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STRUCTURAL CHANGE AND ECONOMIC GROWTH: WORLWIDE TRENDS IN THE DOWNWARD MANUFACTURING ERA

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Abstract

The structural change literature has documented that all countries experience important sectoral reallocations during their development process, namely a fall in agriculture, a hump shape in manufacturing and a large increase in services. Since the latter is the sector with the lowest productivity growth, this paper aims at studying if the worldwide economic growth rate will decrease in the years to come due to the structural change effect. To this end, it is first documented that more than 90% of the countries are in falling region of the manufacturing sector and that the worldwide share of manufactories is falling since the mid-1970s. At the same time, it is also showed that countries with larger manufacturing sector tend to exhibit faster GDP growth, especially the developed ones. However, taking the world as a unique economy it is also found that the fastest growing subsectors in services and manufacturing experience higher productivity growth than the service and manufacturing sectors as a whole, so this can offset for the loses in aggregate productivity growth due to structural change. This finding reinforces the balanced growth path result present in general theoretical models. Finally, when examining the worldwide pattern of falling of manufactures, it is founded that the drop occurs abruptly and exclusively during periods of economic crises, which may be seen as a challenge to the existing explanations for structural change and leaves the door open for new mechanisms.

Keywords: Structural change, aggregate productivity, economic growth, manufacturing sector, services sector, balanced growth path.

Introduction

Structural change is observed in all economies of the world and refers to the phenomenon of persistent and systematic variation in the ratio of the different sectors in the economy (agriculture, manufacturing and services[1]) to total value added[2], hours worked and consumption.

Structural change does not occur as a random or stochastic process, but presents some stylized facts that have been studied in early contributions by Clark (1957), Chenery (1960), Kuznets (1966), Syrquin (1998). In the last two centuries, the rise of GDP per capita has been associated with a decrease in the share of value added and hours worked in agriculture, an increase of these shares in the service sector, and with a hump-shaped evolution of these shares in the manufacturing sector. That is, they are increasing for lower levels of development and decreasing for higher levels of development.

One of the most interesting features of structural change is precisely this hump shape in the evolution of the shares in value added and hours worked in the manufacturing sector. When the industrial revolution began, most people assumed that the world had entered in the era of continued growth in manufacturing that would impose its dominance on the overall economy. For many decades the growth in manufacturing seemed unstoppable, but since the 70's the weight of the manufacturing sector within the economy has been falling, creating the hump shape that characterizes the evolution of the mentioned variables.

This evolution of the manufacturing sector has important implications for the performance of the aggregate productivity, which in turn is the main variable that determines the evolution of wages and GDP per capita, Echevarria (19997).

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[1] Agriculture corresponds to International Standard Industrial Classification (ISIC) divisions 1-5 and includes forestry, hunting, and fishing, as well as cultivation of crops and livestock production.

Manufacturing corresponds to ISIC divisions 10-45 and includes manufacturing (ISIC divisions 15-37). It comprises value added in mining, manufacturing (also reported as a separate subgroup), construction, electricity, water, and gas.

Services correspond to ISIC divisions 50-99 and they include value added in wholesale and retail trade (including hotels and restaurants), transport, and government, financial, professional, and personal services such as education, health care, and real estate services

[2] We use indistinctly value added or GDP in constant values for referring to the same variable

Aggregate productivity[3] is the sum of the productivity of the different sectors in the economy (services, manufacturing and agriculture) weighted according to the proportion that represents each sector in total value added. Thus, the aggregate productivity growth rate (hereinafter APGR) depends essentially on the productivity growth rate in manufacturing (hereinafter MPGR), the productivity growth rate in services (hereinafter SSPGR) and in agriculture, and on the relevance of these sectors in the economy.

If these sectors are stable in their share to total value added and their productivity growth rate remains constant, this does not involve changes in APGR. But as a process of structural change occurs and the share of these sectors in the economy varies, and to the extent that productivity across sectors also differs, the APGR can evolve depending on which sectors gain or lose weight.

Duarte and Restunica (2010) have investigated which is the productivity growth associated with each of these sectors through a sample of 29 countries for the period 1956-2004. For the whole sample the annualized growth rate of labor productivity between 1956 and 2004 has been highest in agriculture (4%), second in industry (3.1%) and lowest in services (1.3%). This ranking of growth rates of labor productivity across sectors is observed in 23 of the 29 countries of the sample although there is enormous variation in sectoral labor productivity growth across countries.

To the extent that it is widely accepted that productivity in the service sector is significantly lower than that of the manufacturing and agriculture sectors together with the fact that services sector is increasing their weight in the global economy at the same time that the manufacturing sector is losing weight, it could seem obvious to think of the APGR will tend to the lower SSPGR, and if furthermore the SSPGR and the MPGR remains constant, the APGR will decrease along time inexorably.

The present work aims to answer the main question: Will the APGR and so the GDP per capita growth be lower in the coming years due to the process of structural change? Thus, the present work is an empirical study of the implications of structural change for the aggregate income growth of countries. Its purpose is to analyze whether the world economy tends to a lower and lower economic

[3] The measure of productivity considered thorough the article is the hourly value-added based labor productivity according to the definition of the OECD included in their Measuring Productivity OECD Manual (2001).

growth or on the contrary we can expect a balanced growth path as the theoretical models predict. This study aims at answering:

1) Whether the world has entered or not into an era of aggregate decline in the manufacturing share of GDP and at which speed the global economy transits the downward part of the hump shape. If the manufacturing ratio has entered into the falling region, the global APGR and GDP per capita are likely to converge to the lower SSPGR.

2) Whether SSPGR and MPGR is actually constant, decreasing or increasing over time.

3) Whether countries with larger manufacturing to GDP ratio reach larger GDP per capita growth rates than countries with lower manufacturing share of GDP.

The first contribution of the article is the analysis of the structural change taking the world as if it were a single economy. This has been carried out adding data from the World Bank Database for all countries, and from the World Input-Output Database (WIOD) for the 39 major economies.

In addition to determine whether the world has entered the phase of declining industry, analyzing the global economy as a single one allows us to see what the patterns generated by structural change are. Thus it is possible to determine that the manufacturing share of GDP falls exponentially, and that structural change occurs abruptly and entirely in periods of crisis. This gives us indications to think of in new elements that promote structural change and opens the door to new theoretical formulations.

The second contribution is to make a forecast of the global trend of APGR taking into account the effects of structural change in terms of sectors, but also in terms of subsectors. Forecasts relating structural change to APGR trend has been done on individual countries, Bah and Brada (2009) for countries from Central Europe which have recently entered the European Union, but had not yet been made for all the world as a whole. In addition, the work formulates a specific analysis of structural change at subsectors level. So the services and manufacturing sector are broadly disaggregated into 17 subsectors to more accurately predict the future trend of APGR. Finally the article presents a study of the correlation between economic growth and the weight of manufacturing in GDP for a sample of all countries of the world, for which is founded a positive relationship between these variables.

