FROM DIVERSIFICATION TO SPECIALIZATION: STRUCTURAL CHANGE AND TECHNOLOGICAL INTENSITY OF INDUSTRY IN SELECTED COUNTRIES

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Abstract

Based on findings of Imbs and Wacziarg (2003), whose empirical study established the existence of a U-shaped pattern of evolution of sectoral concentration in relation to the level of per capita income (countries first diversify, then start specializing), this paper aims at determining more precisely the path of structural change followed by some individual countries during the last decades and at comparing it both to the pattern found by the authors and to the path followed by other countries in particular. In this context, the article tries to determine the path of specialization that has been followed by this selected group of countries in terms of its technological content. The main objective of the paper is, then, to verify whether the recent process of specialization of the industrial structure of these countries has been toward sectors involving higher technological complexity.

Key-words: structural change, diversification, specialization, economic development, technological intensity.

JEL Classification: O14; O30; O57

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1. INTRODUCTION

The relationship between industrial structure and economic development has not yet been totally established. A more traditional view supports that the specialization based on comparative advantages, no matter what is its nature, is an optimal solution for the welfare promotion. On the other hand, some authors argue that the specific pattern of specialization matters, and is even crucial both to the rhythm and to the accomplishment of the development process.

More recently, the economic literature has explored a different question. At least in less developed countries (LDCs), there would be reasons to expect that specialization is not always the best type of structural change in terms of its impact on economic growth. Some factors are given to sustain, instead, that diversifying the industrial structure is a more effective way of increasing the level of development. The debate related to the dilemma between specializing the industrial structure in a few sectors or diversifying the national industry more equally across sectors has stimulated the development of a number of empirical studies, and some of which have been successful in the establishment of relevant stylized facts.

Among these is the seminal work of Imbs e Wacziarg (2003). After correlating measures of sectoral concentration of production with levels of per capita income from a large number of countries along time, the authors have demonstrated the existence of a normal U-shaped pattern for the path of specialization of the industrial structure in those countries. This result means that, in general, countries first diversify their industrial structure, until attaining a certain level of per capita income, after which they start specializing again. Nonetheless, as presented in the study, the minimum point of this curve corresponds to a relatively high level of per capita income, of about US$ 9.000 of 1985 (value close to the level attained by Ireland in 1992). This fact could lead to the conclusion that, in general, only countries that are already rich start this new process of specialization of their industrial structure. Specialization could not, in that case, have generated this same economic development, as argued by Rodrik

(2004).

Nonetheless, through the comparison of the Brazilian process of structural change with paths of specialization pursued by countries as Australia, Canada, US, Korea and Taiwan, Carvalho and Kupfer (2007), have concluded that the structural transition towards specialization has occurred at relatively lower levels of per capita income in the Brazilian industry than in all the other studied countries.

Considering the vision of Rodrik (2004), and assuming, then, that industrial diversification could have the better impacts on economic development, we can conclude that a country only should start its process of specialization if it is toward sectors that are capable to generate an even higher level of economic growth. It seems important to make sure, thus, if this new process of specialization followed by different countries has been toward sectors involving more technologically complex activities. In this context, an early specialization process could be considered premature, or prejudicial to the economic development of countries, especially if it is toward sectors that are less dynamic in terms of demand or productivity growth, as seems to be the Brazilian case.

A first approach to verify these hypotheses includes, then, an evaluation of the technological content of the industrial structure of countries along their path of diversification and specialization. Based on the findings of Imbs and Wacziarg (2003), this paper aims at determining more precisely the path of structural change that has being followed by some individual countries in the last decades and at comparing it both to the pattern found by the authors and to the path followed by each other. Subjacent to this purpose is verifying whether the recent process of specialization of the industrial structure of these countries has been toward sectors involving higher technological complexity.

To attend these objectives, this work is divided in four sections, after this introduction. The next section summarizes the recent empirical and theoretical debate about possible existing relationships between sectoral diversification and economic development. Then, a third section is dedicated to a methodological discussion of the econometric method, the different databases and measures chosen for the determination of the countries' path of structural change. Finally, a fourth section presents and analyzes the empirical results of this study. The last section brings some final remarks as a conclusion to the paper.

2. SPECIALIZATION AND STRUCTURAL DIVERSIFICATION IN THE RECENT LITERATURE ON ECONOMIC DEVELOPMENT

During the last years, some new ideas based on the concept of structural transformation, and especially, on technological change and sectoral diversification are emerging as an explanation for the economic development process[3]. Inside this debate, the conviction in the existence of a positive relation between structural diversification and development is supported by the seminal work of Imbs and Wacziarg (2003), which, as already mentioned, confirmed the presence of some regularities in the relationship between the level of per capita income of different countries and the degree of specialization of their industries.

In order to study the pattern of evolution of sectoral diversification-concentration, Imbs e Wacziarg (2003) have analyzed a large group of countries, using three distinct databases (ILO, UNIDO and OECD), which imply in using different levels of sectoral disaggregation (1,2 or 3 digits) and distinct periods of analysis (1969-1997, 1966-1993, 1960-1993, respectively). Several measures of concentration are calculated, making use of the share of sectors in terms of value added or employment. According to the authors, the results found by means of the different measures of concentration, databases and sectoral shares show to be highly correlated, demonstrating its robustness.

In spite of the predominance of theories that predict a monotonic relationship between income and specialization, the work of Imbs and Wacziarg (2003) concludes that sectoral concentration is related to per capita income by a U-shaped curve. In this sense, the authors suggest the existence of a natural path of economic development in two stages: an increase of diversification until a certain level of per capita income is followed by an increase of sectoral concentration. In addition, the empirical work of the authors shows that the second stage, in which countries start specializing again, only occurs at relatively high levels of per capita income, and thus, at more advanced stages of the economic development process. Therefore, as argues Rodrik (2004), if it is expected that only developed countries specialize, specialization could not have caused this same development. Instead, it would be plausible to assume that structural diversification had a relevant role in this development process.

Even though, in a certain way, the authors' conclusions may be attributing to two successive stages of economic development each of the existing theoretical visions on specialization and diversification: at one side, those who support that level of income and

sectoral diversification are positively correlated, and at the other, those who defend that specialization in sectors with comparative advantages helps countries develop.

By the orthodox side, Imbs and Wacziarg (2003) present two main kinds of arguments that are commonly used to justify sectoral diversification in terms of its impact on economic development. Firstly, some theories are based on the structure of preferences of economic agents. By this vision, agents characterized by non-homothetic preferences are assumed to change their pattern of consumption with the increase of their income. These income-effects would imply in an increase on the diversity of consumed goods, and consequently, in some degree, on a higher diversification of supply. Secondly, arguments of *portfolio*, such as in Acemoglu and Zilibotti (1997), consider that diversification occurs endogenously, as the result from agents' decisions of investing in projects/sectors with no correlated risks. According to this argument, after an initial capital requirement for each sector, opportunities for diversification increase with capital accumulation. Thus, the higher is the number of opened sectors, the easier would be to diversify risk, and then, to invest in more productive projects. Development would then be achieved together with the expansion of markets and opportunities for diversification.

In a heterodox or structuralist view, at least in the case of less developed economies, the diversification of the industrial structure is seen as benefic for the economic development, since it decreases a country's dependence of more sophisticated and higher income-elasticity imports in relation to its exports (arguments of Prebisch, 1981 and followers), reducing then the external disequilibrium and stagnation that are intrinsic to these economies. Besides that, a diversification of output could lead to a diversification of exports, decreasing the dependence on a few commodities, and consequently, the volatility of the exports income. By this point of view, specialization only could be benefic if it is toward more technologically complex and of more dynamic demand sectors.

