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Manufacturing and Economic Growth in Developing Countries, 1950-2005

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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.

For the total sample, we find a moderate positive impact of manufacturing on growth in line with the engine of growth hypothesis. Splitting our sample into three subperiods, we only find a direct effect of manufacturing on growth for the middle period 1970-1990. We also find interesting interaction effects of manufacturing with education and income gaps. In a comparison of the subperiods, it seems that since 1990, manufacturing is becoming a more difficult route to growth than before.

Keywords: Structural Change, Manufacturing, Engine of Growth, Catch-up

JEL: O40 (Economic Growth.General); O14 (Industrialisation, Manufacturing and Service Industries); N6 (Manufacturing and Construction)

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1 Introduction:

This paper addresses the question of the importance of manufacturing for economic development. In the older 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 the advanced economies. In developing countries the share of services is also substantial. It is now argued that service sectors such as software, business processing, finance or tourism may act as leading sectors in development and that the role of manufacturing is declining. The prime exemplar for this perspective 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; Jorgenson et al. 2005).

On the other hand, the East Asian experience documents the key role that industrialization has played in the economic development of developing countries in the past fifty years. [3] Further, all historical examples of success in economic development and catch up since 1870 have been associated with successful industrialization (Szirmai, 2009).

This paper sets out to investigate whether manufacturing has led to economic growth in a large panel of countries during the post-war period. The proposition to be tested is that manufacturing has a significant positive effect on growth in developing countries, and that this effect of manufacturing is stronger than that of other sectors. This is referred to as the engine of growth hypothesis. The approach is empirical. We employ a regression framework using a dataset of 88 countries, including 21 advanced economies and 67 developing countries, covering the period 1950-2005. Among other things, we investigate whether the role of manufacturing in growth has

[3] When we speak about industrialization 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)

changed over time, thus addressing the above mentioned question about whether the role of manufacturing has recently been waning recently in favour of services.

The paper is structured as follows. In section 2, we start with the observation that until 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 summarized in section 3. Section 4 reviews some of the recent contributions in the literature. Data and methods are discussed in section 6. The empirical results are presented in section 7. Section 8 concludes.

2 The Emergence of Manufacturing in Developing Countries

Since the Industrial Revolution, manufacturing has acted as the primary engine of economic growth and development. Great Britain was the first industrializer 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 industrialization 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-colonized countries in the tropics remained predominantly agrarian, while the Western world and the Asian latecomer Japan industrialized. 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. Industrialization became synonymous with wealth, economic development, technological leadership, political power and international dominance. The very concept of development came to be associated with industrialization. Industrialization was rightly seen as the main engine of growth and development.

In developing countries, moves towards industrialization 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.[4] But developing countries still remained predominantly dependent on agriculture and mining. Arthur Lewis (1978a, b) has argued that the shear profitability of primary exports was one of main reasons for the specialization 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 industrialization, 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 industrialization. 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 industrialization in the late nineteenth century, but industrialization only took off after these countries freed themselves from 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

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[4] 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.

countries. Some developing countries have experienced a process of rapid catch up which was invariably tied up with successful late industrialization (Szirmai, 2008, 2012).

Table 1: Structure of Production, 1950-2005
(Gross value added in agriculture, industry, manufacturing and services as percentage of GDP at current prices)

	1950				**1960**				**1980**				**2005**			
	AGR	IND	MAN	SER	AGR	IND	MAN	SER	AGR	IND	MAN	SER	AGR	IND	MAN	SER
Asia (15)	49	14	10	36	37	22	15	41	23	33	22	44	14	33	22	53
Latin America (24)	29	25	15	46	23	29	17	48	16	32	20	51	10	31	15	59
Middle East and North Africa (10)	31	23	9	46	23	27	11	49	12	39	14	49	11	33	13	52
Africa (18)	43	22	11	34	42	21	8	37	29	28	12	43	28	27	10	45
Developing countries (67)	37	22	12	42	31	25	13	44	21	32	17	47	16	31	15	53
Advanced economies (21)	16	40	29	45	12	41	30	47	4	33	20	57	2	26	14	68

AGR= Agriculture, IND = Industry, MAN = Manufacturing, SER = Services. Industry includes mining, manufacturing, construction and utilities)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. For a detailed discussion of sources see Szirmai, 2009, Annex Table 1.