The article is organized as follows: In section 1, the paper analyses whether the world has already entered in the era of the decline in the manufacturing share of GDP. Section 2 studies how many countries have entered into the phase of declining in manufactures. Section 3 examines the velocity and characteristics of structural change in the downward part of the manufacturing hump shape, that is whether this loss of weight is linear or exponential. Section 4 examines whether the evolution of the growth rate of productivity in the service and manufacturing sectors are constant, increasing or decreasing and which evolution is predictable in the future. Section 5, empirically analyses whether countries with lower manufacturing to GDP ratio observe also lower GDP per capita growth rate compared with countries with higher manufacturing to GDP ratio.

1. Has the world entered into an era of global decline of manufacturing?

In this section we study in what stage is the world economy with respect to the phenomenon of structural change and if the world ratio of manufacturing has entered the downward phase of the hump shape or not. This analysis will give us a qualitative and quantitative information about the phase of the structural change in which the world stay. The world is analysed as a single economy.

The data used are provided by the World Bank (World Development Indicators) and variables used are the ratio of total manufacturing to value added for all Members of United Nations in constant dollars (base 2005) for the period 1962-2012.

For each country is calculated the GDP by sectors for each year of the period 1962-2012, then these amounts for all countries are added to get for each year the total amount of GDP generated by services, manufacturing and agriculture and we divide that sum by the total GDP. Thus we get the annual world ratio of sectors to total GDP (results for manufacturing sector in appendix).

$$World\ GDP\ \%\ Manuf_{year\ t} = \frac{\sum_{i=1}^{n} GDP\ Manuf_{country\ i,year\ t}}{\sum_{i=1}^{n} Total\ GDP_{country\ i,year\ t}}$$

Figure 1 Structural change of the global economy, hump shape of the manufacturing to GDP ratio 1962-2012
Source: own calculations from World Bank data

From figure 1 it is clearly observable that since 1974 the world economy has entered into the era of the decline of manufacturing. Moreover, as Herrendorf et al (2014) shows all developed countries have entered into the downward manufacturing era –in relative terms- (with the exception of South Korea that maintains an approximately constant ratio).

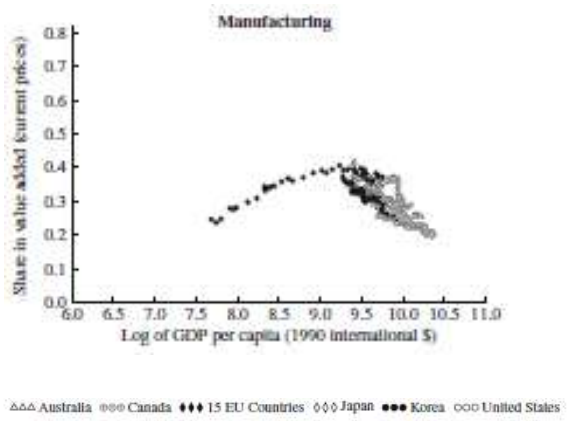

Figure 2 Hump shape of the manufacturing to total GDP ratio for the developed countries.
Source: Herrendorf et al. (2014)

The only thing that could revert this trend would be the fact that in developing economies such as China or India the ratio of manufacturing to GDP was increasing substantially. But this is not happening. In the case of China since 2006 the manufacturing sector has also entered into the downward part of the hump shape and in the case of India since 2011.

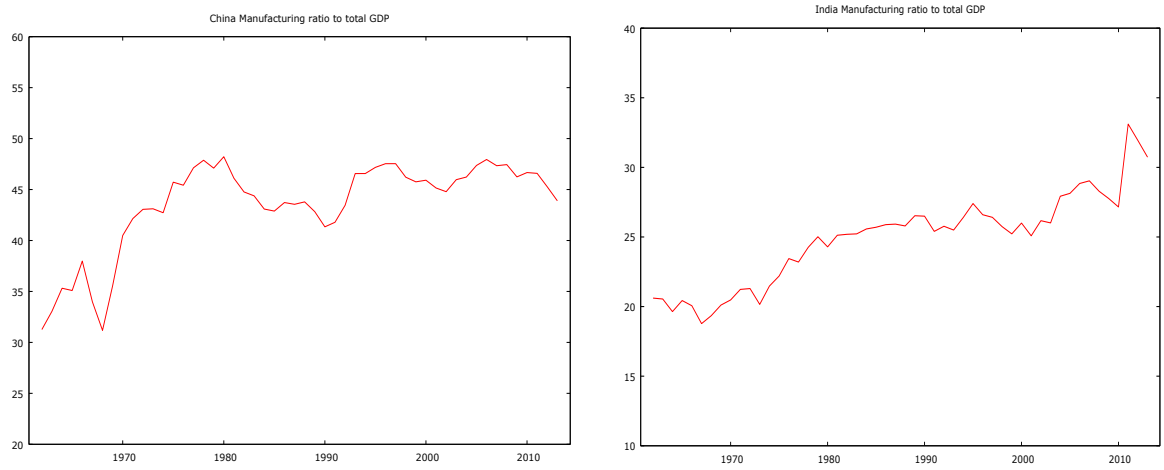

Figure 3 China and India manufacturing ratio to total GDP
Source: own calculations from World Bank data

Regarding this facts we can conclude that the world has irreversibly entered into the downward part of the hump shape. What is up to study then is whether the entrance in the downward manufacturing region implies a lower APGR and economic growth rate.

2. How many countries have entered into the era of declining manufacturing worldwide?

Once we know that the world taken as a single economy has entered the era of the decline of manufacturing, it is also possible to determine whether a majority of countries and their economies have also entered the phase of decline in manufacturing or the phenomenon of structural change only affects the most developed economies, i.e., the ones with highest level of GDP.

In determining quantitatively how many countries have entered the phase of decline in manufacturing this foreshadow how many countries is expected GDP per capita growth rate progressively brings over to the SSPGR.

To carry out this analysis we first determine for each country which is the peak point of the share of manufacturing to total value added. Then for the time series data after the peak point it is calculated the average ratio of manufacturing to total value added. We also use time series data for the period 1960-2013 for all members of United Nations provided by the World Bank.

We classify the countries according to how much it has decreased the average of manufacturing to GDP ratio after the peak point compared to the peak point.

Countries type A: The peak point is the last data of the time series and, therefore, the manufacturing sector is even gaining weight in the economy (16 countries) [4].

Countries type B**:** the average weight of manufacturing after the peak point is between 0% and 5% lower than the peak point. The manufacturing sector to total value added ratio performs a smoothly diminishing trend. We already cannot say that the trend is irreversible (15 countries) [5].

Countries type C: the average weight of manufacturing after the peak point is between 5% and 10% lower than the peak point. The weight of the manufacturing sector observes a clear diminishing trend. We can say that the trend is becoming irreversible (10 countries) [6].

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[4] Bangladesh, Bhutan, Bolivia, Burkina Faso, Colombia, Congo Rep., Ecuador, Egypt Arab Rep, Eritrea, Nicaragua, Sri Lanka, Tanzania, Gabon, Ghana, Iran, Timor.