Imbs and Wacziarg (2003) also present some theoretical arguments in favor of specialization, in terms of its positive impact on economic efficiency. Besides some Ricardian theories, which consider that countries should specialize in the production of goods in which they have comparative advantages, the authors present arguments based on concepts of economic geography, such as the vision of Krugman (1991), which gives importance to demand externalities in the explanation of the agglomeration of economic activities in specific regions or cities.

Nonetheless, aiming to find other factors or characteristics besides the level of income

[3] For a discussion on this subject, see Hausmann and Rodrik (2003).

that could affect the localization of a country in the curve, the authors also evaluate experiences of individual countries. In this context, Imbs and Wacziarg highlight the existence of a certain degree of heterogeneity in the levels of per capita income that correspond to the minimum value of sectoral concentration amongst different countries (distinct inflection points). More precisely, the authors notice that some countries have started specializing at relatively low levels of per capita income, such as Ireland (at about 7.000 constant 1995 dollars). Countries that attained a minimum level of specialization relatively earlier, according to their results, are in average more opened to trade. On the other hand, even closed economies start specializing, but only after achieving a higher level of per capita income. Per capita income and trade openness could hence, according to the authors, be considered as substitutes in the determination of the stages of diversification.

Finally, assuming that stages of diversification would result from the interaction between the increase of productivity and the costs of commercialization, Imbs and Wacziarg (2003) consider that structural transformation responds to the trade policy realized and to the rates of economic growth. In this context, the authors makes reference to the work of Chenery et al (1986), which arguments that economies that followed growth strategies based on exports expansion have industrialized earlier, have attained higher rates of total factor productivity and have achieved faster the industrial structure of an advanced economy.

Summarily, it is clear that there are two categories of factors that could be related to this kind of path of structural change. Firstly, there are factors that are endogenous to the economic growth, which justify the existence of a pattern in the shape of the relation between GDP per capita and the level of diversification across countries. Inside this group of factors, could be included some theories that were already mentioned, especially those that are related to changes in patterns of consumption and investment (ex.: non-homothetic preferences of consumers, portfolio, etc.). Besides that, ideas based on the existence of differentials in productivity growth, technological substitution of some goods by others, cycle product models and other theories related to technical change seem to fit in this category.

In the second group, there are factors which are exogenous to the economic growth of countries, and which are not correlated with the GDP per capita. These factors can be explaining the heterogeneity in the inflection points and in the shape of the curves of different countries (which does not mean that exogenous factors could not generate uniformity among countries). All factors associated with international trade and with the level of trade openness could be classified in this category, including the ricardian argument. Thus, the implementation of trade liberalization and export-led growth policies, could lead to

specialization, while infant-industry protection and imports substitution could stimulate diversification. Besides trade and industrial policy, factors as the country size, access to capital markets and other systemic characteristics could be relevant for the explanation of these movements.

In an analogy with the debate on the causes of de-industrialization (synthesized by Rowthorn and Wells, 1987), one question that appears from this discussion is whether this process of structural change and the industrial specialization after a certain level of per capita income should be seen with worry, or whether is it a natural phenomenon, caused by factors that are internal to these economies.

In this context, it is important to keep in mind the view of Shaffaedin (2005, p.17), which in a study focused on the impacts of trade liberalization on the path of structural change of developing countries, admits that one could expect along the economic development process of an advanced economy, an increase of the share of manufacturing in GDP until a certain point, after which this share starts declining. According to the argument of Rowthorn and Wells (1987), this process of de-industrialization is the natural result of a successful economic development process. This process could be due, in the case of developed countries, to the higher elasticity of income of services in relation to manufacturing, or even to the competition of imports from LDCs (including relocation of production and outsourcing). However, Shaffaeddin (2005) considers that this is not the case of developing countries, where de-industrialization could have been caused by a reorientation of the industrial structure toward specialization in activities in which these countries have static comparative advantages, a direct consequence of the process of trade liberalization. The problem of this phenomenon is that, as points out the author, trade liberalization tends to help sectors that are already sufficiently mature before it, what in the case of LDCs means to stimulate activities involving the production of less technologically complex goods.

For the same reason, the U-shaped pattern of specialization established by Imbs and Wacziarg (2003) for the studied group of countries must be seen differently in the case of developing countries. The idea is that, analogously to the vision of Shafaeddin (2005), a premature specialization could have negative impacts on economic development. It must be clear, thus, when this U-shaped path comes as the natural result of a successful economic development process, or, oppositely, when the inflection of this path has been accelerated by factors that are exogenous to this process. In this last case, it could be relevant to evaluate if this inflection was prejudicial or benefic to the economic development of the country.

3. METHODOLOGY

Firstly, this study aims at reproducing the empirical analysis of Imbs and Wacziarg (2003) for individual countries, in order to verify if their path of structural transformation are similar to the U-shaped pattern found by the authors. The main idea is, then, to correlate measures of sectoral diversification with variables of macroeconomic performance, as did the authors, but instead of assembling data from different countries in a unique pool of observations, the study will analyze separately the selected countries and test the proximity of their behavior to the normal pattern found by Imbs and Wacziarg (2003).

Trying to follow the same method used by the authors for the determination of a relationship that varies along time (but for individual countries), this study also chose to use an econometric procedure based on non-parametrical local regressions (*lowess*), in order to extract a smoothed curve from the data, and thus, establish results with a better graphic representation. Actually, non-parametric regressions are interesting when one wants to avoid the imposition of a model or a specific functional form to the relationship studied. The application of the *lowess* procedure consists in realizing local regressions for an explicative variable *x* on an independent variable y, what implies in running a non-parametric regression for each observation of the sample, by means of a weighting scheme that gives more importance to values that are next to that observation. By this procedure, the shape of the curve that corresponds to the observations of a low level of per capita income does not affect the shape of the curve for the high-levels of income. For the same reason, outliers do not have much impact on the resulted curve.

As point out the authors, this procedure demands two arbitrary choices. Firstly, the *lowess* method requires determining the length of the interval of data that will be included in each local regression, which is called the bandwidth. Secondly, the procedure needs the choice of a weighting system for the data that are inside the bandwidth. More precisely, the system may attribute the same weight for all the observations of the bandwidth, or a lower weight for the values that are more distant to the observation for which the regression is being run. Differently from Imbs and Wacziarg (2003), who chose a fixed bandwidth of US$ 5000 of per capita income and the same weight for all the observations included in this interval, this study has used a standard *lowess* procedure[4]. In this standard method, the chosen bandwidth is J=0,75, which means that two thirds of the total observations are used in each local regression, and the weighting system is tricubic, which weights each observation *j* in the

regression of an observation *i* with W_{ij} defined below:

$$W_{ij} = \left(1 - (dist_{ij} \,/\, dist\max_i)^3\right)^3,$$

in which $dist_{ij}$ is the distance between the observation *i* (center of the local regression) and an observation *j* that is included in the bandwidth, and $dist\max_i$ is the maximum distance between the observation *i* and all the other observations that are included in the bandwidth.

In the present study, as in Imbs and Wacziarg (2003), the explicative variable *y* corresponds to a measure of the level of sectoral specialization, and the independent variable *x* is the per capita income of the country (in 1990 dollars). The distinct observations of *x* and *y* are the annual values of each index for the considered country. Finally, the estimated values of *x* that are obtained from the local non-parametric regressions will form a smoothed curve relating *x* to *y*.