Table 1 documents the process of structural change during the period 1950-2005, making use of our new dataset. It documents the shares of agriculture, industry, manufacturing and services for a sample of 67 (mostly large) developing countries and 21 advanced economies. In 1950, 37 per cent of developing countries' 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 developing economies was already 42 percent in 1950, making it the largest sector. 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 (Clark, 1940; Kuznets, 1965; Syrquin, 1988).

In 1950, the share of manufacturing in developing countries was only 12 per cent of GDP compared to 29 per cent in the advanced economies. This is low in comparative perspective, but higher than one would expect for countries that are just embarking on a process of industrialization.[5] The only countries which really had negligible shares of manufacturing were Tanzania, Zambia, Nigeria and Sri Lanka. Latin America was 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 18 per cent in the early eighties. Between 1980 and 2005, the share of manufacturing continued to increase in many Asian economies, but we observe deindustrialization in Latin America and Africa. The most important sector in developing countries in 2005 is the service sector, accounting for around 53 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 higher than to that of the advanced economies.

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). There is an *empirical correlation* between the degree of industrialization and the level of per capita income in developing countries (Rodrik, 2009). The developing countries which now have higher per capita incomes have seen the share

[5] The average African manufacturing share for 1950 is implausibly high. One would have expected percentages in the range of 0-6% rather than 11 per cent on average. It is likely that the early national accounts for developing countries focus on the formal sector and exaggerate the share of manufacturing, and hence they tend to underestimate informal activities and agricultural output.

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. In cross section analyses, the relationship between per capita GDP and share of industry or manufacturing is curvilinear rather than linear, with low levels of per capita GDP associated with low shares of manufacturing, intermediate levels with high shares and high income economies with lower shares (an inverted U shape, e.g. Rodrik, 2009). For developing countries this implies a positive relationship between GDP per capita and shares of manufacturing.

Our working hypothesis, which we will put to the test in an econometric model, is that this correlation between levels of GDP per capita and shares of manufacturing results from a causal relationship between industrialization and growth. Theoretical and empirical arguments for this hypothesis are discussed below.

First, it is argued that productivity is higher in the manufacturing sector than in the agricultural sector (Fei and Ranis, 1964; Syrquin 1984, 1986). The transfer of resources from agriculture to manufacturing (i.e., industrialization) provides a *structural change bonus*. This is a temporary effect, i.e., it lasts as long as the share of manufacturing is rising. Similarly, the transfer of resources from manufacturing to services provides a *structural change burden* in the form of Baumol's disease (Baumol, 1967). 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 (Riddle, 1986; Timmer and de Vries, 2009, De Vries, 2010; Marks, 2009; Inklaar et al., 2008; Triplett and Bosworth, 2006) but has definitely been part of the engine of growth argument in the past (Rostow, 1960; Gerschenkron, 1962; Kitching, 1982, Higgins and Higgins, 1979) .

Next, compared to agriculture, the manufacturing sector is assumed to offer 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 share of manufacturing will contribute to aggregate growth. The engine of growth hypothesis implicitly argues that capital intensity in manufacturing is higher than in other sectors of the economy. However Szirmai (2009) has shown that this is not always the case.

In the third place, the manufacturing sector offers special opportunities for *economies of scale*, which are less available in agriculture or services, and for both *embodied and disembodied technological progress* (Cornwall, 1977). The latter argument is of particular importance. Technological advance is seen as being concentrated in the manufacturing sector and diffusing 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 (Mahanolobis, 1953).

