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Is Manufacturing Still an Engine of Growth in Developing Countries?

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Abstract

Since the middle of the eighteenth century, manufacturing has functioned as the main engine of economic growth and development. However, in recent research, questions have been raised concerning the continued importance of the manufacturing sector for economic development. This paper reexamines the role of manufacturing as a driver of growth in developing countries in the period 1950-2005.

The paper makes use of a newly constructed panel dataset of annual value added shares (in current prices) for manufacturing, industry, agriculture and services for the period 1950-2005. Regression analysis is used to analyse the relationships between sectoral shares and per capita GDP growth for different time periods and different groups of countries. Besides an analysis of the contribution of manufacturing to growth, we also examine the contribution of manufacturing and services to growth accelerations, using a modified version of the Hausmann, Pritchett and Rodrik definition of growth accelerations. The empirical analysis is generally consistent with the engine of growth hypothesis. The role of manufacturing seems to be of particular importance during growth accelerations.

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1 Introduction:

This paper addresses the question of the importance of manufacturing for economic development. In the older development economics literature, there was a near consensus that manufacturing was the high road to development. Success in economic development was seen as synonymous with industrialization. This consensus now seems to be unravelling. In advanced countries, service sectors account for over two thirds of GDP. This alone gives the service sector a heavy weight in economic growth. In developing countries the share of services is also substantial. It is now argued that services sectors such as software, business processing, finance or tourism may act as leading sectors in development and that the role of manufacturing is declining in developing economies. The prime exemplar for this is India since the 1990s. Other authors argue that it is not manufacturing as a whole that is important, but subsectors of manufacturing such as ICT (Fagerberg and Verspagen, 1999).

On the other hand, the East Asian experience documents the key role that industrialisation has played in the economic development of developing countries in the past fifty years. All historical examples of success in economic development and catch up have been associated with successful industrialisation (Szirmai, 2009).

This paper tackles these questions empirically, analysing a dataset of 90 countries, including 21 advanced economies and 69 developing countries, covering the period 1950-2005. The focus of the analysis is on the 'Engine of Growth Hypothesis' which posits that manufacturing is the key sector in economic development. We examine questions such as how important has manufacturing been in growth and catch up in developing countries in the post-war period and what can we learning from these experiences about the future role of manufacturing in development?

The paper is structured as follows. In section 2, we briefly note that till 1950, industrialization had bypassed much of the developing world. We document the subsequent process of structural change in developing countries and the increased importance of developing countries in the structure of world manufacturing. The theoretical and empirical arguments for the Engine of Growth hypothesis are summarised in section 3. Sections 4 and 5 review some of the recent contributions in the literature and develop hypotheses which guide our empirical analyses. Data and methods are discussed in section 6. The preliminary empirical results are presented in section 7. Section 8 concludes.

2 The Emergence of Manufacturing in Developing Countries

2.1 Background

Since the Industrial Revolution, manufacturing has acted as the primary engine of economic growth and development. Great Britain was the first industrialiser and became the technological leader in the world economy. From Great Britain manufacturing diffused to other European countries such as Belgium, Switzerland, and France and later to the United States. (Crafts, 1977; Bergier, 1983; Pollard, 1990; Von Tunzelmann, 1995). Famous latecomers to the process of industrialisation were Germany, Russia and Japan

What about the developing countries? From the middle of the nineteenth century onwards, the world economy had divided into industrial economies and agricultural economies (Arthur Lewis, 1978 a, b; Maddison, 2001, 2007). Colonies and non-colonised countries in the tropics remained predominantly agrarian, while the Western world and the Asian latecomer Japan industrialised. Industrial growth in the West created an increasing demand for primary products from developing countries. Technological advances in transport, infrastructure and communication expanded the opportunities for trade. Thus, the colonial division of labour came into being. Developing countries exported primary agricultural and mining products to the advanced economies. Industrial economies exported their finished manufactured goods to the developing countries. Industrialisation became synonymous with wealth, economic development, technological leadership, political power and international dominance. The very concept of development came to be associated with industrialisation. Industrialisation was rightly seen as the main engine of growth and development.

In developing countries, moves towards industrialisation were scarce and hesitant. Towards the end of the nineteenth century, one finds such beginnings in Latin American countries such as Brazil, Argentina, Chile and Mexico and large Asian countries such as India and China.[3] But developing countries still remained predominantly dependent on agriculture and mining. Arthur Lewis has argued that the shear profitability of primary exports was one of main reasons for the specialisation of developing countries in primary production. But colonial policies also played a negative role (Batou 1990). For instance, in India, textile manufacturing suffered severely from restrictive colonial policies which favoured production in Great Britain.

Whatever the reasons, the groundswell of global industrialisation, which started in Great Britain in the eighteenth century, swept through Europe and the USA and reached Japan and Russia by the end of the nineteenth century, subsided after 1900 (Pollard, 1990). With a few exceptions, developing countries were bypassed by industrialisation. The exceptions were countries such as Argentina, Brazil and South Africa which profited from the collapse of world trade in the crisis years of the 1930s to build up their own manufacturing industries, providing early examples of successful import substitution. In Asia, China and India experienced some degree of industrialisation in the late nineteenth century, but industrialisation only took off after these countries freed themselves from

[3] Around 1750, the Indian textile industry was producing around one quarter of global textile output (e.g. Roy, 2004). However, the basis of production was more artisanal than industrial. Marc Elvin (1973) even argues that China created the world's earliest mechanized industry between the 10th and the 14th century, before becoming caught in what he calls the high-level equilibrium trap resulting in centuries of stagnation.

colonialism and external domination. On the whole, the developing world remained overwhelmingly oriented towards primary production.

This started to change in 1945. After a pause of fifty years developing countries rejoined the industrial race in the post-war period (e.g. Balance, et al., 1982). Since World War II, manufacturing has emerged as a major activity in many developing countries and the shape and structure of global manufacturing production and trade has changed fundamentally. The colonial division of labour of the late nineteenth century has been stood on its head. Large parts of manufacturing have relocated to developing countries which supply industrial exports to the rich countries. Some developing countries have experienced a process of rapid catch up which was invariably tied up with successful late industrialisation (Szirmai, 2008, 2010).

2.2 Structural Change and the Emergence of Manufacturing in Developing Countries, 1950-2005

The following tables document the process of structural change in developing countries in the period 1950-2005, making use of our new dataset. Table 2 presents shares of agriculture, industry, manufacturing and services for a subsample of 29 larger developing countries. In 1950, 41 per cent of developing country GDP originated in the agricultural sector. It declined dramatically to 16 per cent in 2005. It is worth noting that the average share of services in the advanced economies was already 40 percent in 1950, far higher than the total share of industry. Thus, the pattern of structural change in developing countries differs radically from the traditional patterns of structural change, in which the rise of industry precedes that of the service sector.

In 1950, the share of manufacturing in developing countries was only 11 per cent of GDP compared to 31 per cent in the advanced economies. This is low in comparative perspective, but much higher than one would expect for countries that are just embarking on a process of industrialisation.[4] The only countries which really had negligible shares

[4] It is likely that the early national accounts for developing countries focus on the formal sector and thus will exaggerate the share of manufacturing,. They tend to underestimate informal activities and the

of manufacturing were Tanzania, Zambia and Nigeria and Sri Lanka. Latin America is by far the most industrialised region in 1950.

The average share of manufacturing increased in all developing countries between 1950 and 1980, peaking at around 20 per cent in the early eighties. Between 1980 and 2005, the share of manufacturing continued to increase in many Asian economies, but there were processes of deindustrialisation in Latin America and Africa. This was most marked in Latin American countries where the share of manufacturing declined from 24 to 18 percent on average. In the advanced economies, the share of manufacturing declined substantially from 31 percent in 1945 to 17 percent in 2005. The most important sector in 2005 is the service sector, accounting for around 70 per cent of GDP, up from 43 per cent in 1950.

In comparative perspective we observe a long-run increase in the shares of manufacturing in developing countries and a long-run contraction in the shares of manufacturing in the advanced economies. By 2005, the average share of manufacturing in the developing world is somewhat higher than in the advanced economies. But the deindustrialisation trend which characterises the advanced economies is also visible in Africa and Latin America after 1980.

agricultural sectors, even though several of the national account do present estimates of the non-monetary sectors.