For measuring the level of industrial specialization, this study used the Gini-Hirschmann coefficient (GH), which simply normalizes to the interval of 0 to 100 the square ratio of the Hirchmann-Herfindahl Índex (IHH), usually employed for the determination of the level of industrial concentration. The GH of a country *j* is given by:

$$GH_j = 100 \cdot IHH^{1/2} = \left(\sum_{i=1}^{n} \left(X_{ij} / X_j\right)^2\right)^{1/2},$$

in which X_{ij} is the value added of the activity *i* produced by country *j* ;

X_j is the total value added in country *j*' s industry.

and *n* is the number of sectors in its industrial structure.

Thus, the higher the GH index, more specialized (less diversified) is the industrial structure of the country. The GH assumes the maximum value of 100 when the specialization is complete, which would mean that there is only one industrial activity in the country. Inversely, when the production is much diversified, the share of each sector in the industrial structure will be low, leading to a GH close to zero[5].

[4] The *lowess* procedure was realized by means of the *loess* function of the statistical software R.
[5] The theoretical limit of the GH index depends on the number of existing sectors in the industrial classification used, being as close to zero, as more uniformly distributed is production in a large number of industrial sectors.

As stressed in UNCTAD (1995), some statistical problems involve the measurement of the level of specialization/diversification of an industry. In the first place, it is important to keep in mind that movements in the relative prices among different products affect measures of diversification that are calculated through shares in current values of value added. Thus, it is sometimes impossible to distinguish between a “passive” diversification, caused by changes in prices, and an “active” diversification, related to changes in the volume produced by each activity.

However, in this study, it is assumed that a process of sectoral concentration due to changes in relative prices, or "passive", is also important for the analysis. More precisely, we assume here the view that this type of concentration also sets a process of specialization of the industrial structure, in the sense that, even by means of price movements, it increases the dependence of the country regarding a few sectors, rather than distributes this dependence more equally across sectors. For this reason, and also considering the weakness of the available data of value added in constant prices, which are calculated through sectoral deflators not always reliable, it is given more importance in this work, as in Imbs and Wacziarg (2003), to the phenomenon of specialization in terms of value added at current prices and employment, the latter variable being free of such problems.

In addition, it is important to clarify that the GH index is only useful for describing the diversification of the industrial structure as a whole, and it can not be used for measuring diversification from a sector to the other, or within a sector. In fact, the level of disaggregation of data in the industrial classification affects much the absolute value of the index, occasionally leading to some problems on the results interpretation: the concentration index tends to be as higher, as lower is the number of industrial sectors included in the analysis. A change in classification could even cause changes in the overall shape of the path of diversification followed by each country.

In a second step of the empirical work, the technological content of the industrial structure of each country is measured for different years through a summary index based on the OECD High-Technology Sector and Product classification[6]. The empirical study analyzes the evolution of the index for the different countries of the sample, in order to conclude whether specialization occurs as an upgrade of the industrial structure, or, instead, whether it is frequently regressive.

[6] This indicator has the failure of not considering changes in the technological intensity of each activity over time (which despite being supposedly increasing for all sectors, can vary differently across the activities).

More precisely, based on the review of the OECD high-tech industries and product classification by Hatzichronoglou (1997), this study has created a measure of technological intensity of the industrial structure in a year *t* as follows:

$$PIT_t = 0.\sum s_i + \frac{1}{3}\sum s_j + \frac{2}{3}\sum s_k + \sum s_l$$

Where s_i is the share in value added or employment of the sectors classified as low tech, s_j is the share in value added or employment of the sectors classified as medium-low tech, s_k is the share in value added or employment of the sectors classified as medium-high tech and s_l is the share in value added or employment of the sectors classified as high tech.

The index is calculated using value added (at current or constant prices) and employment data, and varies from zero to 1, assuming the maximum value in the hypothetical situation in which all the industrial value added or employment is concentrated in the sectors classified as having high-technological complexity.

Finally, it seems important to make some considerations about the different databases used in this study. Data of value added and employment were extracted from the 60-Industry Database available in Groningen (2006), which combines information from the OECD STAN Database with data from national accounts of the countries. The Groningen (2006) database gives data for 56 activities (ISIC rev. 3 classification), for years from 1979 to 2002 or 2003 (it depends on the country). However, since the main purpose of this study is evaluate the path of diversification inside industry, only data from manufacturing and mining activities (28 sectors) were included in the regressions, excluding services and agriculture.

All values of GDP per capita, exhibited in 1990 International Geary-Khamis dollars, were extracted from the historical series of Maddison (2007) in order to simplify the comparison between the turnaround points of the different countries' curves.

4. EMPIRICAL RESULTS

As already highlighted, seeking a comparative assessment of the experience of structural change of different countries, this study has tried in a first place to reproduce the experiment of Imbs and Wacziarg (2003), described in the previous section. In fact, from the application of the method of LOWESS, many of the countries surveyed have shown a U-shaped pattern of specialization, as envisaged by the authors. Furthermore, the estimated curves seem in general to fit very well to the observations of the sample, conferring

robustness to the results.

At first, the empirical study of this chapter was conducted for the 22 countries of the Groningen database, for which data are available from 1979 until 2002 or 2003. The results indicate that when based on data from value added at current prices or employment, the GH index is U-shaped in relation to per capita income in about 60% of cases. In other approximately 20% of cases, the study resulted in a path of increasing GH (process of specialization of the structure) for all levels of per capita income. For the other countries of the sample, the study found volatile or not fitted curves.

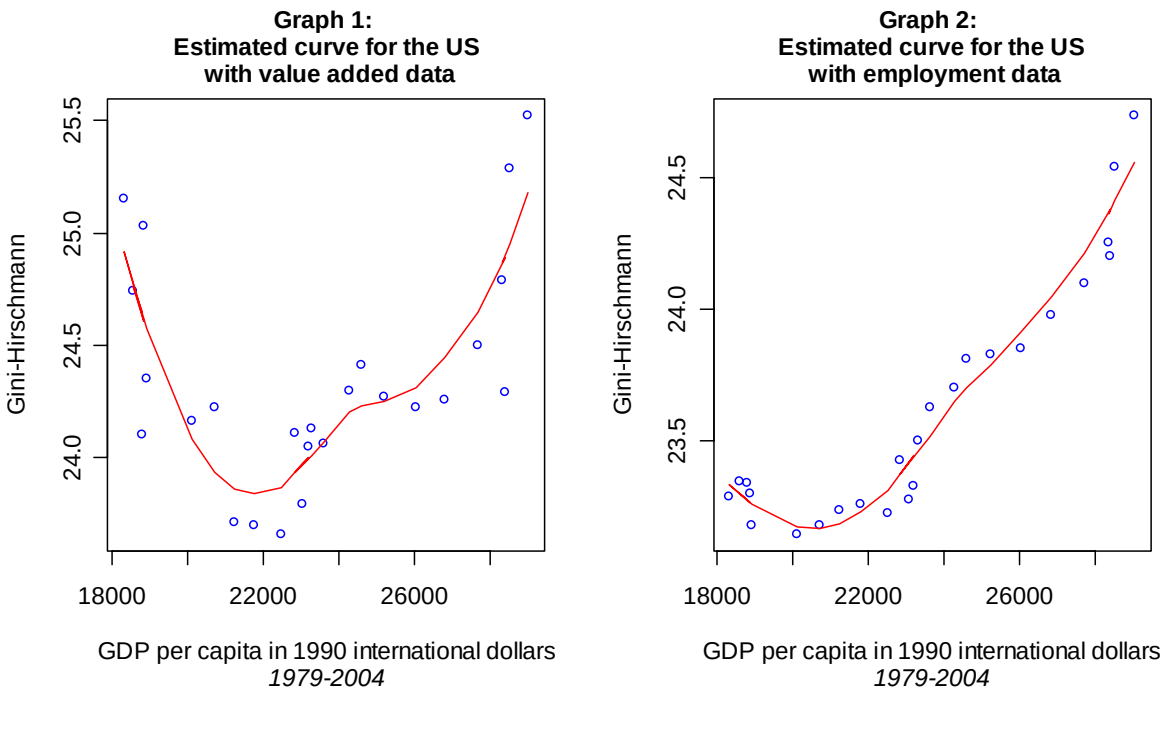
In addition, it was noticed that in 62% of cases where the study found U-shaped curves for the process of specialization in terms of value added measured in current prices, a U-shaped path was also found for the GH calculated by means of shares in employment, and vice versa, indicating that there is a large area of intersection between the two situations.