Linkage and spillover effects are assumed to be stronger in manufacturing than in agriculture or mining. The idea of linkage effects refers to the direct backward and forward purchasing relations between different sectors and subsectors. Linkage effects create positive externalities to investments. Spillover effects refer to the disembodied knowledge flows between sectors. Spillover effects are a special case of externalities, related to investment in knowledge and technology. Linkage and spillover effects are presumed to be stronger for manufacturing than in other sectors (Hirschman, 1958). Intersectoral linkage and spillover effects between manufacturing and other sectors such as services or agriculture are also very powerful.[6] (see Cornwall, 1977, but also Tregenna, 2007).

The final argument refers to demand effects. As per capita incomes rise, the share of agricultural expenditures in total (consumption) 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 therefore have a demand impediment to growth, unless they can profit from expanding world markets for manufacturing goods, i.e., industrialise. In recent years, a related argument has been made for services (Falvey and Gemmel, 1996;

[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 capitalized on agriculture manufacturing linkages (also referred to as the balanced growth path).

McLachlan et al. 2002; Iscan, 2010). 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

The evidence for the engine of growth hypothesis in the 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 hypothesis 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 turns out to be higher 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 we use below, 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 role of manufacturing in 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 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, but construction and services also turn out to be important, especially for manufacturing growth.

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 growth acceleration, this leading role is taken over by the service sector, though manufacturing continues to have an important positive contribution.

In sum, the existing 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 most advanced economies.[7]

5 Research Question

To guide our empirical analysis we have taken a strong version of the engine of growth hypothesis as our point of departure. We hypothesize that during the period 1960-2005 there is a positive and significant relationship between the share of manufacturing in GDP and the (subsequent) rate of growth of GDP per capita. This is the question that will guide our econometric analysis.

We examine this hypothesis by regressing per capita GDP growth rates over five year periods (1950 – 1965, 1965 – 1970, etc.) on manufacturing shares at the beginning of these five-year periods (1950, 1965, etc.). We add the share of services at the beginning of the five year periods in order to compare manufacturing as an explanatory variable for growth, to services. 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. Finally we examine these relationships for different periods and different groups of countries. More specifically, we are interested in the question whether manufacturing is more important for growth in developing countries, and whether the importance of manufacturing is declining over time as suggested by some of the existing literature.

6 Data and Methods

6.1 Data definitions and sources

We constructed our own dataset of sectoral shares for the period 1950-2005 as follows. The World Bank World Development Indicators (WDI) contains information about the value shares at current prices of major sectors: agriculture, industry, manufacturing and services. These data

[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.

originally derive from the UN national accounts database, 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 UN national accounts statistics (paper publications) for the early years and the missing years, and also used other sources to fill gaps in the database (such as the Groningen Growth and Development Centre 60 industry, 10 industry and EUKLEMS databases, the UNIDO Industrial Statistics database, and, incidentally, country sources). The manufacturing data are described in detail in a 2009 working paper by Szirmai (2009).

For per capita growth we used the Maddison dataset of historical GDP statistics (Maddison, 2009) as our basic source of data. For human capital, one of our control variables, we used the Barro and Lee (2010) dataset for average years of education for the population of above fifteen years of age. We filled in a few gaps in these data using Lutz et al (2007), Cohen and Soto (2007) and Nehru (1995). Additional control variables were population size, an index of openness and climate zone. The index of openness (exports plus imports in local as percentage of GDP) was taken from the Penn World Tables (version 6.3, openness defined in current prices), supplemented by data from the World Tables. Climate zone was measured as the percentage of land area in a temperate climate zone, based on data from Gallup et al (1999). Because this variable has a very bimodal distribution, with peaks near 0 and 100, we transformed it to a binary variable that is 1 for countries with >50% of their land area in the temperate climate zone. Population data were derived from World Population Prospects: The 2008 revision (UN, 2009), Taiwan from Maddison, 2009, West Germany and Czechoslovakia from GGDC Total Economy Database.