Table 1: Structure of Production, 1950-2005

(Gross value added in agriculture, industry and services as percentage of GDP at current prices, 29 developing countries)

	1950 (a)				1960 (b)				1980				2005 (c)			
	AG	IND	MAN	SERV	AG	IND	MAN	SERV	AG	IND	MAN	SERV	AG	IND	MAN	SERV
Bangladesh d	61	7	7	32	57	7	5	36	32	21	14	48	20	27	17	53
China	51	21	14	29	39	32	27	29	30	49	40	21	13	48	34	40
India	55	14	10	31	43	20	14	38	36	25	17	40	18	28	16	54
Indonesia	58	9	7	33	51	15	9	33	24	42	13	34	13	47	28	40
Malaysia	40	19	11	41	35	20	8	46	23	41	22	36	8	50	30	42
Pakistan	61	7	7	32	46	16	12	38	30	25	16	46	21	27	19	51
Philippines	42	17	8	41	26	28	20	47	25	39	26	36	14	32	23	54
South Korea	47	13	9	41	35	16	10	48	16	37	24	47	3	40	28	56
Sri Lanka	46	12	4	42	32	20	15	48	28	30	18	43	17	27	15	56
Taiwan	34	22	15	45	29	27	19	44	8	46	36	46	2	26	22	72
Thailand	48	15	12	37	36	19	13	45	23	29	22	48	10	44	35	46
Turkey	49	16	11	35	42	22	13	36	27	20	17	54	11	27	22	63
Argentina	16	33	23	52	17	39	32	44	6	41	29	52	9	36	23	55
Brazil	24	24	19	52	21	37	30	42	11	44	33	45	6	30	18	64
Chile	15	26	17	59	12	41	25	47	7	37	22	55	4	42	16	53
Colombia	35	17	13	48	32	23	16	46	20	32	24	48	12	34	16	53
Mexico	20	21	17	59	16	21	15	64	9	34	22	57	4	26	18	70
Peru	37	28	15	35	21	32	20	47	12	43	20	45	7	35	16	58
Venezuela	8	48	11	45	7	43	11	50	6	46	16	49	4	55	18	40
Congo, Dem. Rep.	31	34	9	35					27	35	15	38	46	27	7	28
Cote d'Ivoire	48	13		39	48	13		39	26	20	13	54	23	26	19	51
Egypt	44	12	8	44	30	24	14	46	18	37	12	45	15	36	17	49
Ghana	41	10		49	41	10		49	58	12	8	30	37	25	9	37
Kenya	44	17	11	39	38	18	9	44	33	21	13	47	27	19	12	54
Morocco	37	30	15	33	32	26	13	42	18	31	17	50	13	29	17	58
Nigeria	68	10	2	22	64	8	4	28	21	46	8	34	23	57	4	20
South Africa	19	35	16	47	11	38	20	51	6	48	22	45	3	31	19	67
Tanzania	62	9	3	20	61	9	4	30			12		46	17	7	37
Zambia	9	71	3	19	12	67	4	21	15	42	19	43	23	30	11	47
Averages:																
Asia	49	14	10	36	39	20	14	41	25	33	22	42	13	35	24	52
Latin America	22	28	16	50	18	34	21	48	10	40	24	50	7	37	18	56
Africa	44	19	9	36	37	24	10	39	25	32	14	43	26	30	12	45
Developing countries	41	19	11	40	33	25	15	42	21	35	20	44	16	34	18	51
16 OECD countries e	15	42	31	43	10	42	30	48	4	36	24	59	2	28	17	70

Notes

a. Earliest year for which data are available: 1950, except for Morocco, Taiwan and Thailand, 1951; China and Tanzania, 1952; South Korea, 1953; Malaysia and Zambia, 1955; Ghana, Ivory Coast, 1960. Belgium, 1953, West Germany, Italy and Norway, 1951, Japan, 1952;

b China, 1962, proportions for 1960 not representative due to collapse of agriculture in great leap forward 58-60; Morocco, 1965, manufacturing share Tanzania, 1961

c Canada 2003 instead of 2005, Venezuela 2004

d. Bangladesh 1950-59, same data as Pakistan

e. Australia, Austria, Belgium, Canada, Denmark, Finland, France, (West) Germany, Italy, Japan, The Netherlands, Norway, Sweden, Switzerland, UK, USA.

Sources:

See detailed discussion of sources in Annex Table 1. The primary sources used are: UN, Yearbook of National Accounts Statistics, 1957, 1962 and 1967; Groningen Growth and Development Centre, 10 sector database, http://www.ggdc.net/index-dseries.html; World Bank, WDI online, accessed April 2008;. World Tables, 1980; OECD, 1950, unless otherwise specified from OECD, National Accounts, microfiche edition, 1971. Japan 1953 from GGDC ten sector data base

Table 2 presents average shares of manufacturing for a much larger sample of 63 developing countries, including many smaller economies. The full country data including many smaller economies are reproduced in Szirmai, 2009, Annex Table 1. Table 3 confirms the trends and patterns of table 2, though the average peak value for the share of manufacturing in 1980 is somewhat lower for all developing countries than the countries selected in table 2.

Table 2: Shares of Manufacturing in GDP in 67 Developing Countries, 1950 – 2005 (at current prices)

	1950	1955	1960	1965	1970	1975	1980	1985	1990	1995	2000	2005
Average 20 Asian countries	7.7	11.2	12.5	14.2	16.8	18.2	20.5	20.1	19.4	19.0	18.7	20.1
Average 25 Latin America countries	15.1	15.7	16.9	18.3	18.2	19.1	19.7	19.5	18.7	17.3	16.3	14.6
Average 22 African countries	12.1	8.0	9.3	8.9	9.8	11.3	11.5	11.7	14.0	12.2	11.7	11.0
Average 67 Developing countries	12.2	12.3	13.4	13.8	14.8	16.2	17.1	17.0	17.4	16.2	15.6	15.1
Average 21 Advanced economies	29.6	28.6	30.4	30.5	23.3	19.6	18.3	17.5	17.7	16.8	16.2	13.3

Source: see Annex Table 1.

3 The Engine of Growth Argument

The arguments for the engine of growth hypothesis are a mix of empirical and theoretical observations (for more detail, see Szirmai 2009)

1. There is an *empirical correlation* between the degree of industrialisation[5] and per capita income in developing countries. The developing countries which now have higher per capita incomes have seen the share of manufacturing in GDP and employment increase and have experienced dynamic growth of manufacturing output and manufactured exports. The poorest countries are invariable countries that have failed to industrialise and that still have very large shares of agriculture in GDP.
2. Productivity is higher in the manufacturing sector than in the agricultural sector. The transfer of resources from agriculture to manufacturing provides a *structural change bonus*.
3. The transfer of resources from manufacturing to services provides a *structural change burden* in the form of Baumol's disease. As the share of the service sector increases, aggregate per capita growth will tend to slow down. Baumol's law has been contested in the more recent literature but has definitely been part of the engine of growth argument in the past.
4. Compared to agriculture, the manufacturing sector offers special *opportunities for capital accumulation*. Capital accumulation can be more easily realised in spatially concentrated manufacturing than in spatially dispersed agriculture. This is one of the reasons why the emergence of manufacturing has been so important in growth and development. Capital intensity is high not only in manufacturing but also in mining, utilities, construction and transport. It is much lower in agriculture and services. Capital accumulation is one of the aggregate sources of growth. Thus, an increasing

[5] When we speak about industrialisation in this paper we explicitly focus on the role of manufacturing. In the ISIC classifications the industrial sector also includes mining, utilities and construction. Many papers on industrialisation fail to make a clear distinction between industry and manufacturing (e.g. Rodrik, 2009)

share of manufacturing will contribute to aggregate growth. The engine of growth hypothesis further implicitly argues that capital intensity in manufacturing is higher than in other manufacturing. However Szirmai (2009) has shown that this is not always the case.

5. The manufacturing sector offers special opportunities for *economies of scale*, which are less available in agriculture or services.