The same does not occur when the GH index is calculated from value added data in constant prices of 1995, when only 43% of countries for which the series of sectoral deflators is available present U-shaped curves. In other approximately 20% of the countries, data shows an upward path of specialization for the different stages of development, and in three of the 21 countries (14% of the sample), there is a continuous process of industrial diversification when measured by value added in constant prices (Canada, Japan and Portugal). In the remainder of the sample, the estimated curves did not fit to the observations or seemed to be too volatile.

Still, a little more than a half of the U-shaped curves that were measured in terms of value added at current prices, have shown to be also U-shaped when calculated in constant prices. It is worth emphasizing that the differences found between the paths of specialization measured by value added at current prices or at constant prices may result from the existence of movements in relative prices, but also from the disability of the deflators used for the calculus, as mentioned above.

Graphs from 1 to 12 present the estimated paths of diversification for some of the studied countries, as well as their observed values of GH, in terms of value added at current prices and employment. The choice of such countries has tried to cover two basic criteria. The first one was the shape in U and the quality of fitness of the curves to the observations. The second one was the need of having countries with different degrees of economic development in the study. More precisely, among the countries for which the empirical study has found U-shaped paths for both value added (at current prices) and industrial employment (regardless of the outcome observed for value added in constant prices), this work has picked up for a deeper analysis some advanced economies with very different histories of

development (United States, Japan, United Kingdom and Netherlands) and two emergent Asian economies (Korea and Taiwan).



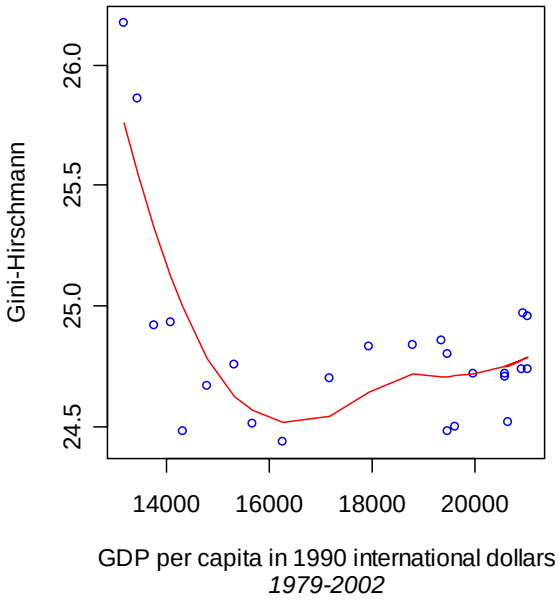
Source: Created with data from Groningen (2006)

By observing Graphs 1 and 2, which show the curves estimated by the method of LOWESS for the path of specialization in terms of value added at current prices and employment, respectively, followed by the North American industry over its recent economic development process, it is important to observe that the point of maximum diversification of the industrial structure (point of inflection of the curve) occurs at a level of per capita income that is very similar in both cases (about I$ 22,000 in 1990, in Graph 1 and I$ 21,000 in Graph 2). These levels of per capita income correspond to the level of development reached by the U.S. during the second half of the 80's, which can be considered a very high stage of economic development, confirming then the stylized facts found by Imbs and Wacziarg (2003).

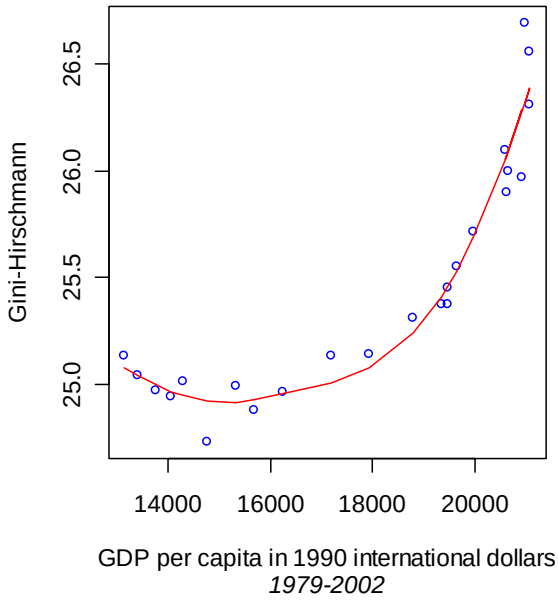
Both in terms of value added and employment, the path of diversification pursued by the American industry from 1979 to 2002 was very close to the U-shaped pattern found by Imbs and Wacziarg (2003) and the inflection point occurs at the highest level of per capital income of all the studied countries. Nevertheless, the total variation of the Gini-Hirschmann index in the considered period was much smaller in US than in other countries, showing that

at least in terms of sectoral diversification, there was not much structural transformation in the American industry during the last two decades. In fact, the industrial structure in the US was already relatively diversified in the beginning of such period, with a GH of 25, a level that has declined to 23 in the minimum point of the curve, and increased to 25,5 in the end of the period of analysis.

Graph 3:
Estimated curve for Japan
with value added data



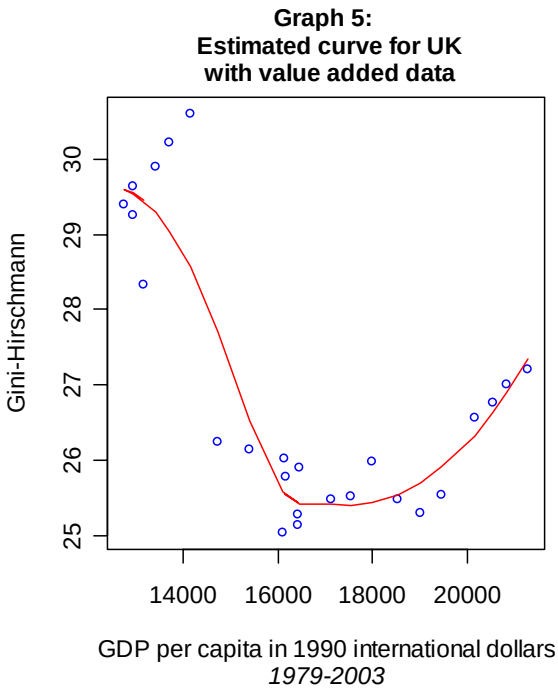
Graph 4:
Estimated curve for Japan
with employment data