[5] Guatemala, Indonesia, Kenya, Korea Rep., Kuwait, Libya, Maldives, Micronesia Fed.Sts., Myanmar, Panama, Peru, Swaziland, Thailand, Vietnam, Yemen Rep.

[6] China, Czech Republic, Hungary, India, Jordan, Lao PDR, Qatar, Senegal, Slovak Republic, Slovenia

Countries type D: the average weight of the industry after the peak point is more than 10% below the peak point. The weight of the manufacturing sector related to the overall economy observes a clear diminishing trend. We can say that the trend is irreversible and that more it is consolidated for some time (139 countries)[7]

Countries excluded from the analysis: countries for which World Bank do not provide data (13 countries)[8].

Table 1: Average manufacturing to GDP ratio with respect to the peak point

Countries Type A	Countries Type B	Countries Type C	Countries Type D
8,42%	7,9%	5,2%	73%
(16 countries)	(15 countries)	(10 countries)	(139 countries)

Source: own calculations and World Bank Database

[7]*Between 10% and 20% lower* (45): Afghanistan, Algeria, Angola, Azerbaijan, Bahamas, Belarus, Benin, Cambodia, Cameroon, Costa Rica, Cote d'Ivoire, Croatia, Dominican Republic, El Salvador, Estonia, Ethiopia, Fiji, Guinea, Hondura ,Kazakhstan, Madagascar, Malaysia, Mali, Mauritania, Mauritius, Mexico, Mongolia, Montenegro, Morocco, Norway, Papua New Guinea, Philippines, Poland, Portugal, Sao Tome and Principe, Serbia, Singapore, St. Kitts and Nevis, Suriname, Syrian Arab Republic ,Tonga, Trinidad and Tobago, Tunisia, Turkey, Venezuela RB.

More than 20% lower (94): Albania, Antigua and Barbuda, Argentina, Armenia, Australia, Austria, Bahrain, Barbados, Belgium, Belize, Bermuda, Bosnia and Herzegovina, Botswana, Brazil, Brunei Darussalam, Bulgaria, Burundi, Cabo Verde, Canada, Central African Republic, Chad, Chile, Comoros, Congo Dem. Rep., Cuba, Cyprus, Denmark, Djibouti, Dominica, Finland, France, Georgia, Germany, Greece, Grenada, Guinea-Bissau, Guyana, Iceland, Ireland, Italy, Jamaica, Japan, Kiribati, Kyrgyz Republic, Latvia, Lebanon, Lesotho, Liberia, Lithuania, Luxembourg, Macedonia FYR, Malawi, Malta, Moldova, Mozambique, Namibia, Nepal, Netherlands, New Zealand, Niger, Nigeria, Oman, Pakistan, Palau, Paraguay, Romania, Russian Federation, Rwanda, Saudi Arabia, Seychelles, Sierra Leone, Solomon Islands, Somalia, South Africa, Spain, St. Lucia, St. Vincent and the Grenadines, Sudan, Sweden, Switzerland, Tajikistan, Togo, Turkmenistan, Tuvalu, Uganda, Ukraine, United Arab Emirates, United Kingdom, United States, Uruguay, Uzbekistan, Vanuatu, Zambia, Zimbabwe.

[8] Andorra, Equatorial Guinea, Gambia, The Haiti, Iraq, Israel, Korea Dem. Rep., Liechtenstein, Marshall Islands, Monaco, Samoa, San Marino, South Sudan.

The results are very clear in the sense that a huge majority of countries are in the era of the decline in manufacturing, up to 78.2% (type C and D). Furthermore, these countries represent a large fraction of the global GDP. All developed countries are included in types C and D.

An interesting finding related to this process is that the industry does not expect to reach a predetermined maximum weight with respect to GDP to begin its descent. While it seemed that there existed a somewhat predetermined peak point (around 40% of GDP) for developed countries before to start the decline, the peak point when we account for all countries greatly varies.

3. How fast is the manufacturing sector shrinking?

Knowing what is the trend and speed that takes structural change in the manufacturing sector is useful to determine future projections in the weight of manufacturing to total GDP and to know how fast the APGR would be approaching to the values of the SSPGR.

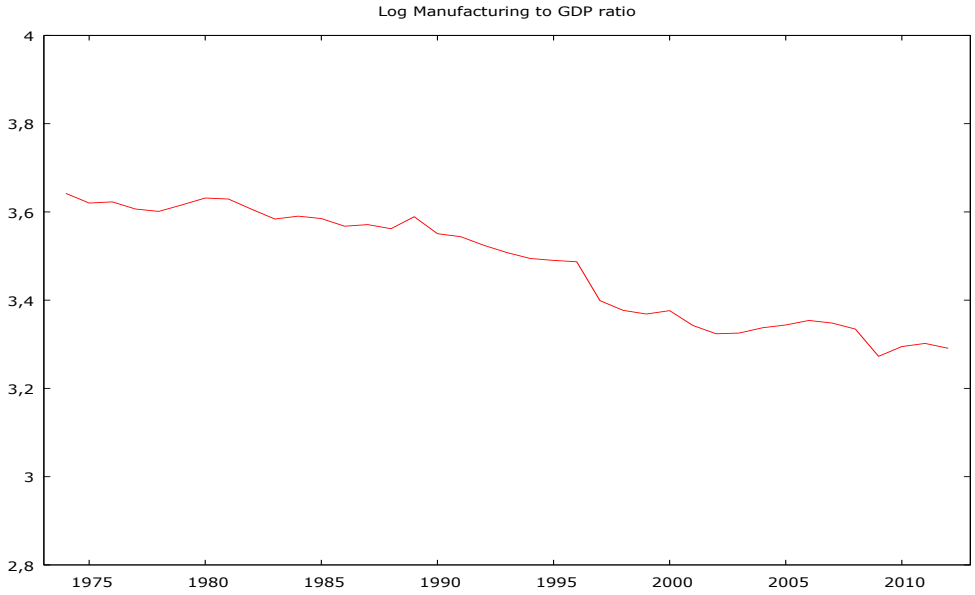


Figure 4 Time series of the downward part of the world manufacturing to GDP ratio
Source: own calculations and World Bank data

As we can see from time series shown in figure 4 it is clearly a non-stationary series. To model it, estimate and draw forecast from the time series we need to disentangle the nature of unsteadiness. From a first superficial inspection the non-stationary could be determined by the presence of a trend or successive level shifts.

First we analyze whether the existence of a trend could be the reason of the non-stationarity. To adjust the trend we do regressions for the time period 1974-2012 and for different types of possible functional forms. Here y_t is the manufacturing to GDP ratio, t is a variable of time and u_i is the error term.