6.2 Methods

We estimate panel regression models. Our main dependent variable is growth of GDP per capita per five year period (GR). The explanatory variables are the shares of manufacturing (MAN), and services (SER) in GDP at the beginning of each five year period. GDP per capita relative to the US (RELUS) at the beginning of each five year period represents the distance to the global productivity leader (a low value of RELUS implies a large gap). Human capital (EDU) at the beginning of each five year period is our measure of absorptive capacity. Other variables include log population size (LNPOP), climate zone (CLIMATE), the degree of openness (OPEN), and time-intercept dummies for each of the 9 five year time periods between 1960 and 2005.

Because our data are a panel, we can account for unobserved country characteristics by including either fixed or random effects in the model, and do not have to rely only on OLS. Table 2 summarizes our data in terms of the means and standard deviations. The standard deviation is broken down into the two dimensions of the panel, i.e., between countries ("Between") and over time, within countries ("Within"). As the table shows, the within component of our dependent variable (the growth rate of GDP per capita) is fairly large (larger than the mean, and almost twice as large as the between component). This means that this variable is especially volatile over time, within single countries. Compared to this time volatility, the volatility between countries is relatively limited.

Table 2: Descriptive statistics of the panel dataset

			Standard Deviation			Observations		
Variable		Mean	Overall	Within	Between	# obs.	# countries	T-bar
Growth rate	1950-2005	2.2	3.1	2.8	1.4	954	92	10.4
Manufacturing share	1950-2005	17.8	8.3	4.5	7.2	833	92	9.1
Service share	1950-2005	49.4	12.0	7.4	10.2	836	92	9.1
Per capita GDP relative to USA	1950-2005	0.30	0.27	0.07	0.26	957	92	10.4
Education	1950-2005	5.2	2.9	1.5	2.5	922	88	10.5
Climate	1950-2005	0.28	0.45	0	0.45	1012	92	11.0
Openness	1950-2005	64.1	42.9	20.5	37.5	946	92	10.3
Ln population	1950-2005	9.2	1.7	0.4	1.7	1003	92	10.9

Note: T-bar indicates the average number of observations per country.

This pattern is exactly the 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 countries). These particular characteristics of the dependent and independent variables imply that we cannot rely purely on fixed effect estimations. These estimations eliminate the between effects completely, by expressing the data as deviations from the country means. Given the slow-changing nature of our explanatory variables, we would expect these between effects to be relatively strong, and hence we would like to include them in the estimations. Random effects estimations will do so, because they include both a within and a between element.

However, random effects estimations require that the country specific effect is independent of the explanatory variables. A Hausman test (of random vs. fixed effects) is customary to check whether this requirement is fulfilled. If the Hausman text rejects the random effects estimation method, using fixed effects is the alternative that is usually opted for. In our case, the regressions that we will document below reject the random effects model. However, rather than resorting to fixed effects estimations only, we will use the Hausman & Taylor (1981) estimation method. This is essentially a random effects method that takes the dependency between the country effect and some of the dependent variables into account by using instrumental variables for the affected explanatory variables (i.e., the "endogenous" variables). The method requires that at least one of the instruments is time-invariant.

The Hausman-Taylor estimations also require us to determine which of the explanatory variables are endogenous, i.e., correlated with the country effect. To do this, we follow a procedure inspired by Baltagi et al. (2003) and also applied in Jacob and Osang (2007). In this procedure, we run a regression with our dependent variable growth and, one at a time, a single explanatory variable. Both a random effects and a fixed effects estimation is done, and a Hausman test is carried out to test whether the random effects estimation is appropriate. If it is, the variable is considered as exogenous (i.e., not correlated with the country effect). If the Hausman test indicates that the random effects estimation is not appropriate, we consider the variable as endogenous in the Hausman-Taylor estimations. Thus, openness and country size are shown to be exogenous. The climate zone variable is taken as the time-invariant exogenous variable without any testing (i.e., we assume rather than test that geography is exogenous).