6. The manufacturing sector offers special opportunities for both *embodied and disembodied technological progress* (Cornwall, 1977). Technological advance is concentrated in the manufacturing sector and diffuses from there to other economic sectors such as the service sector. The capital goods that are employed in other sectors are produced in the manufacturing sector. It is also for this reason that in the older development economics literature the capital goods sector – machines to make machines – was given a prominent role.

7. *Linkage and spillover effects* are stronger in manufacturing than in agriculture or mining. Linkage effects refer to the direct backward and forward linkages between different sectors and subsectors. Linkage effects create positive externalities to investments in given sectors. Spillover effects refer to the disembodied knowledge flows between sectors. Spillover effects are a special case of externalities which refer to externalities of investment in knowledge and technology. Linkage and spillover effects are presumed to be stronger for manufacturing than within other sectors. Intersectoral linkage and spillover effects between manufacturing and other sectors

such as services or agriculture are also very powerful.[6] (see Cornwall, but also Tregenna, 2007).

8. As per capita incomes rise, the share of agricultural expenditures in total expenditures declines due to low income elasticity and the share of expenditures on manufactured goods increases (*Engel's law)*. Countries specialising in agricultural and primary production will not profit from expanding world markets for manufacturing goods and will start falling behind. In recent years a similar argument has been made for services. As per capita incomes increase, the demand for services may increase. But for services that are not traded internationally, the increasing demand for services may be more a consequence of growing income than a driver of growth.

4 Review of the literature

Contributions of manufacturing can be measured in different ways: using growth accounting techniques and econometric analysis (Bosworth, Collins and Chen, 1995; Fagerberg and Verspagen, 1999, 2002, 2007; Timmer and de Vries, 2007, 2009). Growth accounting techniques analyse what proportion of a given growth rate of national income derives from growth of manufacturing, weight growth rates with value added shares. These techniques are straightforward and transparent. But they do tend to underestimate the contributions of structural change and the emergence of dynamic sectors, because they do not take various

[6] The engine of growth hypothesis does not deny the importance of growth in other sectors. On the contrary, the neglect of agriculture in post-war development policy is seen as a negative factor contributing to urban-industrial bias. Successful examples of industrialisation in East and South Asia such as Korea, Taiwan, China, Indonesia and India capitalised on agriculture manufacturing linkages (also referred to as the balanced growth path).

external effects and intersectoral spillovers into account (Section 3, arguments 6 and 7). These spillover effects are better captured with econometric techniques.

The evidence in the secondary literature is mixed. The older literature tends to emphasise the importance of manufacturing, the more recent literature places finds that the contribution of service sector has increased. Also, in the more recent literature one finds, that manufacturing tends to be more important as an engine of growth in developing countries than in advanced economies and also more important in the period 1950-1973 than in the period after 1973.

Fagerberg and Verspagen (1999) regress real growth rates of GDP on growth rates of manufacturing. If the coefficient of manufacturing growth is higher than the share of manufacturing in GDP, this is interpreted as supporting the engine of growth hypothesis. Fagerberg and Verspagen find that manufacturing was typically an engine of growth in developing countries in East Asia and Latin America, but that there was no significant effect of manufacturing in the advanced economies.

In a second article Fagerberg and Verspagen (2002) examine the impact of shares of manufacturing and services on economic growth in three periods: 1966-72, 1973-83 and 1984-95 for a sample of 76 countries. They find that manufacturing has much more positive contributions before 1973 than after. The interpretation in both papers is that the period 1950-1973 offered special opportunities for catch up through the absorption of mass production techniques in manufacturing from the USA. After 1973, ICT technologies started to become more important as a source of productivity growth, especially in the nineties. These technologies are no longer within the exclusive domain of manufacturing, but operate in the service sector.

Szirmai (2009) examines the arguments for the engine of growth for a limited sample of Asian and Latin American developing countries. He focuses on capital intensity and growth of output and labour productivity. His results are again somewhat mixed. In general he finds support for the engine of growth hypothesis, but for some periods capital intensity in services and industry is high than in manufacturing. In advanced economies productivity growth in agriculture is more rapid than in manufacturing.

Rodrik (2009) regresses growth rates of GDP for five year periods on shares of industry in GDP in the initial year, following the same approach as in this paper, but not distinguishing manufacturing from industry. He finds a significant positive relationship and interprets the growth of developing countries in the post war period in terms of the structural bonus argument. He explicitly concludes that transition into modern industrial activities acts as an engine of growth. But he is rather vague about what he means by modern. It also includes the famous Ethiopian horticulture activities studied by Gebreeyesus and Iizuka (2009). For Rodrik structural transformation is the sole explanation of accelerated growth in the developing world.

Tregenna (2007) analyses the important of manufacturing for South African economic development and concludes that manufacturing has been especially important through its strong backward linkages to the service sector and other sectors of the economy.

For India two recent papers reach contradictory conclusions. Katuria and Raj (2009) examine the engine of growth hypothesis at regional level for the recent period and conclude that more industrialised regions grow more rapidly. On the other hand Thomas 2009 concludes that services have been the prime mover of growth resurgence in India since the 1990s. A similar position is taken by Dasgupta and Singh (2006). In an econometric analysis for India Chakravarty and Mitra (2009) find that manufacturing is clearly one of the determinants of overall growth, construction and services also turn out to be important, especially for manufacturing growth. Is Industry still the engine of growth? An econometric study of the organized sector employment in India (2009)]

A recent article by Timmer and de Vries (2009) also points to the increasing importance of the service sector in a sample of countries in Asia and Latin America. Using growth accounting techniques, they examine the contributions of different sectors in periods of growth accelerations, in periods of normal growth and in periods of deceleration. In periods of normal growth they find that manufacturing contributes most. In periods of acceleration, this leading role is taken over by the service sector, though manufacturing continues to have an important positive contribution.

In sum, both the empirical information contained in this paper and the secondary literature presents a somewhat mixed picture. Manufacturing is seen as important in several papers, especially in the period 1950-73 and in recent years more so in developing countries than in advanced economies. In the advanced economies, the contribution of the service sector has become more and more important and the share of services in GDP is now well above 70 per cent in the advanced economies.[7]

5 Research Questions/Hypotheses

To guide our empirical analysis we have formulated a set of working hypotheses which take a strong version of the engine of growth hypothesis as point of departure.

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[7] As prices of services have increased far more than those of industrial goods, the share of the service sector in constant prices has increased far less and the contribution to growth will also be less than when measured at current prices.

1. *Is there a positive relationship between the value added share of manufacturing and growth of GDP per capita? Our hypothesis is that there is a positive relationship for our 90 countries in the period 1950-2005.*

We examine this hypothesis by regressing per capita GDP growth rates in five year periods on manufacturing shares at beginning of these five-year periods. A significant positive relationship indicates that expansion of the share of manufacturing contributes to economic growth.

2. *Is the relationship between the value added share of manufacturing and per capita GDP growth stronger than that between the value added share of services and growth of per capita GDP? Our hypothesis is that the relationship between manufacturing and growth is strong than between services and growth.*

We add the share of services to the regression. If the coefficient of manufacturing shares is substantially higher than the coefficient of service sector shares, this is interpreted as support for the engine of growth argument. Also, if the coefficient of manufacturing share is significant and the coefficient of services is not, this is interpreted as support for the engine of growth argument

3. *Does the relationship between the share of manufacturing and growth of GDP per capita become weaker over time?*

If we find that the relationship between the share of manufacturing and growth is becoming weaker over time, this indicates that manufacturing has acted as an engine of growth in the early post-war period, but no longer fulfils this function in more recent years. Our working hypothesis is that the relationship between manufacturing and growth will be stronger in the period 1950-75 than in the period 1975-2005.
This is assessed by adding time dummies to the regression equation and estimating the intercept shifts for each of the time periods.