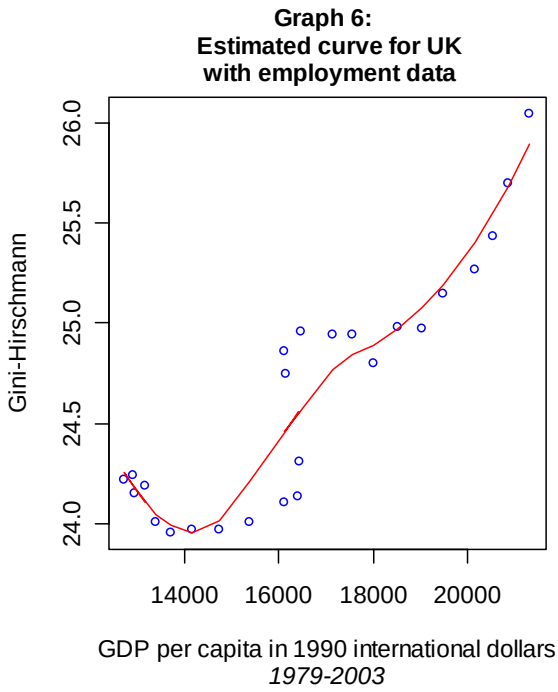


Source: Created with data from Groningen (2006)

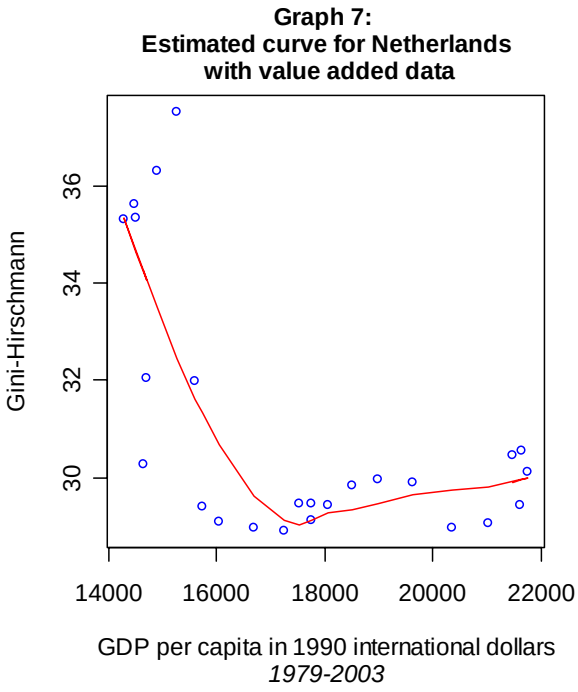
In Japan, the point of maximum diversification of the industrial structure has occurred at approximately I$ 16,000 of income per capita in the case of value added, and nearly I$ 15,000 in the case of employment. In a similar way, the English industry begins the process of specialization at about I$ 17,000 in terms of value added and I$ 14,000 in employment (Charts 3 to 6). Finally, in Netherlands, the inflection point of the curve occurs at approximately I$ 18,000 both in terms of value added (at current prices) and employment.

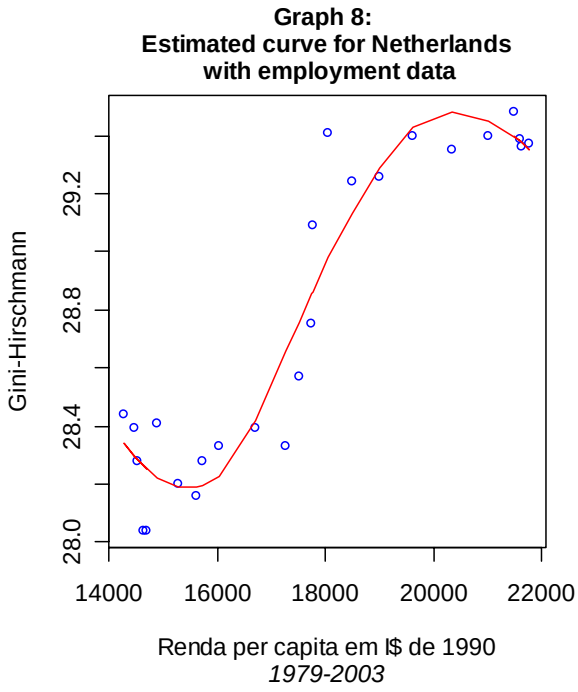
Thus, it is clear that in the four different paths already studied in this section, the inflection point has truly occurred in a relatively advanced stage of the economic development process of those countries, as predicted by Imbs and Wacziarg (2003).





Source: Constructed with data from Groningen (2006)



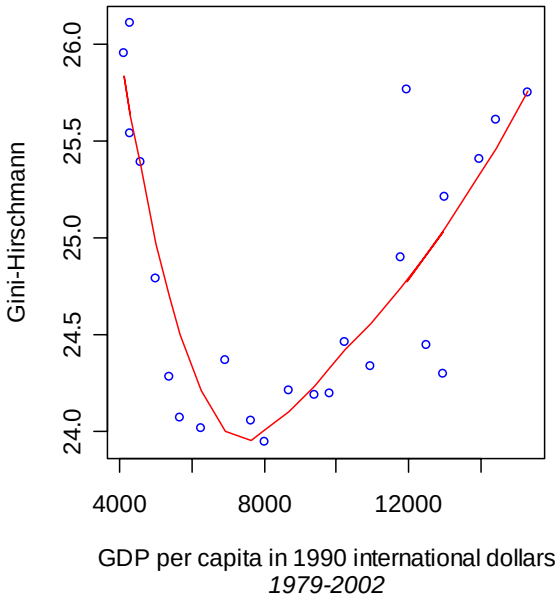


Fonte: Elaboração própria a partir de Groningen (2006)

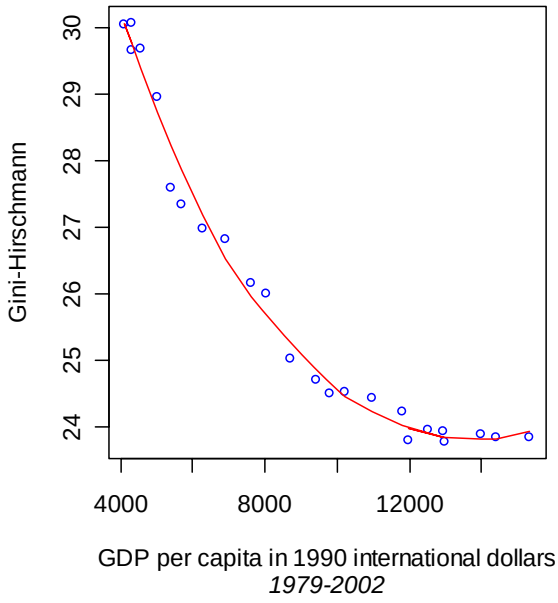
In Charts from 9 to 12, we can observe that East-Asian countries, such as Korea and Taiwan, have also generally pursued an industrial path of diversification in two stages, from 1979 and 2002, with an increase of diversification followed by an increase of specialization.

Nonetheless, the level of per capita income that corresponds to the maximum diversification of their industries is below the levels found for US, UK and Japan, leading to the conclusion that the industrial structure of those East-Asian countries has started its movement toward specialization a quite earlier, in terms of their development process. More precisely, Taiwan has started the inflection of its path of diversification in value added and employment at a level of about I$ 12.000 of per capita income, which is still higher than such level in Korea, of I$ 8.000 (in value added).