With all our panel estimation methods, we must be careful about the assumption we make in estimating the parameters for different time periods (i.e., a subset of the nine 5-year blocks that make up the temporal dimension for each country, e.g., 1950 – 1975, 1975 – 1990 and 1990 – 2005). One way to implement this would be to estimate the model separate for different time periods. This would amount to assuming that in every individual time period, the country has a different country effect (either random or fixed). Alternatively, we estimate the model for all time periods together and let the coefficients vary by interacting them with time period dummies. In this case, each country has a country effect that is fixed over the entire period 1990 – 2005. We opt for the latter method, although our results do not vary much when the first option is chosen.

7 Results

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

We start by estimating the model on the complete sample (665 observations, 89 countries) and present the basic random effects (RE), fixed effects (FE), Hausman Taylor (HT) and between (BE) specifications below in Table 3. The between specification estimates the model in a pure cross-country way by using averages over time of all variables (within each country). This is the only model that we employ that does not contain any country-specific effects, and we include it only for comparison to the other models.

The Hausman test rejects random effects as an appropriate model (*p*-value of the test is 0.024). Therefore we consider the Hausman-Taylor estimations more appropriate than the random effects estimation. The share of manufacturing in GDP (MAN) is significant in all four specifications. Despite our earlier worries about the limited within-variability of our explanatory variables, the fixed effects estimator provides a stronger effect of manufacturing than either the random effects or the Hausman-Taylor estimator. It thus seems that our choice for Hausman-Taylor as the main estimator for subsequent estimations is a conservative one. The between estimation yields a coefficient for manufacturing that is about as large as the fixed effect model. Like the fixed effects estimation, the Hausman-Taylor estimation provides high values for rho (the share of country effects in unexplained variance), while rho is much lower for the random effects estimator. Because the fixed effects estimator does not put any restrictions on the fixed effects, the high value for rho adds further confidence in the Hausman-Taylor estimation, because it produces country effects that are as important as in the fixed effects model.

Table 3: Determinants of growth: the basic run 1950-2005

Variable	Random effects coef	SE	sig	Fixed effects Coef	SE	sig	Hausman-Taylor Coef	SE	sig	Between Coef	SE	Sig
MAN#	0.045	0.018	**	0.065	0.039		0.045	0.021	**	0.063	0.030	**
SER#	0.020	0.020		0.017	0.026		0.022	0.016		-0.005	0.020	
RELUS#	-4.326	0.827	***	-9.123	2.168	***	-7.181	1.296	***	-4.011	1.000	***
EDU#	0.224	0.079	***	-0.184	0.244		-0.220	0.159		0.338	0.106	***
KGATEMP	1.526	0.349	***	(dropped)			4.073	1.353	***	1.183	0.420	***
OPEN	0.010	0.006		0.008	0.009		0.008	0.005		0.014	0.005	***
LNPOP	0.220	0.136		-2.420	0.914	**	-0.372	0.297		0.316	0.123	**
D55-60	-0.950	0.365	***	-0.546	0.331		-0.740	0.401	*	-8.391	7.210	
D60-65	-0.089	0.374		0.893	0.448	**	0.442	0.407		-28.313	7.535	***
D65-70	-0.017	0.382		1.333	0.493	***	0.699	0.428		15.939	7.582	**
D70-75	-0.459	0.461		1.495	0.675	**	0.615	0.491		-19.690	5.570	***
D75-80	-0.912	0.499	*	1.564	0.773	**	0.475	0.532		3.440	7.028	
D80-85	-3.320	0.483	***	-0.355	0.830		-1.636	0.597	***	-11.577	5.831	*
D85-90	-2.418	0.506	***	0.933	0.940		-0.519	0.670		-1.728	4.899	
D90-95	-2.391	0.541	***	1.418	1.091		-0.207	0.737		-6.333	4.457	
D95-00	-2.470	0.642	***	1.907	1.288		0.043	0.821		-5.661	6.067	
D00-05	-2.280	0.682	***	2.456	1.375	*	0.455	0.890		-10.137	6.312	
Constant	-1.020	1.693		25.101	7.775	***	5.463	2.887	*	3.221	4.266	
Rho	0.126			0.837			0.831					
# obs	790			790			790			790		
# countries	88			88			88			88		
R2 within	0.14			0.18								
R2 between	0.28			0.02						0.51		
R2 overall	0.19			0.00								