4. *Is there a positive relationship between the share of manufacturing and the rate of growth during growth accelerations?*

Is there a significant relationship between the share of manufacturing and growth during growth accelerations? Is this relationship between manufacturing shares and growth stronger during growth accelerations than during non-accelerations. Interpretation. If manufacturing is indeed the engine of growth, its contribution should be especially pronounced during growth accelerations (or periods of catch up, see below). *Our working hypothesis is that the impact of manufacturing on growth is stronger during growth accelerations.*

Growth accelerations are defined using a version of the Hausman, Pritchett and Rodrik methodology (Hausman et al 2005). Our units of analysis are five year periods. We classify the five periods as either being part of a growth acceleration or not being part of a growth acceleration (reference group). A five year period is 'part of a growth acceleration' if at least three years of the five year period are part of a growth acceleration.[8] Using both intercept and slope shift dummies, we can then see how the coefficients change in acceleration periods, compared to non acceleration periods. *We expect the coefficient in the acceleration periods to be higher than in the non-acceleration periods.*[9]

5. *Is the relationship between the share of manufacturing and growth during growth accelerations stronger or weaker than that between the share of services and growth?*

Question 5 is a further elaboration of question 4 We need to compare the coefficients of manufacturing and services in periods of growth acceleration. Using shift and share methods, Timmer and de Vries (2009) find that services are more important in periods of

[8] SZ. Add footnote about the difference between our definition of a growth acceleration and that of Hausmann et al.

[9] An alternative way is to use a logit type analysis to assess whether the chances of a period being an acceleration period is affected by the shares of manufacturing.

growth acceleration, while manufacturing is more important in other periods. *Our working hypothesis is that the coefficient of manufacturing share is higher than that of services in general and that the difference between the coefficients is greater in acceleration periods than in non-acceleration periods.*

6. *Are there systematic differences between the role of manufacturing in countries with different characteristics (e.g. level of GDP per capita, human capital and region)*

Our working hypotheses/expectations are the following
a. the relationship between share of manufacturing and growth is weaker at higher levels of GDP per capita than at lower levels. (i.e. more advanced economies are less dependent on manufacturing for their growth)
b. the relationship between the share manufacturing and growth will be stronger in countries with high levels of human capital. The rationale for this hypothesis is that the relationship between shares of manufacturing and GDP per capita growth should be stronger if the absorptive capacities of the country are better developed. Education is seen as an important aspect of absorptive capacities.

6 Data and Methods

6.1 Discussion of the dataset

We constructed our own dataset of sectoral shares for the period 1950-2005 as follows.
The World Bank World Development Indicators (WDI) contain information about the value shares at current prices of major sectors: agriculture, industry, manufacturing and services. These data originally derive from the UN national accounts but still have many gaps and holes. For most developing countries the data are only available from 1966 onwards. We complemented the WDI data set with data from the early United national accounts statistics for the early years and the missing years and used other sources to fill gaps in the database such as the Groningen Growth and Development 60 industry, 10 industry and EUKLEMS databases, the UNIDO data base and incidental country sources. The manufacturing data are described in detail in a 2009 working paper by Szirmai (2009).

For human capital we used the Barro and Lee (2000) dataset for average years of education for the population of above fifteen years of age. We filled in gaps in these data using Lutz et al 2007 and Nehru (1995). We retropolated the 1960 data to 1955 and 1950 using the country growth rates of 1960-65. The results are quite plausible though at a later stage we hope to replace these estimates by estimates from the earliest UNESCO publications which contain data back to 1946. The retropolation allows us to keep the 1950 observations in the panel dataset.

For per capita growth we use the Maddison dataset (Maddison, 2009) as our basic source of data. For the sake of comparison we also use the Penn World Tables dataset.

6.2 Methods

We estimate a panel regression model. Our dependent variable is growth of GDP per capita per five year period. The independent variables that we will use are the shares of manufacturing (MAN), and services (SER) in GDP, GDP per capita relative to the US (RELUS), education level (EDU), and time-intercept dummies for each of the 11 five year time periods between 1950 and 2005. [10]

Fixed versus random effects

The first question is whether we should use fixed or random effects. This boils down to the question whether the country-effects are correlated with the other independent variables in the model. If such correlation is present, fixed effects are usually considered the better choice. Otherwise, random effects are more satisfactory. To test this, we estimate both models (fixed and random effects) on the same data, and then perform the Hausman test. The problem is that the Hausman test is sometimes hard to calculate, because its assumptions (about asymptotic behaviour of the estimators) are violated. This

[10] We dropped the population size variable LNPOP. This variable complicates the analysis considerably, and doesn’t add much insights.

may express itself in various ways, most often by a negative value of the test-statistic (which is Chi-square, and therefore should be positive). If that happens, we cannot make a well-founded choice between fixed and random effects.

A different question is whether the effects (random or fixed) are significant. This is tested by using different tests. In our case, these are almost always significant. This means that we always prefer a random effects or fixed effects model over the OLS model.

Finally, one other option is to estimate the between model. In this model, all available observations for a country are averaged, and the regression is run on these averages. Consequently, this ignores all time aspects. It is a model to estimate long-run tendencies. Its drawback is that from an econometric point of view it is not very satisfactory because it ignores unobserved differences between countries.

A final note: when we estimate a random effects model, we must be careful in estimating the model for different subsamples. This model assumes that every observation for country contains a fixed (for that country) effect, and together (over the countries) these effects are normally distributed. The random country effect is part of the residual (= actual observation minus the predicted one). The regression coefficients are chosen in such a way that this country effect is a normal distribution (over countries), and the "other" (standard) part of the residual is minimized.

Now think about the consequences of this when we split the sample up into two different country groups (this is the least problematic case). We can either implement this by estimating a random effects model separately for each of the two groups. Then, we assume that the country effects in each of the two groups is normally distributed. The alternative is to estimate one big model with slope-dummies. Now we are assuming that the country effects of the two groups together form one (big) normal distribution. These are obviously two different assumptions, and they will generally lead to differences in the estimated coefficients. This is paradoxical, because with normal OLS, the two methods would yield the identical results. It is not obvious to us which of the two assumptions is better, although intuitively econometricians would prefer the option of estimating one model with slope-dummies.

Now consider another possibility: splitting on some other variable, for example time. For simplicity assume again that we split the observations into two groups (e.g. before and after 1975). It is a quite different case from the previous one. Remember that we assume that each country has a "random" effect that is fixed over time (for that country). Suppose that we estimate our model separately for the two time periods. This means that we assume that in each of the two subsamples, the country (potentially) has a different random effect. If, instead, we estimate one model with slope dummies, the country still has only a single random effect that holds across all its observations. This principle also holds for all other ways of splitting up the sample (except for the previous case of country groups).

What is a better assumption to make: a single random effect per country over the complete sample, or separate random effects for a single country in each of the subsamples? Researchers engaged in estimating regression trees with random effects would certainly answer "the first". But is it really the case, from a theoretical point of view? Let us give two arguments why it might not be. First, if the splitting-up of the sample represents "structural change", then why would this structural change be limited to the parameters of the model? Why would the random effect not change as well? Second, the structural breaks that we estimate are very discontinuous, e.g., the parameters change suddenly from one observation to the next, and are constant before and after the break. If the change in country effects is more smooth in reality, the residuals just before and after the break will look rather strange ("non-smooth"). This will have an impact on the estimated country random effect, and also on the estimated parameter values.

For the time being we have chosen for the option of estimating fixed and random country effects for the whole sample. But further research is needed here.

Comparing fixed effects, random effects and between effects

In the previous paragraph, we discussed the question how to estimate the fixed and random effects and the methods used to select a preferred specification. In this paragraph we will go a step further and argue that there is no need to select a preferred specification. One can learn more from the comparison of the different specifications.

Our dataset is an unbalanced panel of 92 countries, and 11 5-year subperiods, covering the 1950 – 2005 period. The basic econometric question, as in all panel datasets, is how we deal with potential country level effects that may have an effect on our dependent variable, but are not observed as an independent variable in our dataset. Failure to include such effects, or adjust the estimation method for them, will bias the estimated coefficients, and hence lead to unjustified conclusions with regard to our research questions.