Table 2: analysis of the regressions with different possible functional forms

Functional Form	Performance	Results
$y_t = B_0 + B_1 t + u_i$	Linear trend with an intercept B_0 and slope B_1	B_0 =39,4 p-value=2,31e-023 *** R^2= 0,93 DW=0,42
$\Delta y_t = B_0 + u_i$	First differences, linear trend with slope B_0. Helps us to control for autocorrelation.	B_0 =−0,29 p-value=0,0109 ** DW=2,053
$y_t = B_0 + B_1 t + B_2 t^2 + u_i$	Quadratic trend. Depending on the sign of coefficients increasing or decreasing effects of time variable.	B_0 =38,8 B_1= −0,249 p-value=0,0002 *** B_2 =−0,0023 p-value=0,1223 R^2= 0,937 DW=0,45
$\log(y_t) = B_0 + B_1 t + u_i$	Exponential trend. An increase in one unit of time implies a B_1x100% increase in y.	B_0 =3,68 B_1= −0,01 p-value=1,14e-022 *** R^2= 0,927408 DW=0,40
$\Delta\log(y_t) = B_0 + u_i$	Exponential trend in first differences. An increase in one unit of time implies a B_0x100% increase in$y$.	B_0 =−0,0092 p-value=0,00126 ** DW=2,03

The functional form that shows a lower p-value and avoids the presence of autocorrelation is:

$$\Delta\log(y_t) = B_0 + u_i$$

From the regression we have obtained an statistically significant coefficient of -0,0092 (at a 5% significance level). From the economic point of view the value of the coefficient -0,0092 means that for each year since 1974, where the manufacturing sector reached the peak point, manufacturing has lost every year an average of 0.92% of their ratio to total GDP.

Now we are ready to analyze in more detail the time series figure:

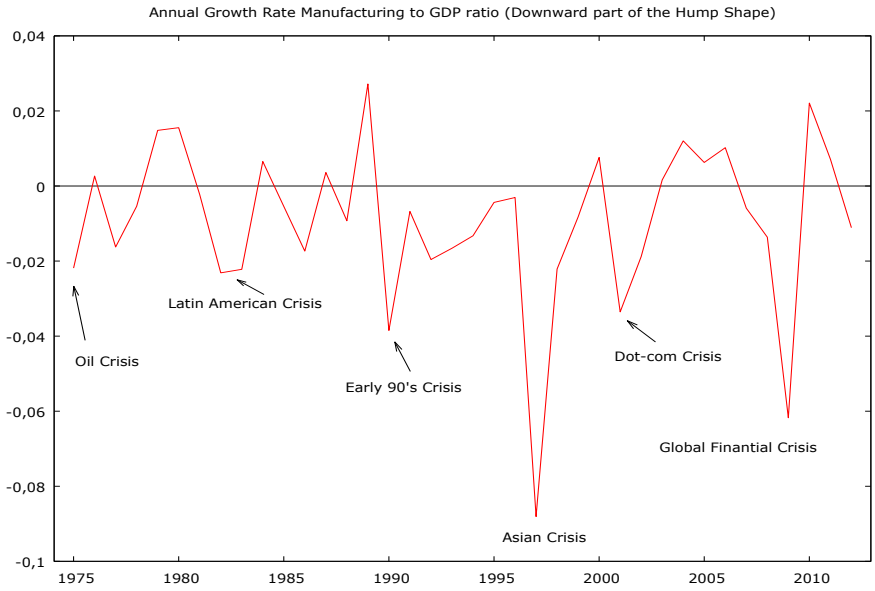


Figure 5 Annual growth rate manufacturing to GDP ratio since 1974
Source: own calculations and World Bank data

Observing in detail figure 5 it can be drawn some interesting issues. First we can see how for the years that coincides with an economic crisis manufacturing sector loss considerable weight. This means that during the period of the crisis the decline in GDP by manufacturing is larger in relative terms than in the service sector. However, in the years after the crisis and until a new crisis occurs the share of manufacturing in GDP seems unchanged and oscillating around a 0 mean. Could it be that the adjustment in the weight of manufacturing was an abruptly process from shocks produced by crisis?

It becomes necessary to contrast this hypothesis empirically. It is clear that a larger weight is lost in manufacturing sector coinciding with shocks caused by crises[9]. Thus we can control the regression for these shocks incorporating shift level dummies (one dummy for each crisis, adopting a value of 0 before the crisis and a value of 1 from the crisis). The regression is performed in log-levels:

$$\log(y_t) = B_0 + B_1 t + B_2 DSL75 + B_3 DSL\,83 + B_4 DSL90 + B_5 DSL92 + B_6 DSL97 + B_7 DSL98 + B_8 DSL01 + B_9 DSL09 + u_i$$

[9] 1975 Oil Crisis, 1983 Latin American Debt Crisis, 1990 US Savings & Loans Crisis, 1992 Speculative attacks on European Currencies, 1997-98 Asian Crisis, 2001 Dot-com Crisis and 2008/09 World Financial Crisis.

Table 3: regression in log-levels for the time series of the downward part of the manufacturing hump shape

Dependent variable: d_l_ MantoGDPratio74/12

	Coeficient	*Desv. Típica*	*t-ràtio*	*Valor p*	
const	3,6422	0,0116427	312,8313	<0,00001	***
LS75	−0,0242568	0,0131287	-1,8476	0,07488	*
LS83	−0,0364208	0,00971896	-3,7474	0,00079	***
LS90	−0,0301183	0,0103686	-2,9048	0,00696	***
LS92	−0,045726	0,0103385	-4,4229	0,00013	***
LS97	−0,101061	0,0130677	-7,7337	<0,00001	***
LS98	−0,0245981	0,0135465	-1,8158	0,07975	*
LS01	−0,0338447	0,00964745	-3,5082	0,00149	***
LS09	−0,0472439	0,00937211	-5,0409	0,00002	***
Time	**−0,000235632**	0,00101917	-0,2312	**0,81878**	

R-quadrat 0,993526 R-quadratajustat 0,991516

From the analysis of the regression we can find a very interesting result. Once we control for the significant shocks caused by crisis (8 out of 39 years) it is not observed any tendency in the evolution of the manufacturing to GDP ratio growth rate. We cannot reject the null that the parameter of interest B_1 is equal to 0 with a large p-value of 0,81. This means that in periods between crises manufacturing ratio is growing similar to that of total GDP, and weight loss in manufacturing occurs from shocks caused by crises not offsets in subsequent periods.

We can also calculate averages of manufacturing to GDP growth rate ratios for the between crisis periods to be confident about this statement.

Table 4: average of manufacturing to GDP growth rate ratios, between crisis periods

Period	Average Manufacturing to total GDP ratio growth rate
1976 to 1980	0,15%
1984 to 1989	0,09%
1995 to 1996	-0,37%
1999 to 2000	-0,02%
2002 to 2007	0,09%
2010 to 2012	0,61%
Total Average Inter-Crisis Periods	0,09%

Source: own calculations from World Bank data

As table 4 shows the average growth rate is positive for four periods and only for two periods is a little bit negative. Furthermore when we account the average of manufacturing to GDP growth rate in all the periods between crises this value is in fact positive. So from both the regression and from this calculation we can conclude that there is not any structural change in manufacturing sector in periods between crises.

This finding can help us to better understand what the engine of structural change is. In recent years two different proposals emphasize different economic forces behind structural transformation, Kongsamut et al (2001) and Ngai and Pissarides (2007). The Kongsamut model assumes that different income-elasticities in agriculture, manufacturing and services are the engine of structural change, while the Ngai and Pissarides (2007) model poses that changes in relative prices and the fact that agriculture, manufacturing and services are complementary goods (price elasticity <1) are the cause of structural change.

