	-1.97e-09***	***	323	-0.0001514**	4.54e-09*	***
324	-9.41e-06	1.04e-10		324	0.0000278***	-7.27e-13		324	0.0000466***	-1.74e09***	***
331	-0.0000121	9.07e-11		331	0.0000423***	-6.33e-10***		331	-0.0000293***	8.30e-10***	***
332	0.0000425***	-1.19e-09***	***	332	0.0000338***	1.38e-12		332	0.0000458***	1.14e-09***	***
341	5.30e-06	-4.08e-10*		341	0.0000158***	-5.31e-10***	***	341	0.0000464***	-9.32e-10***	***
342	0.0000441***	-8.63e-10***	**	342	0.0000145***	-4.85e-10***	***	342	0.0000406***	-7.18e-10***	**
351	0.0000284***	-8.14e-10***	***	351	-4.42e-06	-2.29e-11		351	0.0000356***	-7.86e-10***	***
352	3.84e-07	-8.05e-11		352	-0.0000488***	9.35e-10***	***	352	0.000013**	1.36e-10	
353	0.0000227***	-7.00e-10***	***	353	-0.0000189***	4.79e-10***	***	353	0.0000128***	-7.71e-10***	***
354	0.0000294***	-8.63e-10***	***	354	0.000048***	-1.49e-09***	***	354	0.0000216***	6.18e-11	
355	-0.0000648***	1.38e-09***	***	355	-9.81e-09***	2.22e-10**		355	0.0000589***	-1.71e-09***	***
356	-1.23e-06	-3.85e-10***		356	0.0000263***	-5.18e-10***	**	356	0.0000399***	-9.05e-10***	***
361	0.0000401***	-1.28e-09***	**	361	0.0000275***	-4.56e-10***	*	361	0.0000544***	-1.80e-09***	***
362	0.0000444***	-1.30e-09***	***	362	0.0000156***	-4.43e-10***	***	362	0.0000588***	-1.50e-09***	***
369	-0.0000177***	3.53e-10***		369	-9.93e-06	1.72e-10		369	0.0000428***	-1.43e-09***	***
371	5.15e-06	-3.39e-10		371	-0.0000102***	4.78e-11		371	0.0000591***	-1.55e-09***	***
372	0.0000312***	-6.37e-10**	*	372	0.0000265***	-4.66e-10***	***	372	-1.67e-06	2.20e-10**	
381	0.0000243***	-7.28e-10***	***	381	-3.37e-06	1.65e-10**		381	0.0000385***	-7.04e-10***	***
382	0.0000508***	-1.10e-09***	***	382	8.73e-06***	-2.54e-10***	**	382	0.000062***	-1.40e-09***	***
383	0.0000151	-6.26e-10***		383	0.0000264***	-7.10e-10***	***	383	0.0000581***	-1.25e-09***	***
384	0.0000229***	-7.01e-10***	***	384	-3.83e-06	3.07e-10**		384	0.0000427***	-7.26e-10***	**
385	0.0000399***	-6.16e-10**		385	-5.99e-06	2.85e-10***	*	385	-0.0000275***	7.71e-10***	***
390	7.59e-06	-3.97e-10*		390	0.0000365***	-5.14e-10***		390	3.52e-06	1.47e-10	

NOT SIGNIFICANT *Significant at a 10 % level**Significant at a 5 % level***Significant at a 1 % level

*A note to be made is that the dependent variable, the RSCA index for output, import and export (RCA_OutputN, RCA_Import_N and RCA_ExportN), varies only in the range [-1,1] with these limits as the extreme values, whereas gdp per capita PPP (gdp_pcppp_c2000) increases over a larger range, so that a single increase in gdp per capita PPP, will naturally give a minor change in the respective RSCA index.

Source: Made by author

A6 – Table 4: Summary - **RCA_ImportN** with cubic vs. quadratic terms

ISIC	**N**	gdp^3	R^2	ISIC	**Inverse U**	gdp^2	U-test	R^2	**Best fit?**	**Difference**
323	x	**	0.2783	323	x	***	***	0.2746	**Cubic**	**0.0037**
341	x	**	0.1163	341	x	***	***	0.1116	**Cubic**	**0.0047**
342	x	**	0.1459	342	x	***	***	0.1451	**Cubic**	**0.0008**
351	x	*	0.0424	351					**Cubic**	
354	x	***	0.1441	354	x	***	***	0.1262	**Cubic**	**0.0179**
361	x	***	0.1904	361	x	***	*	0.2170		
362	x	***	0.0728	362	x	***	***	0.0701	**Cubic**	**0.0027**
372	x	***	0.1633	372	x	***	***	0.1899		
381	x	**	0.0399	381					**Cubic**	
382	x	***	0.1140	382	x	***	**	0.0616	**Cubic**	**0.0524**
383	x	***	0.2302	383	x	***	***	0.2044	**Cubic**	**0.0258**
385	x	***	0.1159	385					**Cubic**	

NOT SIGNIFICANT *Significant at a 10 % level**Significant at a 5 % level***Significant at a 1 % level

***gdp^2** here refers to whether both criteria for an inverse N or a N relation is satisfied, i.e. whether the gdp_pcppp_c2000, the Sqr_gdp_pcppp_c2000 and the Cub_gdp_pcppp_c2000 coefficients are significant.

The table shows that R^2 for the regressions with significant N from the cubic regressions and the result from the respective quadratic regressions in comparison. The difference in R^2 is shown in the far right column. As is seen some of these regressions have a higher R^2 in the case of cubic, i.e. the pattern is more like an N – rising, falling, then rising again, than an inverse U – rising then falling.

Source: Made by author

Appendix 7: Overview over Income Groups

A7 – Table 1: Schrever and Koechlin`s Income-Groups (100 = 21.500 US Dollars (1999))