The basic econometric toolbox offers two principal ways to deal with unobserved country-level effects that influence growth: fixed effects and random effects. In the first case, the country-level effects are captured by including (in the regression model that explains growth) an intercept dummy variable for each country. This means that all observations corresponding to an individual country have their own intercept. In effect, this intercept will capture the mean value of the growth rate of the country over all time periods. In formal terms,

$$g_{it} = c_i + \beta X_{it} + \varepsilon_{it},$$

where g is the growth rate, c is a constant, X is a vector of explanatory variables, β is the vector of coefficients that we want to estimate, ε is the usual disturbance term, and i and t are subscripts denoting country and time period, respectively. This equation may be rewritten by subtracting the country averages (indicated by a bar above a variable) on both sides[11]

$$g_{it} - \bar{g}_i = \beta(X_{it} - \bar{X}_i) + \varepsilon_{it}.$$

[11] Remember that a (least squares) regression in which all the explanatory variables are at their average will exactly produce the average value of the dependent variable, and also remember that the average of the country-specific constant is equal to that constant (i.e., it does not vary over time).

This form of the regression equation shows that the coefficient vector β in the fixed effects model can be estimated without explicitly estimating the country effects (country intercepts), because these effects vanish from the equation when we subtract country averages, while the coefficient vector β remains identical.

Such an approach is known as the *within* approach. The term refers to the fact that this form looks at variation within countries, as opposed to between countries. All variance that is related to the between country dimension has been eliminated from the model by subtracting the country averages from the dependent and independent variables. Note that even if we do not implement the estimation by subtracting country averages, this characterization of the model still holds, because the coefficient vector β is the same between the two forms. In other words, whether we include country-specific intercepts, or we transform the data to the *within* format, makes no difference: the estimated coefficients β will only capture the variation over time, within countries.

Although this is sound from the econometric point of view, it may not be very helpful for the theorist who is interested in knowing the effect of a particular variable on growth. Even if the country effects are estimated and documented, the regression does not relate them to any of the variables in *X*. In particular, one may think of a situation where an independent variable of interest is, more or less, fixed within a country, but varies strongly between countries. In such a case, the within regression will not attribute much explanatory power to the variable, because its effect will go into the fixed effects.

The so-called *between* approach may yield useful insights in such a situation. This approach focuses on the country intercepts themselves, and asks how the independent variables are related to these. Because the intercepts are constant over time (but differ between countries), the variables that explain them must, naturally, change only slowly over the time scale of the estimation, but must show some variation between countries. The *between* approach is implemented as a regression that uses the average values of the variables that were subtracted on both sides of the equation in the *within* formulation. In formal terms:

$$\bar{g}_i = \gamma + \phi \bar{X}_i + e,$$

where all symbols are as before, γ is a constant, ϕ is a parameter vector similar (but not identical) to β, and e is a normal disturbance term.

The estimated coefficients (γ and ϕ) of the *between* model provide insights into which of the variables *X* drive the fixed effects that the *within* estimation accounts for. In this way, the two models are complementary to each other, rather than substitutes.

The random effects model can be seen as a hybrid form that combines the *within* and *between* models, because it does not apply any transformation of the data (either subtracting averages, as the *within* approach does, or using these averages in the estimation, as the *between* approach does). Instead, it assumes that the (unobserved) country effects that we want to account for are themselves drawn from a normal distribution. With this assumption, the country specific effect can be seen as a part of the disturbance term in the econometric estimation. Because, in that case, the disturbance term no longer has the usual form, the random effects model applies a different estimation technique (of which the details do not concern us here). However, because it uses untransformed data, the coefficients that are estimated in the random effects model take into account both the variation *between* countries, and the variation *within* a country (over time).

Table 3: Descriptive statistics of the panel dataset

Variable	Average value	Overall standard deviation	Within standard deviation	Between standard deviation
Growth rate	2.33	3.05	2.75	1.37
Manufacturing share	17.7	8.44	4.89	7.02
Services share	49.4	12.0	7.35	10.2
Education level	4.80	2.78	1.29	2.52
GDP per capita relative to US level	0.30	0.27	0.074	0.26

How does this matter in the case of our data? As Table 3 shows, the within component of our dependent variable (the growth rate of GDP per capita) has a fairly large within standard deviation (as compared to the between standard deviation). This means that this variable is rather volatile over time, within a single country. Compared to this time volatility, the volatility between countries is relatively limited.

This pattern is exactly opposite for the explanatory variables. For all of them, the *between* standard deviation is larger than its *within* counterpart. This means that the explanatory variables are relatively more volatile between countries than they are over time (within a country).

These particular characteristics of the dependent and independent variables imply that we cannot rely purely on *within* estimations. These estimations ignore the *between* effects, and given the slow-changing nature of our explanatory variables, we would expect the *between* effects to be relatively strong. The random effects estimations will be interesting also, because they include both a *within* and a *between* element. Thus, rather than relying on a mechanistic approach in which test statistics decide which is the preferred model, we will consider all three models, and ask what they have to say about long-run vs. short-run effects of the explanatory variables on economic growth.

7 Results

7.1 The "Simple Story": The Effect of Manufacturing on Growth

We start by estimating the model on the complete sample (786 observations, 89 countries) and present the basic random effects (RE), fixed effects (FE) and between (BE) specifications below. The Hausman test accepts random effects as a good model, but in line with the discussion in the previous section, we discuss and compare all three models.

The share of manufacturing in GDP (MAN) is significant in the random effects and between estimations; it is not in the fixed effects estimation. That MAN does not perform in the fixed effects regression has to do with the correlation between general country effects and manufacturing shares and the modest degree of within country variation of manufacturing shares (see discussion in section 6). In all subsequent specifications, manufacturing performs least in the fixed effect models.

The share of services in GDP (SER) is never significant. Education (EDU) is significant in the RE and BE. The coefficient of country GDP as a percentage of US GDP per capita (RELUS) is negative and significant in all models. The negative coefficient indicates that countries with a larger gap relative to the USA are growing more rapidly than countries closer to the USA. This is consistent with the convergence effects usually found in growth equations. The time dummies in the random effects specification indicate that average growth was lower after 1980, than before this year. The basic run is in line with the engine of growth hypothesis.

Table 4: Basic Run

Variable	re	fe	be
ser	0.016	0.025	-0.015
man	0.044**	0.031	0.058*
relus	-2.920***	-6.974***	-2.269*
edu	0.280***	0.038	0.289**
_Iperiod_2	-1.019***	-0.883**	-10.278
_Iperiod_3	-0.037	0.343	-20.249***
_Iperiod_4	0.137	0.503	-6.746
_Iperiod_5	-0.460	0.077	-14.718**
_Iperiod_6	-0.766	-0.163	-6.127
_Iperiod_7	-3.151***	-2.425***	-14.318**
_Iperiod_8	-2.259***	-1.599**	-2.428
_Iperiod_9	-2.188***	-1.379**	-5.912
_Iperiod_10	-2.190***	-1.254	-13.834**
_Iperiod_11	-1.904***	-0.942	-8.236
_cons	1.607	3.168**	10.714**

legend: * p<.1; ** p<.05; *** p<.01

7.2 Adding Interaction Terms for Sector Shares and Income Gaps relative to the USA.

The next step is to include an interaction term between manufacturing and RELUS: MANREL. A similar interaction term for services (SERREL) will be added later. The estimation results are presented below in table 5.

The Hausman test does not work. Manufacturing is significant in all three models. In random effects model, the interaction term MANREL is significant with a negative sign. This suggests that manufacturing has a more positive impact on growth at low levels of RELUS, and a more negative impact at high levels of RELUS. (The coefficient of RELUS itself becomes non-significant when MANREL is entered into the regression.)

The point where the impact of the interaction term is zero is at -(coef MAN)/(coef MANREL), which is at 64.2.9% of US GDP per capita. The average value of RELUS is around 30% of US GDP. We can plug in this average value and test whether (coef man)+0.3*(coef MANREL) is significantly different from zero in the random effects estimation. It is indeed significant (p value 0.005). Thus, we conclude that the effect of manufacturing on growth is stronger for the poorest countries with the largest income gaps.