Graph 9:
Estimated curve for Korea
with value added data



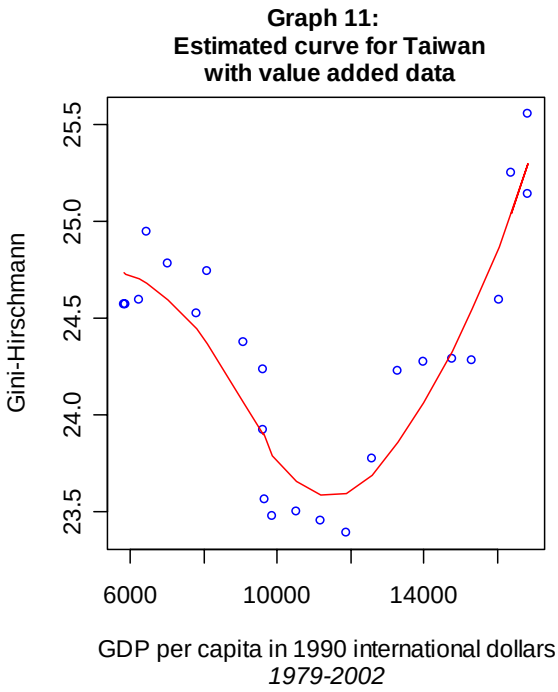
Graph 10:
Estimated curve for Korea
with employment data

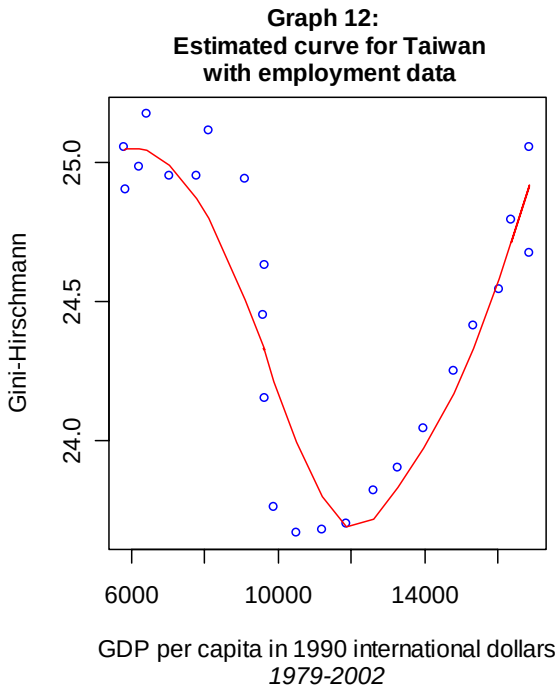


Fonte: Elaboração própria a partir de Groningen (2006)

As emphasized by Rodrik (2004), if it is generally expected that specialization only occurs in advanced stages of development, it is not possible to establish this specialization as a factor of economic development. Obviously, this stylized fact comes in a different direction than the traditional trade models, which defend the specialization of production based on comparative advantages, independently from the stage of development of each country. Considering the vision of Rodrik (2004), and assuming, then, that industrial diversification have the better impacts on economic development, we can conclude that a country only should start its process of specialization if it is toward sectors that are capable to generate an even higher level of economic growth. It seems important to make sure, thus, if this new process of specialization followed by different countries has been toward sectors involving

more technologically complex activities.





Fonte: Elaboração própria a partir de Groningen (2006)

In order to evaluate this hypothesis, the technological content of the industrial structure of each country is measured for different years through a summary index of technological intensity (PTI) based on the OECD High-Technology Sector and Product classification, as already described in the previous section.

Table 1 presents for the United States the evolution, in terms of GDP per capita and time, of the two summary indexes already described in the previous section (GH and PTI), which were created to quantify two aspects of the industrial structure of these countries, in terms of value added (at current prices) and employment. By observing the GH index, it is possible to distinguish, as already done with Graphs 1 and 2 for the US, the different stages of diversification of the industrial structure (in relation to the level of per capita income) for each country: these stages are marked in the table by a horizontal line. In fact, these tables were created with the main objective of associating these stages of diversification with the evolution of the parameter of technological intensity (PTI), which summarily measures the technological content of value added or employment of these industries.

Table 1

Summary indexes for the industrial structure of the US

Real GDP per capita	Year	GH (VA)	PTI (VA)	GH (Emp)	PTI (Emp)
18325	1982	25,15	0,388	23,29	0,352
18577	1980	24,74	0,380	23,35	0,350
18789	1979	24,10	0,383	23,34	0,347
18856	1981	25,03	0,385	23,30	0,352
18920	1983	24,35	0,392	23,18	0,349
20123	1984	24,16	0,402	23,15	0,355
20717	1985	24,22	0,399	23,18	0,360
21236	1986	23,71	0,396	23,24	0,357
21788	1987	23,70	0,400	23,26	0,354
22499	1988	23,66	0,400	23,23	0,355
22849	1991	24,11	0,399	23,43	0,351
23059	1989	23,79	0,398	23,28	0,355
23201	1990	24,05	0,396	23,33	0,354
23298	1992	24,13	0,396	23,50	0,347
23616	1993	24,06	0,398	23,63	0,342
24279	1994	24,30	0,400	23,70	0,340
24603	1995	24,41	0,397	23,81	0,342
25230	1996	24,27	0,402	23,83	0,346
26052	1997	24,22	0,407	23,85	0,349
26824	1998	24,26	0,412	23,98	0,351
27699	1999	24,50	0,404	24,10	0,350
28347	2001	24,79	0,397	24,25	0,350
28403	2000	24,29	0,406	24,20	0,350
28535	2002	25,29	0,394	24,54	0,343
29037	2003	25,52	0,396	24,73	0,341

In this context, it is possible to notice, through the observation of Table 1, that during the first stage of diversification of the industrial structure of the US in terms of value added (until about I$22,000 of per capita income), the PTI shows a certain increase, indicating a process of diversification that incorporates sectors with a higher technological complexity. After this mark, the PTI index seems to oscillate more, but still shows an increase, attaining its maximum value (0.412) at more than I$26,000 of GDP per capita (1998). After this point, the index seems to stagnate or to decrease slightly.

In terms of employment, in spite of many oscillations, the PTI index has shown, as could be expected, a small decrease between the lowest and the highest level of GDP per capita of the series. In fact, the share of each sector in employment can be inversely proportional to its level of productivity, which tends to be higher in high-tech activities. For this reason, an augment of the PTI index in terms of value added may be accompanied by a decrease of this same index when measured by employment data.

Table 2

Summary indexes for the industrial structure of Japan

Real GDP per capita	Year	GH (VA)	PTI (VA)	GH (Emp)	PTI (Emp)
13163	1979	26,17	0,369	25,13	0,283
13428	1980	25,86	0,378	25,04	0,298
13754	1981	24,92	0,388	24,97	0,301
14078	1982	24,93	0,389	24,94	0,302
14307	1983	24,48	0,394	25,01	0,308
14773	1984	24,67	0,412	24,73	0,322
15331	1985	24,76	0,415	24,99	0,325
15679	1986	24,51	0,408	24,88	0,329
16251	1987	24,44	0,403	24,96	0,326
17185	1988	24,70	0,411	25,13	0,326
17943	1989	24,83	0,422	25,14	0,331
18789	1990	24,84	0,423	25,31	0,329
19355	1991	24,86	0,421	25,37	0,331
19478	1993	24,48	0,408	25,45	0,330
19482	1992	24,80	0,415	25,37	0,331
19637	1994	24,50	0,407	25,55	0,322
19979	1995	24,72	0,414	25,71	0,323
20594	1999	24,72	0,423	26,10	0,332
20616	1996	24,71	0,421	25,90	0,327
20662	1998	24,52	0,422	26,00	0,330
20929	1997	24,74	0,423	25,97	0,328
20969	2002	24,97	0,410	26,69	0,336
21051	2000	24,74	0,426	26,31	0,332
21062	2001	24,96	0,414	26,56	0,335

A summary analysis of Table 2, which refers to the Japanese industry, leads to the conclusion that the parameter of technological intensity has significantly increased, both in terms of value added and employment, during the entire period of study. Even though, it is possible to discern a lower rhythm of rise of the PTI during the final stage of specialization of the industrial structure (below the marks), when compared to the growth in the first stage of development.