In the model Ngai and Pissarides (2007) while changes in relative prices occurs from different ratios of productivity growth across sector (it is assumed that productivity growth for each sector is constant). From this model it is expected gradual structural change. This implies a linear or exponential structural change trend type, but not abrupt and sudden adjustments.

Since our calculations are made based on the deflated value added, the structural change represented in figure 4 only express changes in real variables. To properly contrast the data with this model that takes into account the change in relative prices as the driver of structural change data would have been represented on the basis of nominal values.

Nevertheless, I think of two hypotheses can be raised to explain the structural change performance in the ratio of manufacturing. The first is based on the Kongsamut model that assumes homotheticity of the manufacturing demand as income grows (and non-homotheticity for the agriculture and services demand). A possible extension that could draw the "staircase" showed by structural change would be devised assuming manufacturing demand with respect to income as non-homothetic in times of crisis and as homothetic in periods between crises.

Thus, in periods between crises actual consumption of manufactured goods would grow at the same rate than total consumption while in periods of economic crisis manufacturing consumption would decrease more abruptly than total consumption. In this respect it is known that in times of crisis the consumption of durable goods are particularly affected, Engel et al. (2011). Also following a similar reasoning the hump shape could be explained by applying a somewhat measure of saturation with respect to consumption in manufacturing goods assuming that on average income increases steadily.

The other hypothesis that could be launched is that a combination of both models explains the performance of the structural change. We can think of periods of economic growth as periods where the manufacturing prices do not adjust downward to increases in relative manufacturing productivity. When a shock and a crisis occurs as relative prices of manufacturing are higher than its equilibrium level, manufacturing consumption suffers from a dramatic break down (higher than the average reduction in consumption). The relative prices then adjust rapidly to allow for an increase on sales and when the real manufacturing consumption gradually achieve the prior levels, as manufacturing prices have decreased in relative terms, at the end of the adjustment the nominal value of the manufacturing consumption represents a lower manufacturing to GDP ratio.

In the transition until the end of the adjustment the increase in real manufacturing consumption is higher than the average increase in consumption in order to offset for the break down but to the extent that manufacturing relative prices have dropped, the nominal value of manufacturing consumption increases at the same rate of average consumption, so the share of manufacturing in GDP remains constant during the transition.

Finally, when the economy starts a new period of economic expansion prices became again sticky and these will not adjust until the next shock, reinforcing the fact that manufacturing to GDP ratio remains constant until the following crisis.

Let us work for future empirical and theoretical studies able to contrast this hypothesis.

3.1 A possible forecast

We can also face a possible forecast of manufacturing to GDP ratio, for instance 18 years from 2012. In doing so we look at the trend found in the first regression of this section:

$$\Delta\log(Manuf\ to\ GDP\ ratio_t) \approx -0{,}92\% + u_i$$

To the extent that we cannot know with certainty the future shocks that will lead to a sharp adjustment of the manufacturing ratio, we assume that future shocks will be distributed in a similar way that prior ones. Then the average weight loss of manufacturing will be placed around the 1% per year on average. The weight loss of approximately 1% annual in manufacturing to GDP ratio puts us in projections for the next eighteen years:

Table 5 : manufacturing to GDP ratio forecast

Year	Ratio forecast	Year	Ratio forecast
2013	26,59	2022	24,29
2014	26,33	2023	24,05
2015	26,06	2024	23,81
2016	25,80	2025	23,57
2017	25,54	2026	23,33
2018	25,293	2027	23,10
2019	25,04	2028	22,87
2020	24,79	2029	22,64
2021	24,54	2030	22,42

Source: own calculations

The prediction is that in the next 18 years world manufacturing will lose approximately four percentage points to GDP ratio. Will this lose in the share of manufacturing weaken the APGR to the extent that SSGR is lower than MPGR? We address the answer to this question in the next section.

4. Is the productivity growth rate in services constant?

In this section we address the key issue of whether SSPGR is constant over time or not. This is a crucial issue in our analysis. From the above results we can assume that APGR is gradually approaching the values of SSPGR insofar agriculture and manufacturing lose weight in favor of services.

Although it may seem to be the contrary that fact does not necessarily mean that APGR decreases over time. The APGR may not decrease if the SSPGR and MPGR were not constant and increased (one or both) up to compensate for the weight loss in manufacturing.

The issue is, how can we determine if SSPGR and MPGR have a constant, increasing or decreasing trend? The way is by making a disaggregation of the services and manufacturing sectors on subsectors and analyze whether these subsectors have different productivities and whether are driven by patterns of structural change. In the presence of structural change at the subsector level and if it is the case that subsectors by expand their weight in the GDP are more productive than the sector average, the sector as a whole will gain productivity to the extent that when calculating the weighted average productivity growth rate these subsectors also would account for a higher weight and for a higher productivity weight. If this increase will be enough to avoid falls in APGR will depend on the magnitude and on the speed of the manufacturing decline.

We are ready to address the empirical analysis to verify whether reality approaches any of these scenes or not. I proceed as follows: for the 39 United Nation members[10] included in the World Input-Output database (WIOD) we obtain for the three broad sectors and for the period 1995-2009 the total value added, price levels of gross value added (base 1995), and total hours worked by persons engaged. We also obtain the same data for the 17 subsectors[11] in which the

[10] Australia, Austria, Belgium, Brazil, Bulgaria, Canada, China, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, India, Indonesia, Ireland, Italy, Japan, Korea, Republic of Latvia, Lithuania, Luxembourg, Malta, Mexico, Netherlands, Poland, Portugal, Romania, Russia, Slovak Republic, Slovenia, Spain, Sweden, Taiwan, Turkey, United Kingdom, United States.

[11] Sale, maintenance and repair of motor vehicles and motorcycles, retail sale of fuel; Wholesale trade and commission trade, except of motor vehicles and motorcycles; Retail trade, except of motor vehicles and motorcycles, repair of household goods; Hotels and restaurants; Other inland transport; Other water transport; Other air transport; Other supporting and auxiliary transport activities; Activities of travel agencies; Post and telecommunications; Financial intermediation; Real estate activities; Renting of m&eq and other business activities; Public admin and defense, compulsory social security; Education; Health and social work; Other community, social and personal services; Private households with employed persons.

service sector is disaggregated and the 17 subsectors[12] in which de manufacturing sector is disaggregated. These 39 countries represent more than 90% of the global economy.

With these data I calculate the deflated value added for the 39 countries, the labor productivity per hour worked and the average growth in productivity by sectors and subsectors for the period 1995-2009. It is also calculated the share of each sector and subsector to GDP for each year of the series to assess patterns of structural change in the period 1995-2009.