Table 5:
Models with an Interaction Term between the Share of Manufacturing and the Income Gap with the USA

Variable	re	fe	be
ser	0.008	0.022	-0.025
man	0.097***	0.075*	0.102**
relus	0.156	-4.536*	0.143
manrel	-0.151***	-0.118	-0.117
edu	0.262***	0.021	0.284**
_Iperiod_2	-1.002***	-0.873**	-11.355
_Iperiod_3	-0.017	0.339	-20.334***
_Iperiod_4	0.159	0.495	-5.310
_Iperiod_5	-0.451	0.048	-13.681**
_Iperiod_6	-0.821*	-0.230	-7.458
_Iperiod_7	-3.211***	-2.502***	-13.444**
_Iperiod_8	-2.306***	-1.667**	-3.084
_Iperiod_9	-2.254***	-1.464**	-6.438
_Iperiod_10	-2.221***	-1.322	-12.415*
_Iperiod_11	-1.917***	-0.995	-8.855
_cons	1.177	2.688*	10.439**

legend: * p<.1; ** p<.05; *** p<.01

Finally, in table 6, we look at a model with both MANREL and SERREL (and MAN and SER). In this case, the Hausman test prefers the random effects. In the random effects model, neither SER nor SERREL are significant, but both MAN and MANREL are. The coefficients of MAN and MANREL are similar to those in the previous estimation without SERREL.

Table 6:
Models with Interaction Terms between Shares of Both Services and Manufacturing and the Income Gap with the USA

Variable	re	fe	be
ser	0.013	0.034	-0.036
man	0.094***	0.070*	0.110**
relus	1.742	-0.307	-4.884
manrel	-0.159***	-0.147*	-0.102
serrel	-0.023	-0.059	0.079
edu	0.260***	0.002	0.277*
_Iperiod_2	-0.998***	-0.863**	-13.479
_Iperiod_3	-0.009	0.360	-22.754***
_Iperiod_4	0.172	0.533	-5.516
_Iperiod_5	-0.420	0.128	-14.639**
_Iperiod_6	-0.791	-0.146	-8.605
_Iperiod_7	-3.173***	-2.399***	-15.202**
_Iperiod_8	-2.265***	-1.545**	-4.262
_Iperiod_9	-2.198***	-1.305*	-8.388
_Iperiod_10	-2.162***	-1.152	-13.607*
_Iperiod_11	-1.854***	-0.811	-10.392
_cons	0.923	2.058	12.325**

legend: * p<.1; ** p<.05; *** p<.01

Thus, the initial findings are in line with the engine of growth hypothesis. Manufacturing has a positive effect on growth and this effect is more pronounced for the poorer countries.

7.3 Splitting up by Time Periods: Is the Effect of Manufacturing Different in Different Periods

We split the complete time span of 11 periods into 3 sub samples: 1950-1970, 1970-1990 and 1990-2005. We proceed by estimating the model separately for each subperiod to see whether the effects over manufacturing change over time (see hypothesis 3 in section 5 and discussion in section 6.2).

7.3.1 1950-1970

The early period includes periods 1 – 4 (1950 – 1970). In a model with SERREL included, this variable is not significant, and the Hausman test does not work. Therefore, we focus on the model with only MANREL (table 7). The Hausman test does not reject random effects. In the random effects model, nothing is significant, except education (EDU). In the fixed effects model, MAN and MANREL are significant. Interestingly, the signs are reversed relative to those in tables 5 and 6 above. Now, manufacturing has a negative sign and MANREL has a positive sign. The combined effect of MAN and MANREL is positive. This means that according to the fixed effects model, countries that are closer to the US level of income have a more positive effect of manufacturing, and countries that are farther from the US have a negative impact of manufacturing. The "crossover" lies at 49.3%. This result contradicts previous research that find that manufacturing has the most positive contribution to developing country growth in the period 1950-73. The most important effect on growth is a general convergence effect, indicated by the very large coefficient of RELUS in the fixed effects model. Countries far from the frontier grow more rapidly than countries close to the frontier.

The between model also has MAN and MANREL significant, in this case with the "old" signs of table 5 (crossover at 60.8%). This result is consistent with that of table 5. The average growth rates for the whole period are higher in countries with a larger share of manufacturing and lower relative levels of GDP per capita. There is also a significant effect for services, but with a much smaller coefficient than manufacturing.

One should note that the fixed effects focus on explaining the within country variations of growth, so that the two results are not inconsistent.

Table 7
Models Including Interaction between Manufacturing and Income Gap for the Period 1950-1970

Variable	re	fe	be
ser	-0.020	-0.011	-0.046*
man	0.046	-0.211***	0.161***
relus	0.397	-27.668***	4.122
edu	0.260**	0.390	0.188
manrel	-0.095	0.428*	-0.265**
_Iperiod_2	-0.973***	-0.714**	-4.628**
_Iperiod_3	-0.041	0.760*	-6.533***
_Iperiod_4	0.168	0.914**	5.404***
_cons	2.798***	10.636***	3.403*

legend: * p<.1; ** p<.05; *** p<.01

For the sake of completeness, we also document the regression without MANREL in table 8. The Hausman test does not reject random effects in this case either, but MAN is not significant in the random effects model. The coefficients for MAN and MANREL are significant in both FE and BE, as in table 7.

Table 8
Models excluding the Interaction between Manufacturing and Income Gap for the Period 1950-1970

Variable	re	fe	be
ser	-0.013	-0.037	-0.025
man	0.020	-0.125**	0.077**
relus	-1.861	-15.631***	-1.514
edu	0.249*	0.264	0.124
_Iperiod_2	-0.981***	-0.648**	-4.917**
_Iperiod_3	-0.056	0.874**	-7.370***
_Iperiod_4	0.141	1.129***	4.899***
_cons	3.041***	10.002***	4.508**

legend: * p<.1; ** p<.05; *** p<.01

7.3.2 1970-1990

The middle period is defined as periods 5 – 8, i.e., 1970 – 1990. For this period, MANREL or SERREL are never significant. But the inclusion of MANREL has interesting effects on the significance of the other coefficients, so we reproduce two versions of table 9, including and excluding MANREL. When MANREL is dropped, RELUS becomes highly significant and convergence effects dominate all other effects. Also the coefficient of MAN in the random effects specification becomes insignificant.

In the top panel of table 9, the coefficient of manufacturing is significant and positive in the random effects and the between model. The coefficient of services is significant in all specifications, indicating that services are more important in this period than in the period 1950-70.

In the between specification in panel A, the coefficient of manufacturing is significant and substantially larger than that of services.

In the middle period, countries with larger average shares of manufacturing grow more rapidly than countries with smaller shares. But services also make a contribution to growth.

Table 9: Models for the period 1970-1990

Variable	re	fe	be
A. Including MANREL			
ser	0.098***	0.123***	0.066*
man	0.117*	0.087	0.139**
relus	-1.708	-8.532	-2.900
edu	0.306*	-0.155	0.296
manrel	-0.160	-0.271	-0.061
_Iperiod_5	2.129***	0.000	0.000
_Iperiod_6	1.806***	-0.089	11.072**
_Iperiod_7	-0.834**	-2.559***	5.020
_Iperiod_8	0.000	-1.777***	4.133
_cons	-5.733***	0.628	-9.236***
B. Excluding MANREL			
ser	0.100***	0.121***	0.068*
man	0.061	-0.016	0.119***
relus	-5.159***	-13.395**	-4.305**
edu	0.354**	-0.151	0.323
_Iperiod_5	-2.966	0.000	0.000
_Iperiod_6	-3.229*	-0.002	11.609**
_Iperiod_7	-5.869***	-2.418***	5.249
_Iperiod_8	-5.046**	-1.600***	4.440
_cons	0.000	2.228	-9.343***

legend: * p<.1; ** p<.05; *** p<.01

7.3.3 1990-2005

In the last time span (period 9 – 11, 1990 – 2005), SERREL is not significant and has not been reproduced in table 10. When MANREL is included, the Hausman test rejects random effects. With fixed effects, nothing much is significant. In the between model, MAN and MANREL are both significant. The negative sign of MANREL again provides the intuitive result that manufacturing contributes more to growth for countries far behind the US than countries which are closer.

Table 10: Models for the Period 1990-2005

Variable	re	fe	be
ser	-0.023	-0.077	-0.030
man	0.095	-0.190	0.163***
relus	1.076	-34.765***	4.881*
edu	0.316**	0.066	0.111
manrel	-0.153	0.334	-0.278**
_Iperiod_9	0.010	-0.838	0.808
_Iperiod_10	0.082	-0.369	0.000
_Iperiod_11	0.418	0.000	-2.245
_cons	0.000	18.075**	0.691

legend: * p<.1; ** p<.05; *** p<.01

Merging the last two periods into a single one doesn't produce different results. Neither does changing the break between 2nd and 3rd period.