By observing the first and last observations of the English series (Table 3), the PTI seems to have decreased both in terms of valued added and employment during the period of analysis. In addition, it is possible to infer that this decrease was more substantial during the latter stage of specialization of the industrial structure in both cases. Nonetheless, it is important to emphasize that in UK the net reduction of the index was very small in the whole period and there were too many oscillations in both stages, what makes the results very difficult to explore.

Table 3

Summary indexes for the industrial structure of the UK

Real GDP per capita	Year	GH (VA)	PTI (VA)	GH (Emp)	PTI (Emp)
12747	1981	29,39	0,380	24,22	0,357
12931	1980	29,26	0,381	24,24	0,357
12955	1982	29,63	0,381	24,15	0,355
13167	1979	28,32	0,383	24,19	0,355
13404	1983	29,89	0,383	24,01	0,354
13720	1984	30,22	0,383	23,96	0,352
14165	1985	30,59	0,367	23,97	0,351
14742	1986	26,23	0,371	23,97	0,348
15393	1987	26,14	0,369	24,01	0,346
16110	1988	25,04	0,376	24,11	0,347
16133	1992	26,02	0,357	24,86	0,340
16157	1991	25,77	0,366	24,75	0,346
16414	1989	25,14	0,374	24,14	0,349
16430	1990	25,28	0,373	24,31	0,350
16463	1993	25,89	0,357	24,96	0,330
17137	1994	25,47	0,367	24,94	0,331
17561	1995	25,52	0,369	24,94	0,338
17997	1996	25,98	0,367	24,80	0,341
18527	1997	25,47	0,369	24,98	0,341
19026	1998	25,30	0,372	24,97	0,345
19485	1999	25,53	0,372	25,15	0,345
20159	2000	26,55	0,370	25,27	0,349
20554	2001	26,77	0,366	25,43	0,349
20851	2002	27,01	0,363	25,70	0,344
21310	2003	27,21	0,360	26,04	0,339

By Table 4, which refers to Netherlands, it is possible to perceive more clearly two different and simultaneous movements in the summary indexes chosen for the study, both in terms of value added and employment. In the first stage of diversification (GH declines until I$17,000 of GDP per capita), the evolution of the PTI index has revealed an increase of the technological content of the structure of value added and employment of the industry. Subsequently, this process is reverted: in the latter stage of development, in which the GH starts to rise, the PTI has decreased, indicating a specialization toward less technologically complex activities.

Table 4

Summary indexes for the industrial structure of Netherlands

Real GDP per capita	Year	GH (VA)	PTI (VA)	GH (Emp)	PTI (Emp)
14291	1982	35,32	0,333	28,44	0,301
14483	1983	35,63	0,339	28,39	0,305
14525	1981	35,34	0,332	28,28	0,301
14647	1979	30,28	0,333	28,04	0,294
14705	1980	32,06	0,329	28,04	0,298
14900	1984	36,32	0,340	28,41	0,307
15283	1985	37,52	0,344	28,20	0,314
15617	1986	31,98	0,339	28,16	0,316
15737	1987	29,41	0,347	28,28	0,318
16044	1988	29,09	0,348	28,33	0,313
16695	1989	28,97	0,347	28,39	0,310
17262	1990	28,91	0,341	28,33	0,311
17520	1991	29,45	0,334	28,57	0,306
17747	1992	29,13	0,328	28,75	0,302
17765	1993	29,45	0,323	29,09	0,294
18055	1994	29,43	0,330	29,41	0,292
18510	1995	29,83	0,337	29,24	0,293
18988	1996	29,96	0,331	29,26	0,295
19620	1997	29,91	0,334	29,40	0,296
20350	1998	28,97	0,332	29,35	0,298
21025	1999	29,07	0,327	29,40	0,297
21479	2003	30,45	0,320	29,48	0,302
21609	2000	29,42	0,334	29,39	0,299
21642	2002	30,55	0,317	29,36	0,304
21768	2001	30,11	0,326	29,37	0,302

In fact, despite these remarks, it is clear that the evolution of the PTI index in developed countries goes through a certain oscillation or stagnation during the period of analysis. This aspect is partially derived from the fact that the PTI index has been calculated through an OECD classification, which is very aggregated (4 categories), applied to a 2-digit classification (ISIC rev 3), which is not much disaggregated either. Besides that, the industrial structure of these countries is quite mature, and, thus, is not undertaking a substantial process of structural change during this period (even the variations on the GH index are not so significant). For this reason, more clear trends in the PTI can be observed in the case of emerging countries as Korea and Taiwan (Tables 5 and 6, and Graphs 13 and 14, respectively).

In Korea, as shown in Table 5, the PTI index is increasing significantly both in terms of employment and value added (*cf.* Graph 13), at all levels of per capita income, independently from the behavior of the GH index, even if this process seems to be more substantial in the first stage of diversification. This result means that even if the stage of

diversification has incorporated activities involving higher technological complexity, the Korean specialization of the industrial structure is also being progressive in terms of its technological content.

Finally, as in the Korean case, by analyzing the results of Table 6, it is possible to deduce that the technological content of the industrial structure has risen, both in terms of value added (*cf*. Graph 14) and employment in all stages of development between 1979 and 2002 in Taiwan. In fact, the set up of the stage of specialization does not seem to have changed the trend of the PTI index, which has significantly increased during the whole period.

Table 5

Summary indexes for the industrial structure of Korea

Real GDP per capita	Year	GH (VA)	PTI (VA)	GH (Emp)	PTI (Emp)
4114	1980	25,96	0,316	30,05	0,243
4294	1979	26,11	0,329	29,67	0,253
4302	1981	25,54	0,317	30,07	0,238
4557	1982	25,39	0,319	29,70	0,232
5007	1983	24,79	0,333	28,97	0,240
5375	1984	24,28	0,334	27,59	0,256
5670	1985	24,07	0,336	27,34	0,262
6263	1986	24,02	0,345	26,98	0,276
6916	1987	24,37	0,354	26,83	0,289
7621	1988	24,06	0,377	26,17	0,301
8027	1989	23,95	0,380	26,01	0,305
8704	1990	24,21	0,395	25,03	0,324
9409	1991	24,19	0,382	24,71	0,333
9810	1992	24,20	0,380	24,50	0,339
10234	1993	24,46	0,387	24,52	0,344
10959	1994	24,34	0,407	24,44	0,355
11809	1995	24,90	0,424	24,23	0,363
11966	1998	25,77	0,418	23,79	0,379
12507	1996	24,45	0,423	23,96	0,374
12962	1997	24,30	0,424	23,93	0,380
12994	1999	25,21	0,427	23,78	0,379
13985	2000	25,41	0,449	23,88	0,388
14416	2001	25,61	0,436	23,85	0,392
15333	2002	25,75	0,434	23,85	0,392