Once made these calculations I can add data for the whole 39 countries to obtain a weighted average of all these variables. This weighted average values are a good proxy of the world as a whole as these countries represent more than 90% of the global economy. To calculate the global weighted average I determine the weight for each country dividing the country GDP by the sum of the GDP of these 39 countries. Then all variables are multiplied by this ratio and added up the weighted values for each variable. For example, to calculate the weighted average of global SSPGR for the period 1995-2009:

$$World\ Weighted\ Average\ SSPGR_{1995-2009} = \sum_{i=1}^{39} \left(SSPGR_i * \frac{GDP_i}{\sum_{n=1}^{39} GDP_n}\right)$$

$$\text{where} \quad \sum_{i=1}^{39} \frac{GDP_i}{\sum_{n=1}^{39} GDP_n} = 1$$

In this way I proceed with all variables of interest. With regard to the sectoral productivity growth and the sector to GDP ratio we obtain the following results:

[12] Mining and quarrying; Food , beverages and tobacco; Textiles; Leather and footwear; Wood and and cork; Pulp, paper, printing and publishing; Coke, refined petroleum and nuclear fuel; Chemicals and chemical; Rubber and plastics; Other non-metallic mineral; Basic metals and fabricated metal; Machinery; Electrical and optical equipment; Transport equipment; Manufacturing nec, recycling; Electricity, gas and water supply; Construction.

Table 6 : World sector weighted average productivity growth rates and sector to GDP ratio (in %)

Variable	Agriculture	Manufacturing	Services	Total
Av. Productivity growth 1995-2009	3,98	2,91	1,95	2,27
Sector to GDP ratio 1995	4	29,7	66,3	100
Sector to GDP ratio 2002	3,5	28,4	68,1	
Sector to GDP ratio 2009	3,02	27	70	100

Source: own calculations from WIOD data

These results vary somewhat quantitatively compared to those obtained in Duarte and Restunica (2010) for a sample of 29 countries for the period 1956-2004: agriculture (4%), manufacturing (3.1%) and in services (1.3%). In agriculture and manufacturing are very similar but differ significantly on services productivity as is higher in the sample here analyzed. This could be explained by the increased productivity of the service sector in the period 1995-2009 compared to the 1956-2004 period. Financial intermediation services as well as telecommunications have experienced in recent years a significant increase in productivity that the results by Restunica and Duarte (2010) collected only partially.

A first conclusion can be drawn from these results is that the service sector has increased its productivity over the last two decades and therefore we can say that SSPGR has not been constant. In contrast, productivity in the manufacturing sector shows an approximate constant trend. Now we are interested in examine whether the future global productivity of the service sector will grow and what may be the behavior of the manufacturing productivity. First we look at whether there are patterns of structural change within the subsectors of the services sector.

4.1 Structural change at the subsectoral level

First we look at possible structural change patterns within the paths of the subsectors of the services sector.

Table 7: Evolution of the services subsectors (as a share of GDP)

(In green the subsectors that increases their ratio to GDP in both periods 95-01 and 02-09, in orange the subsectors that maintains constant their ratio to GDP)

Subsector	1995 GDP (%)	2002 GDP (%)	2009 GDP (%)	Av PGR 95-09
Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of fuel	1,32	1,34	1,49	2,57
Wholesale trade and commission trade, except of motor vehicles and motorcycles	6,21	7,45	7,93	4,17
Retail trade, except of motor vehicles and motorcycles; repair of household goods	5,63	5,93	5,74	2,83
Hotels and restaurants	2,63	2,63	2,40	0,45
Other Inland transport	2,59	2,47	2,28	1,31
Other Water transport	0,22	0,28	0,38	7,31
Other Air transport	0,45	0,41	0,40	5,95
Other Supporting and auxiliary transport activities; activities of travel agencies	1,15	1,16	1,21	1,61
Post and telecommunications	2,31	3,08	3,82	6,32
Financial intermediation	6,04	6,45	7,02	3,44
Real estate activities	9,66	9,37	9,70	0,73
Renting of m&eq and other business activities	8,02	9,21	10,23	1,92
Public admin and defence; compulsory social security	8,00	7,13	7,14	1,17
Education	3,27	2,98	2,78	-0,16
Health and social work	5,18	4,93	5,52	0,93
Other community, social and personal services	3,53	3,31	3,29	0,55
Private households with employed persons	0	0	0	0,00

Source: own calculations from WIOD

From table 7 we can see that for most subsectors patterns of structural change are clear in the sense that these subsectors grow or decrease on a continuous basis over time (in both periods 1995-2002 and 2002-2009). Only three subsectors maintain a relatively constant trend: Health and social work, Real estate activities, Retail Trade.

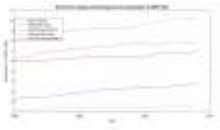
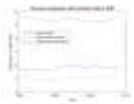


Figure 6 Structural change of growing services subsectors to GDP ratio
Source: own calculations from WIOD data



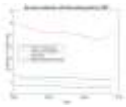


Figure 7 Services subsectors with constant and decreasing ratio to GDP
Source: own calculations from WIOD data

Through simple calculations we can realize that the weight in the service sector of these increasing subsectors is of 46% while the subsectors that loss weights represent 23% and the subsectors that remain constant are approximately 30% of the service sector. The fact that the sectors that gain weight or remain constant represent a 76% of the service sector trigger that the services sector gains weight with respect to GDP as a whole.

Now we look at whether there are structural changes in the manufacturing sub-sector.

Table 8: Evolution of manufacturing subsectors (as a share of GDP)

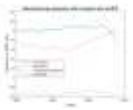
(In green the subsectors that increases their ratio to GDP in both periods 95-01 and 02-09, in orange the subsectors that maintains constant their ratio, in red the subsectors that decreases their ratio)

Manufacturing Subsector	1995 GDP (%)	2002 GDP (%)	2009 GDP (%)	Av PGR 95-09
Mining and quarrying	1,61	1,38	1,24	0,93
Food , beverages and tobacco	2,56	2,33	2,08	1,24
Textiles and textile	1,17	0,97	0,75	2,62
Leather and footwear	0,18	0,15	0,11	3,56
Wood and cork	0,50	0,44	0,34	2,08
Pulp, paper, paper , printing and publishing	1,75	1,54	1,31	2,34
Coke, refined petroleum and nuclear fuel	0,59	0,59	0,65	7,59
Chemicals	2,00	2,09	1,94	3,84
Rubber and plastics	0,83	0,83	0,73	2,48
Other non-metallic mineral	0,94	0,83	0,67	2,61
Basic metals and fabricated metal	2,61	2,36	2,04	1,81
Machinery	1,74	1,56	1,70	4,42
Electrical and optical equipment	2,34	3,54	4,82	8,62
Transport equipment	1,98	2,09	1,87	3,42
Manufacturing nec; recycling	0,65	0,69	0,61	5,97
Electricity, gas and water supply	2,48	2,24	2,17	4,51
Construction	5,68	4,98	4,36	-0,07

Source: own calculations from WIOD data

From the data we can observe in most subsectors of the manufacturing sector are observed patterns of structural change in the sense that growing or decreasing is a persistent behavior (in both periods 1995-2002 and 2002-2009). Only four subsectors maintain a relatively constant trend: Chemical, Machinery, Transportation and Construction equipment.