Summarising our findings for all three periods, we conclude the following. In the between specifications, manufacturing has a significant effect on growth in all periods and this effect is greater when the income gap with the US is larger. Services also have a significant positive effect in the first two periods, but the coefficients are far lower than those of manufacturing. In the third period, services become insignificant.

Comparing the between models in tables 8, 9 and 10, one sees a substantial increase in the coefficient of manufacturing from first to second period. On first sight the coefficient of manufacturing seems even higher in the third period, but one should take the negative sign of the interaction term into account. At the average value of RELUS (0.31), the combined coefficient is 0.078 which is the same as in the first period. Thus we see an increase in the effects of manufacturing from period 1 to 2 and decrease back to the original level in period 3. This differs from our hypothesis 3 which suggested a steady decline in the importance of manufacturing. Also the role of services is more important in periods 1 and 2, than in period 3, when its coefficients are not significant. This contradicts expectations concerning the increasing importance of service led growth, found in some of the recent literature (see section 4).

In the fixed effects models, manufacturing only has an effect in the earliest period where the combined effect of MAN and MANREL is positive. In the other periods there is no significant effect, which indicates that within country changes in the rate of growth are not affected by the shares of manufacturing.

In the random effect models, manufacturing is only significant in t he middle period.
It is the between effects, which provide the strongest evidence in favour of the engine of growth hypothesis.

7.4 Country groups

7.4.1 Asia

We proceed to estimate the model separately for each country group. We start with Asia. The interaction term SERREL is never significant. MANREL is only significant in the between model (not reproduced). In the model with only MAN (and SER) in table 11, the Hausman test does not reject random effects. In the random effects model (and also in the fixed effects model), manufacturing has a significant and substantial positive effect on growth. In the fixed effects model, where part of the effects of manufacturing are captured in the fixed effects, the share of services is significant and it has a higher coefficient than manufacturing. Convergence effects are extremely powerful. There are no significant between effects. Taking the random effects as our preferred specification, this table points to some support for the engine of growth hypothesis for Asia. There are no clear patterns in the time dummies. But otherwise than in the base runs, there is no between effect.

Table 11: Manufacturing and Growth in Asia

Variable	re_AS	fe_AS	be_AS
ser	0.061	0.188***	-0.041
man	0.133***	0.131**	0.134
relus	-4.623*	-11.773***	4.322
edu	0.117	0.614*	0.038
_Iperiod_2	-3.179***	-3.483***	4.288
_Iperiod_3	-2.117**	-2.822**	5.682
_Iperiod_4	-1.985*	-2.774**	0.000
_Iperiod_5	-2.072*	-2.948**	1.475

Variable			
_Iperiod_6	-2.330*	-3.004*	7.643
_Iperiod_7	-3.486***	-4.985***	-9.958
_Iperiod_8	-3.752***	-5.815***	0.755
_Iperiod_9	-2.459**	-5.123**	16.700
_Iperiod_10	-4.074***	-6.933***	5.172
_Iperiod_11	-2.845**	-5.950***	-3.371
_cons	1.216	-3.955	-0.816

legend: * p<.1; ** p<.05; *** p<.01

7.4.2 Advanced economies

In the advanced countries group, SERREL becomes significant, and so does MANREL. The Hausman test does not work. In both the fixed and random effects model, MAN and MANREL are significant, with more backward countries benefitting more from manufacturing (MANREL negative). The crossover is at 71.7% of US income in the fixed effects and 78.5% in the random effects. This is an interesting finding, suggesting that manufacturing continues to be important for growth in the advanced economies.

Table 12: Advanced Economies

Variable	re_ADV	fe_ADV	be_ADV
ser	-0.032	0.025	-0.174
man	0.337***	0.284***	0.583
relus	-3.308	-3.335	-6.881
edu	0.161***	0.208*	0.197*
manrel	-0.438***	-0.325**	-0.752
serrel	0.119**	0.014	0.326**
_Iperiod_2	-0.295	-0.319	0.000
_Iperiod_3	1.040***	1.162***	0.000
_Iperiod_4	1.136**	1.257***	0.000
_Iperiod_5	-0.210	0.264	0.000
_Iperiod_6	-0.123	0.548	-15.459
_Iperiod_7	-1.190**	-0.464	0.000
_Iperiod_8	-0.648	0.102	0.000
_Iperiod_9	-2.396***	-1.316**	-9.671*
_Iperiod_10	-0.920	0.233	0.000
_Iperiod_11	-2.512***	-1.312*	-5.553
_cons	0.574	0.206	3.944

legend: * p<.1; ** p<.05; *** p<.01

Rather unexpectedly services do not have a significant coefficient in the advanced country sample. However, the interaction term (SERREL) is significant and positive in the random and between models. This means that services become more and more important as countries get closer to US GDP per capita levels. This is particularly pronounced in the between model. This means that while manufacturing remains an important determinant of growth, services are important in explaining the differences between average growth rates of the advanced economies. We also see that the interaction term between manufacturing and RELUS causes the effect of manufacturing to diminish over time. These findings are consistent with the literature on the increasing importance of services in advanced economies.

7.4.3 Latin America

In Latin America, services is significant in the random effects model – though this is rejected by the Hausman test - while manufacturing is significant in the between model, but not in the other ones. MANREL and SERREL are also both significant and negative. The coefficients of MANREL are higher than those of SERREL. These results suggest that both manufacturing and services contribute to growth. The between model indicates that average growth rates of countries are affected positively by the share of manufacturing. This is one of the consistent results throughout the analysis.

Table 13: Latin America

Variable	re_LA	fe_LA	be_LA
ser	0.090**	0.000	0.044
man	0.095	0.060	0.160*
relus	21.104**	22.304**	-0.684
edu	0.205*	-0.486**	0.172
MANREL	-0.409**	-0.716***	-0.389
serrel	-0.352**	-0.390**	0.072
_Iperiod_2	-0.268	0.487	-18.800*
_Iperiod_3	-0.038	1.073*	0.000
_Iperiod_4	0.556	1.885***	-28.430**
_Iperiod_5	0.518	2.717***	3.963
_Iperiod_6	0.367	2.624***	-26.797
_Iperiod_7	-4.107***	-1.592**	-37.033***
_Iperiod_8	-2.293***	0.395	5.836
_Iperiod_9	-0.951	1.917*	-26.149
_Iperiod_10	-1.765**	1.523	0.000
_Iperiod_11	-1.694**	1.877*	0.000
_cons	-3.507	4.277	8.305

legend: * p<.1; ** p<.05; *** p<.01

7.4.4 Africa

For Africa we have no model that works well.

From the analysis of the country groupings, we conclude that there are interesting differences between them. Thus, obviously, convergence effects are more important in Latin America and Asia, and not significant in the advanced economies. Between effects of manufacturing are important in Latin America, but not in the other groupings. Manufacturing continues to be important in the advanced economies, but its effect decreases as countries come closer to US income levels, while the effects of services increase.

7.5 Growth accelerations

In this section, we use a modified version of the Hausman/Rodrik growth acceleration concept and examine whether manufacturing contributes more to growth in periods of acceleration.

Hausmann et al. (2005) use three conditions to define a growth acceleration. The first is that the growth rate must be high (specifically, >3.5% per year, measured over an 8-year forward period). The second is that growth must accelerate (specifically, at a point in time *t*, the growth rate over the next 8 years must be 2.0% higher than the growth rate over the previous 8 years). Finally, the level of GDP per capita at the end of the growth acceleration must be higher than the pre-acceleration peak. Hausmann et al. assign this growth acceleration to a single year, but the conditions may also be applied to a longer period. However, in that case, the second condition becomes "self-defeating", because it requires the growth rate to keep accelerating. Thus, we apply the second condition only to the start-year of a growth acceleration. For years following this start year, we check the first and third condition, and as long as these hold, we define the growth acceleration period to continue. The result is a growth acceleration period that may extend over several years. Finally, we "translate" these growth accelerations to our 5-year periods that are used in the regressions. This is done by counting the number of years from the 5 year period that belong to a growth acceleration. If this is 3 or more, we define the 5-year period as one that shows a growth acceleration (we also experimented with a threshold of 2 or 4 years within a 5 year period, but this does not change the results very much).