Summarily, the empirical results of this section suggest a few aspects related to the process of structural change of the industry pursued by the countries studied. Firstly, in spite of a certain degree of heterogeneity in the shape of the estimated curves of diversification in terms of GDP per capita for these countries, the results suggest that most of them have pursued a stage of diversification of the industrial structure before following a process of

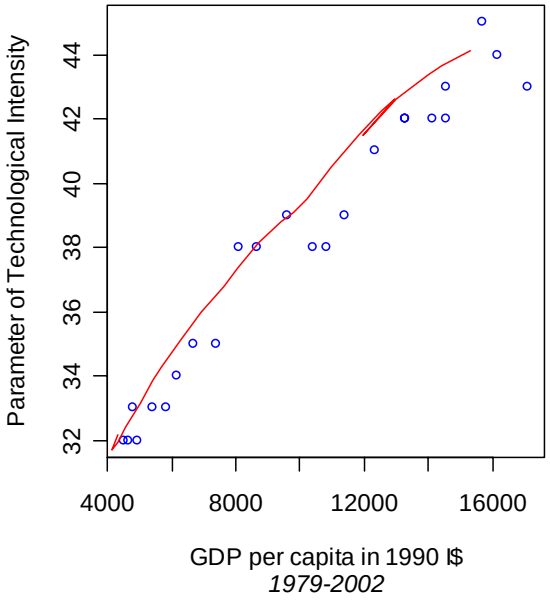
specialization of this same structure (in value added or employment). Secondly, even if the results were difficult to interpret (too much oscillation), it is possible to assume from the tables above that, except for Netherlands, as a general rule, this process of specialization has not interrupted the trend of the summary index (PTI), which has tried to quantify the technological content of the industrial structure. More precisely, this index has been generally increasing in the whole period of analysis for the countries studied in this work, even if this increase has been in many cases more substantial in the stage of diversification of industry (at lower levels of per capita income).

Table 6

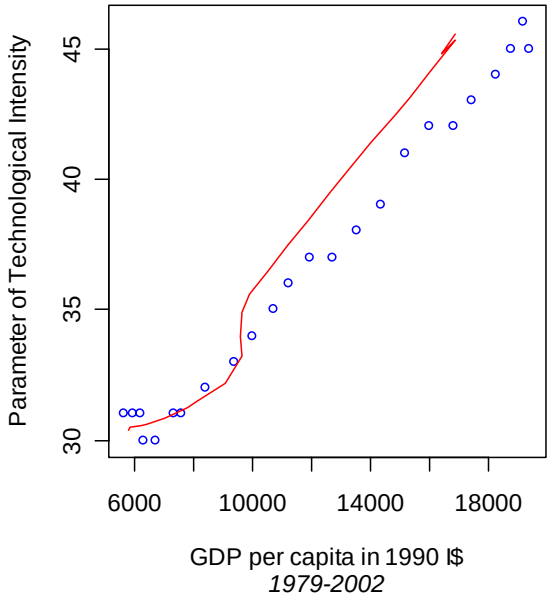
Summary indexes for the industrial structure of Taiwan

Real GDP per capita	Year	GH (VA)	PTI (VA)	GH (Emp)	PTI (Emp)
5831	1979	24,57	0,307	25,05	0,313
5869	1980	24,57	0,307	24,90	0,322
6229	1981	24,59	0,307	24,98	0,316
6446	1982	24,94	0,297	25,17	0,305
7036	1983	24,78	0,305	24,95	0,310
7790	1984	24,52	0,312	24,95	0,320
8113	1985	24,74	0,310	25,11	0,313
9088	1986	24,37	0,318	24,94	0,319
9623	1988	23,92	0,344	24,45	0,334
9641	1987	24,23	0,328	24,63	0,329
9665	1989	23,56	0,352	24,15	0,340
9886	1990	23,47	0,364	23,76	0,351
10522	1991	23,50	0,369	23,67	0,354
11204	1992	23,45	0,373	23,68	0,360
11877	1993	23,39	0,379	23,70	0,366
12597	1994	23,77	0,394	23,82	0,370
13284	1995	24,22	0,410	23,90	0,379
13985	1996	24,27	0,419	24,04	0,385
14795	1997	24,29	0,423	24,25	0,393
15333	1998	24,28	0,434	24,41	0,398
16040	1999	24,59	0,443	24,54	0,400
16378	2001	25,25	0,446	24,79	0,409
16852	2002	25,55	0,452	25,05	0,410
16859	2000	25,14	0,457	24,67	0,407

Graph 13:
Estimated curve for PTI in Korea with value added data



Graph 14:
Estimated curve for PTI in Taiwan with value added data



5. FINAL REMARKS

Based on the empirical study of Imbs and Wacziarg (2003), this work aimed to determine the path of structural transformation pursued by the industry of some individual countries during the last decades.

The realization of an empirical work based on non-parametric local regressions correlating levels of structural diversification-specialization with levels of per capita income for different countries has resulted in smoothed U-shaped curves, similar to those found by Imbs and Wacizarg (2003), for most of the studied countries, both in terms of value added and employment. As already predicted by the authors, the inflection points of these curves in terms of per capita income have occurred at relatively high stages of economic development, but were different across countries, being lower in Korea and Taiwan, and higher in the richer countries analyzed in this study (such as US, UK and Japan).

Since the process of specialization seems to have been launched only after a relatively high level of development, these results, which were established in Imbs and Wacziarg (2003) and confirmed above for some individual countries, suggest that diversification, instead of specialization based on comparative advantages, has accompanied (and probably promoted) the process of economic development of countries, as emphasized by Rodrik (2004).

Nonetheless, in Carvalho and Kupfer (2007), the comparison of the Brazilian process

of structural change with the path of specialization pursued by countries as Australia, Canada, US, Korea and Taiwan with value added data has suggested that the structural transition towards specialization has occurred at relatively lower levels of per capita income in the Brazilian industry than in all the other studied countries. The study considers that the early specialization of the Brazilian manufacturing could have been associated with two phenomenons, both having negative impacts on the level of technological complexity of the industrial structure: trade liberalization and low economic dynamism. This last factor could also explain, in some measure, the structural rigidity that has characterized the Brazilian industry during the last decades.

In a heterodox view, these issues could lead to the conclusion that a process of specialization can be considered premature, or prejudicial to the economic development of the countries, especially if it is toward sectors that are less dynamic in terms of demand or productivity growth, as seems to be the Brazilian case. A first approach to verify this hypothesis includes an evaluation of the technological content of the industrial structure of such countries along their path of diversification and specialization.

In this context, this study has tried to evaluate both in terms of value added and employment the evolution of the technological content of the industrial structure followed by a selected group of countries which have pursued a U-shaped path of specialization. The summary index that has been chosen to measure this technological content has the main deficiency of being based on the OECD classification of high-technology activities, which is too aggregated and does not take account of differences across countries.

Even if the index oscillates too much, the study has concluded that, in general, in the advanced and emergent countries studied in this work, there was an incorporation of more technologically complex activities during the stage of diversification, explaining an increase in the PTI index, which was not interrupted during the latter process of specialization (except in the Dutch case). Thus, as could be expected, most developed and emergent countries studied in this work have not started a process of specialization toward less technologically complex sectors.

The verification of such a phenomenon in the Brazilian case or in other less developed countries (LDC's) could then, as emphasized by Shaffaeddin (2005), be the source of worries. A more precise knowledge of the factors that are causing these processes of specialization, and especially on the effects of trade liberalization to the start of specialization of industry in LDC's, seem to be the main topics that emerge from this work to the research agenda.

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