Figure 8 Structural change of manufacturing subsectors with decreasing ratio to GDP
Source: own calculations from WIOD data



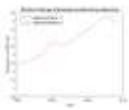


Figure 9 Manufacturing subsectors with constant and increasing decreasing ratio to GDP
Source: own calculations from WIOD data

The weight in the manufacturing sector of decreasing is about 57% while the sectors that remain constant represent 22.7% and subsectors that gains weight are the 20'3% of the manufacturing sector. The fact that in the manufacturing sector the subsectors that lose weight or remain constant represent 79.7% is what drives the manufacturing sector as a whole to diminish their GDP.

4.2 Subsectoral structural change and predicted productivity growth rate

A way to predict trends in sectoral productivity growth is analyzing which is the weighted average productivity growth of the subsectors that gain weight to GDP. For these subsectors of the services sector the average is 2.59 percent, well above the services productivity growth of 1.95 per cent. Insofar, as these subsectors will acquire more weight in the services sector they will able to push the service sector towards higher productivity.

For the manufacturing sector the weighted average productivity growth for the subsectors that gains weight with respect to GDP is 9.66 per cent (very high, especially for electronic equipment productivity) and clearly above the productivity of the manufacturing sector of 2.91 percent. Insofar as these subsectors will expand their weight in the manufacturing sector it will be pushed toward higher productivity (of course a sufficient condition is that subsectors that lose weight do not drop even more their low average productivity growth).

Therefore, from the analysis of the dynamics of structural change in the subsectors level it can be posed the important statement that both the service and manufacturing sector possibly will tend to increase their productivity growth rate in the future. This finding is relevant to the extent that this future expected growth in productivity ratios can offset the negative effect on APGR of the reduction in the weight of manufactures.

In fact it is what has happened since 1995. Table 9 shows how the productivity growth of manufacturing and services sectors has allowed APGR to not diminish despite the global structural change.

Table 9 : global services sector and aggregate productivity growth rate (periods 1996-2001 and 2002-2009)

Services Sector productivity growth rate	Manufacturing productivity growth rate	Aggregate productivity growth rate
1996-2001: 1,92 2002-2009: 1,98	1996-2001: 2,8 2002-2009: 3	1996-2001: 2,26 2002-2009: 2,32

Source: own calculations from WIOD data

From what we observe for the period 1995-2009 and from we can expect in the future from the patterns of subsectors structural change, we can conclude that the balanced growth path the classic models embody is sufficiently proven empirically and probably will remain valid in the future.

5. Do countries with larger manufacturing to GDP ratio grow at higher rates?

In this section we go down from the global level to the country level to look for causal relation between larger share of manufacturing in GDP and GDP per capita growth rate.

We address this section calculating the average GDP per capita growth and the average of the share of manufacturing in GDP for the period 1998-2008 (prior to the economic crisis to avoid the effects of shocks and because we have more data for this period) for all countries excluding the oil countries and mainly tourist countries with always less than 20% of GDP devoted to manufacturing, and proceed to the following regression:

$$y_i = B_0 + B_1 x_{1i} + B_2 x_{2i} + u_i$$

Where y_i is the average GDP per capita growth rate for the period 1998-2008, x_{1i} is the average of the manufacturing to GDP ratio for the period 1998-2008, x_{2i} is the log level GDP per capita in 1999 (that allows us to control for the fact that larger distances from steady state implies higher growth rates), and u_i are the residuals or effects of unobserved variables.

Table 10: Testing the Manufacturing to GDP ratio and GDP per capita growth rate relation

Dependent variable: AllCGDPpercapitaGRAv9908 (n = 114)

	Coeficient	*Desv. Típica*	*t-ràtio*	*Valor p*	
const	2,05155	1,54164	1,3308	0,18599	
AllCMantoGDPAv9908	0,0962039	0,0333862	2,8815	0,00475	***
l_AllCGDPperCapita1999	−0,223439	0,14002	-1,5958	0,11338	

Source: own calculations from WIOD data

From the previous regression a concern arises in relation to compliance with the exclusion restriction E [u | x] = 0. To the extent that higher levels of industrialization could be correlated with a lower population growth rate which in turn would cause a greater increase in the growth rate of GDP per capita. The correlation between industrialization and lower population growth rate has been studied in the quality-quantity leading model Galor and Weil (1999, 2000), which

explains that the demographic transition occurs in an industrial and technological environment where the families reduce the number of children and invest more in their education.

Thus in the previous regression the coefficient B_1 could be overestimated and would not fulfill the ceteribus paribus requirement and causation would not be properly established. So we do a new regression controlling for population growth rate of each country.

Table 11: Regression controlled for population growth rate

Dependent variable: AllCGDPpercapitaGRAv9908 (n = 114)

	Coeficient	*Desv. Típica*	*t-ràtio*	*Valor p*	
const	7,30701	1,60664	4,5480	0,00001	***
AllCMantoGDPAv9908	0,08127	0,0292386	2,7795	0,00640	***
l_AllCGDPperCapita1999	−0,643824	0,140944	-4,5679	0,00001	***
AllCPopGRAv9908	−1,27649	0,213377	-5,9823	<0,00001	***

R-quadrat	0,313237	R-quadrat ajustat	0,294507

Source: own calculations from WIOD data

From this more accurate regression we actually get a slightly lower coefficient of 0.084 instead of 0.091, but the new regression increases significantly the R^2 and p-value is reduced significantly. As we can see from the table 11 and figure 10 the results show a significant coefficient relating variation in the ratio of GDP to GDP per capita growth rate. The value of the coefficient means that when manufacturing ratio increases one percentage point the GDP per capita growth rate increases by a 0.084 percentage points. In other words, a difference of ten percentage points in the weight of manufacturing between two countries would imply a 0,84 percentage point less in GDP growth rate for the less industrialized country.

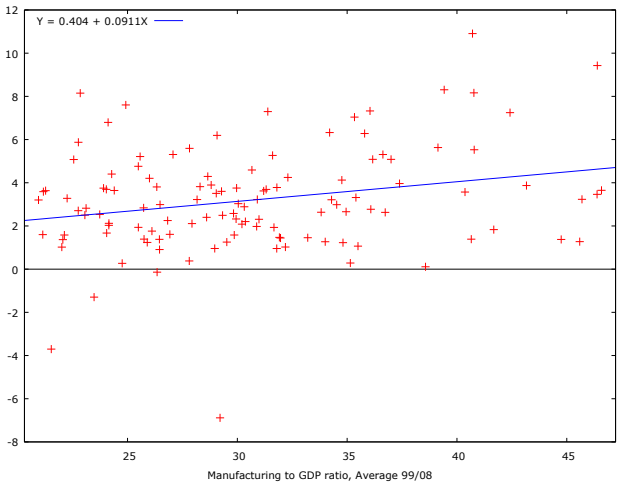


Figure 10 Correlation between GDP per capita growth rate and Manufacturing to GDP ratio (Av. 99-08)
Source: own calculations from World Bank data

We run the same regression for the seventeen[13] most developed countries:

Table 12: developed countries

Dependent variable: GDPpercapitaGRAv98/08					
	Coeficient	*Desv. Típica*	*t-ràtio*	*Valor p*	
const	−1,73524	1,51197	-1,1477	0,26908	
ManGDPratioDevC	**0,134431**	0,054318	2,4749	0,02575	**
R-quadrat	0,289945	R-quadratajustat		0,242608	

Source: own calculations from World Bank data

[13] Australia, Austria, Belgium, Denmark, Finland, France, Germany, Iceland, Italy, Japan, Netherland, Poland, Spain, Sweden, Switzerland, United Kingdom, United States.