Table 14 presents the results with all possible slope shift dummies included, both for services, manufacturing, MANREL and SERREL. This table can be compared with the base run in table 6.

Table 14
The Role of Manufacturing and Services during Growth Accelerations

Variable	re	fe	be
ser	0.013	0.035	-0.027
_Iaccser	0.053***	0.044**	0.066*
man	0.032	0.029	0.036
_Iaccman	0.092**	0.088*	0.087
relus	1.271	-0.075	-0.881
manrel	-0.007	-0.022	0.032
_Iaccmanre1	-0.227***	-0.196***	-0.194
serrel	-0.029	-0.062	0.004
_Iaccserre1	-0.019	-0.019	-0.027
edu	0.204***	-0.032	0.238**
_Iperiod_2	0.592	-0.135	-5.670
_Iperiod_3	1.214**	0.689	-8.744
_Iperiod_4	1.126**	0.612	0.000
_Iperiod_5	0.408	0.056	-11.106*
_Iperiod_6	0.298	-0.029	-0.113
_Iperiod_7	-1.810***	-2.047***	-5.188
_Iperiod_8	-0.550	-0.864*	-3.530
_Iperiod_9	-0.526	-0.669*	-3.794
_Iperiod_10	-0.441	-0.480	-2.810
_Iperiod_11		0.000	-6.853
_cons	-0.576	0.966	5.516

legend: * p<.1; ** p<.05; *** p<.01

Table 14 provides an interesting result. When one adds slope shift dummies for acceleration periods, the coefficients of MAN become non-significant. But the coefficients of the SSD for manufacturing (ACCMAN) are significant in the random and fixed models, and for services (ACCSER) in all models. The coefficient of the SSD for MANREL (ACCMANREL) is also significant in the random and the fixed models.

This indicates that the effects of manufacturing are now captured by the slope shift dummies which account for much of the relationship between manufacturing and growth. This suggests that manufacturing is especially important in periods of rapid growth. The same is true for services, though the coefficients for services are much lower than those for manufacturing.

However, a problem with the specifications in table 14 is the multicollinearity between the SSDs for manufacturing and services. As the values in the non-acceleration periods equal zero, these slope shift dummies are inevitably highly correlated. Therefore, we discuss the effects of manufacturing and services separately in the following two tables.

Table 15
Model Slope Shift Dummies for Manufacturing During Growth Accelerations

Variable	re	fe	be
ser	0.015	0.025	-0.019
man	0.024	0.021	0.000
_Iaccman	0.112***	0.095***	0.166***
relus	0.021	-4.454*	-0.448
manrel	-0.060	-0.053	0.015
edu	0.171**	-0.136	0.188
_Iperiod_3	0.652**	0.570	-11.316
_Iperiod_4	0.799**	0.702	0.000
_Iperiod_5	0.251	0.333	-12.814**
_Iperiod_6	0.047	0.193	-1.226
_Iperiod_7	-2.253***	-1.957***	-5.710
_Iperiod_8	-1.151***	-0.905*	-4.908
_Iperiod_9	-1.101**	-0.671*	-3.027
_Iperiod_10	-1.060**	-0.474	-1.818
_Iperiod_11	-0.645	0.000	-10.724*
_Iperiod_2		-0.375	-5.827
_cons	0.507	2.805	7.085

legend: * p<.1; ** p<.05; *** p<.01

In Table 15 the coefficients of ACCMAN are significant in all models, while the coefficient of MAN becomes non-significant. This suggests that the effects of manufacturing are captured by the slope shift dummies. Manufacturing is especially important in periods of rapid growth.

If one subsequently runs a regression with SSD for services (ACCSER) included instead of the SSD for manufacturing, this shows a similar pattern. The coefficient of services becomes non-significant or negative. The coefficient of the interaction term is significant in all three specifications. Thus, services contribute positively to growth in periods of growth accelerations. But the coefficients for ACCSER are much smaller than those for ACCMAN in table 15, suggesting that the role of manufacturing during growth accelerations is more important than that of services. It is interesting to note that the coefficients of manufacturing are significant in the random effects and between models with the interaction term for services. This confirms the general importance of manufacturing.

The tentative conclusion of this section is that manufacturing is especially important in periods of accelerated growth. Services also play a role, but are less important than manufacturing. This conclusion is consistent with our hypotheses 4 and 5. It contrasts with that of Timmer and de Vries (2009), who argue that it is services that are especially important during growth accelerations.

Table 16
Model with Slope Shift Dummies for Services during Growth Accelerations

Variable	re	fe	be
ser	0.004	0.022	-0.035*
_Iaccser	0.051***	0.043***	0.070***
man	0.047**	0.036	0.069***
relus	-2.065	-5.163	0.179
serrel	0.010	-0.005	-0.017
edu	0.187***	-0.106	0.232**
_Iperiod_2	0.613	-0.307	-7.453
_Iperiod_3	1.182**	0.532	-9.204
_Iperiod_4	1.157**	0.520	0.000
_Iperiod_5	0.569	0.103	-11.111*
_Iperiod_6	0.570	0.135	-1.317
_Iperiod_7	-1.704***	-1.994***	-6.469
_Iperiod_8	-0.534	-0.900*	-4.543
_Iperiod_9	-0.558	-0.728*	-3.210
_Iperiod_10	-0.402	-0.453	-2.408
_Iperiod_11		0.000	-8.355
_cons	0.003	2.447	6.222

legend: * p<.1; ** p<.05; *** p<.01

8 Conclusions

The results of the empirical analysis in this paper are in line with the engine of growth hypothesis. For the whole sample, the share of manufacturing is positively related to economic growth and this effect is more pronounced for the poorer countries. No such effects were found for services. These results are consistent with our first two hypotheses concerning the importance of manufacturing. It should be noted, however, that convergence effects are much more important than the effects of the shares of manufacturing.

The next step in the analysis was to enquire whether the effects of manufacturing and services are different in different time periods. We distinguish three periods 1950-1970, 1970-1990 and 1990-2005. In the between specifications, manufacturing has a significant effect on growth in all three periods and this effect is greater when the income gap with the US is larger. Services also have a significant positive effect in the first two periods, but the coefficients are far lower than those of manufacturing. In the third period, services become insignificant.

Our expectation that the role of manufacturing becomes less important over time is not confirmed. We see that the impact of manufacturing is more important in the middle period than in the early period and then becomes less important in the final period. With regard to services, we find significant effects in the first two periods and hardly any effects in the final period. This runs counter to predictions concerning the increasing importance of service-led growth.

Subsequently, we broke down our sample into four groups of countries: Asia, Latin America, Africa and advanced economies. We conclude that there are interesting differences between country groups. Thus, rather obviously, convergence effects are more important in Latin America and Asia, and not significant in the advanced economies. Effects of average shares of manufacturing on average rates of growth (the between effects) are important in Latin America, but not in the other groupings. Manufacturing continues to be important in the advanced economies, but its effect decreases as advanced countries come closer to US income levels, while the effects of services increase. For Africa, no significant relationships are found.

Finally, we analysed the role of sectors in periods of growth acceleration. Using a modified version of Hausmann/Rodrik growth accelerations, we find that the effects of manufacturing are particularly pronounced in periods of growth acceleration. The tentative conclusion is that manufacturing is especially important in periods of accelerated growth. Services also play a role in growth accelerations, but are less important than manufacturing.

We need to emphasize that these are still very preliminary results. Further analysis is needed before firmer conclusions can be reached.. One future direction for our research is to expand the sample of countries. In particular, former centrally planned economies are now underrepresented. A second direction is to include shares of manufacturing in exports as explanatory variables. A third direction is to focus on the relationships between growth rates of manufacturing and growth rates of the total economy. A fourth direction is to provide more sectoral detail. In particular, we need to distinguish between market services and non-market services and within industry between mining, manufacturing, construction and utilities. Finally, we would like to include policy variables and indicators of institutional characteristics in the analysis.

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