We can also show the corresponding correlation graphic between GDP per capita growth rate and manufacturing to GDP ratio for the developed countries:

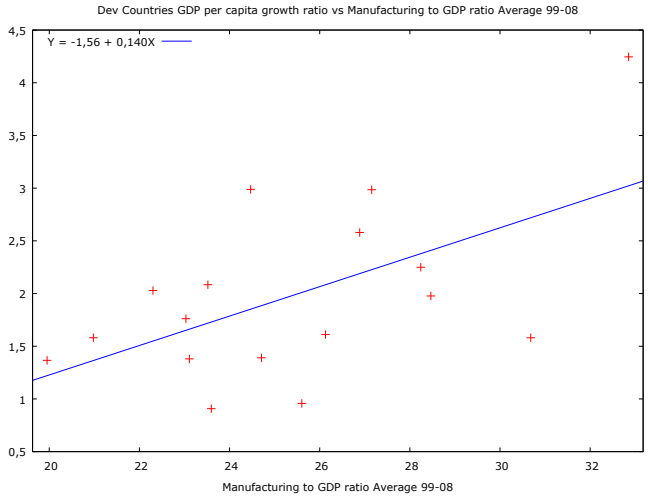


Figure 11 Correlation between Manufacturing to GDP ratio and GDP per capita growth rate (1999-2008) developed countries. Source: own calculations from World Bank data

Here the results show the same qualitatively, but quantitatively the coefficient is economically more significant and increases until 0.13. Among developed countries large manufacturing to GDP ratio implies higher increase in GDP per capita growth rate than when we analyze altogether all the countries of the world. With respect to developed countries the results do not change when we control for population growth rate or initial GDP per capita level as the values of these variables are similar among developed countries.

These regressions denote that those countries able to maintain a high level of industrialization will maintain higher economic growth ratios. When we take the global economy as a unique economy the weight loss of manufacturing is an irreversible fact, but that does not necessarily occur in all countries in the same way and at the same speed. Aspects such as economic specialization, international trade or consumer preferences may determine that a country holds a higher industrialization level than others. This is for instance the Korea's case.

Similarly, in the global economy the decline in manufacturing does not mean necessarily that APGR will be affected, but at the country level, as the regression

do not account for weighted average[14] and instead each country accounts the same in the regression, it seems that the rate of manufacturing in GDP is actually relevant for the evolution of the APGR and the GDP per capita growth rate.

[14] For instance US accounts for 30% of the global economy, so what is happening only in the US can fairly influence the weighted average.

Conclusions

The empirical work carried out by this article has enabled to first determine a pattern of structural change in the world taken it as a single economy. This has allowed to know that the world entered the era of the decline of the manufacturing some decades ago, concretely in the mid 70th began the decline of manufacturing to GDP ratio.

Secondly, an analysis of the structural change phenomenon in all countries of the world has allowed in determining that about 90% of the countries are in the downward phase of the manufacturing hump shape and that there is not a minimum peak point that has to be reached prior to begin the decline in manufacturing. The level that manufacturing reaches prior the onset of the diminishing trend greatly varies between countries.

Third, it has been addressed the impact of structural change in the global aggregate productivity growth rate. The loss of weight for manufacturing with respect to services and the fact that manufactures have a greater ratio of productivity than services, can lead to think of structural change as forcing a decrease in APGR. Empirical data do not confirm this harsh prognosis.

The reason is that in recent years both the MPGR and the SSPGR have increased offsetting the negative impact of structural change on APGR. In the future, productivity ratios of services and manufacturing probably still will go up because the subsectors that increase their relative weight in GDP are more productive than the sector average. This expected increase in productivity in manufacturing and services probably will be able to avoid a slowdown of the global APGR.

Four, at the country level we have found a correlation between the weight of the manufacturing sector in the economy and the growth of GDP per capita even controlling for initial levels of GDP and population growth rate. This indicates that apart from what occurs in aggregate levels for most countries structural change can affect the APGR.

Five, the article address a careful analysis of the downward part of the manufacturing hump shape and it is clear that structural change does not occur with trend but through continuous shocks that impact in periods of economic crisis. This finding suggests extensions of the main theoretical models that explain the structural change. On the one hand through the incorporation of non-homothetic preferences in consumption of manufactured goods in times of crisis

and on the other through the incorporation of some measure of stickiness in prices during periods of economic growth.

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APPENDIX

World manufacturing ratio to total GDP 1962-2012

Year	Ratio manufacturing to total GDP	Percentage increase/decrease	Remarkable fact
1962	26,57		
1963	28,04	5,52	
1964	28,02	-0,06	
1965	30,21	7,81	
1966	31,48	4,20	
1967	30,97	-1,63	
1968	32,13	3,75	
1969	33,27	3,56	
1970	35,89	7,87	
1971	37,02	3,14	
1972	37,05	0,08	
1973	37,63	1,56	
1974	38,17	1,43	Peak Point of the Hump Shape
1975	37,34	-2,16	Oil Crisis
1976	37,44	0,27	
1977	36,84	-1,61	
1978	36,64	-0,54	
1979	37,19	1,49	
1980	37,77	1,57	
1981	37,68	-0,23	
1982	36,82	-2,29	Latin American Debt Crisis
1983	36,01	-2,20	Latin American Debt Crisis
1984	36,25	0,66	
1985	36,05	-0,54	
1986	35,43	-1,72	
1987	35,56	0,36	
1988	35,23	-0,92	
1989	36,20	2,76	
1990	34,84	-3,78	Early 90's Crisis (US savings&loansCrisis)
1991	34,60	-0,67	
1992	33,93	-1,94	Speculative attacks on European currencies
1993	33,37	-1,64	Speculative attacks on European currencies
1994	32,93	-1,32	
1995	32,79	-0,44	
1996	32,69	-0,31	
1997	29,93	-8,43	Asian Financial Crisis
1998	29,28	-2,19	Assian Financial Crisis
1999	29,04	-0,82	
2000	29,26	0,76	
2001	28,29	-3,30	Bursting of dot-com bubble
2002	27,77	-1,86	
2003	27,81	0,16	
2004	28,15	1,21	
2005	28,33	0,63	
2006	28,62	1,03	
2007	28,45	-0,59	
2008	28,06	-1,35	Global Financial Crisis
2009	26,38	-5,99	Global Financial Crisis
2010	26,97	2,24	
2011	27,17	0,72	
2012	26,87	-1,10	