Variables indicated with a # are treated as endogenous in the Hausman-Taylor estimation

Standard errors for random effects and fixed effects are robust (adjusted for clusters)

The share of services in GDP (SER) is never significant, which suggests at first sight that the service sector does not work as an engine of growth in our sample of countries. Education (EDU) is significant in the between and random effects, and not in the fixed effects and the Hausman-

Taylor. The coefficient on our catch-up term (country GDP per capita 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 that are usually found in growth estimations, and which are either related to conditional convergence to a steady state, or to catching-up based growth related to the international diffusion of knowledge (see Fagerberg, 1994). KGATEMP is not significant in the between specification and had to be dropped (because it is time-invariant) in the fixed effects specification. It is significant with a positive sign in the between and Hausman-Taylor estimations, which means that countries in the temperate climate zone tend to grow more rapidly than other countries (i.e., mostly, countries in the tropics and subtropics).

These initial results in Table 3 are in line with the engine of growth hypothesis. In the (conservative) Hausman Taylor specification, a 10 percent-point increase in the share of manufacturing raises growth by 0.5 percent-point. According to the fixed effects estimation, the effect of such an increase in the manufacturing share would be closer to 1 percent-point. Although these effects of manufacturing on growth are far from negligible, their size does not correspond to the effect that one would associate with an industrialization-based growth spurt in some newly industrializing countries, for example in South-East Asia (Fagerberg and Verspagen, 1999). This is not surprising, since our model points to a linear relationship between the share of manufacturing and the growth rate, i.e., the hypothesis is that an increase of manufacturing from a low base-level (e.g., an agricultural economy that starts to industrialize) has the same effect on the growth rate as an increase in manufacturing in a highly industrialized economy. In order to be able to capture the effect of industrialization on development in a broader way, we will have to change the model.

Our preferred way of doing that is by adding interaction effects between the manufacturing variable (MAN) and some of the other explanatory variables in the model, in particular with MANREL and with EDU. How these interaction effects enrich the model will be discussed below. For reasons explained above, we will use the Hausman-Taylor specification as the estimation method for these more elaborate model specifications aimed at exploring the engine of growth hypothesis further (i.e., in subsequent tables only the Hausman Taylor specification will be documented).

7.2 Adding Interaction Terms to the base run.

The new interaction variables that we introduce in the model are MANREL and MANEDU. MANREL is the interaction between manufacturing share (MAN) and the distance to the productivity leader (RELUS). MANEDU is the interaction between manufacturing share (MAN) and average years of education (EDU). In addition to these interaction effects, we leave the original variables (MAN, EDU and RELUS) in the model as well. Because both variables that go into a single interaction variable were considered as endogenous before, we also consider the interaction variables as endogenous in the Hausman-Taylor estimations.

The rationale for including the MANREL variable is that we want to create flexibility in the model to accommodate a growth take-off effect due to industrialization. If industrialization is a factor that may create growth take-off, this implies that the effect of manufacturing (MAN) on growth is different in developing and developed countries. This is exactly the effect that the interaction variable creates, because the marginal effect of MAN on growth now becomes dependent on RELUS. If the impact of manufacturing is larger in developing countries than in developed countries, we expect that the sign of the coefficient on MANREL will be negative, and the coefficient on MAN will be positive. To see why this is the case, consider the partial equation that collects all terms involving MAN, RELUS, and the interaction (MANREL):

$$GR = \alpha MAN + \beta RELUS + \gamma EDU + \phi MANREL + \varphi MANEDU, \qquad \text{(eq. 1)}$$

where α, β, γ, ϕ and φ are parameters that we estimate in the regression model.

We start by presenting a modified version of the engine of growth hypothesis that argues that industrialization is a core element of a catching-up based growth strategy. To consider this idea in its purest form, we initially set $\phi=0$ (this will be relaxed later). Then, the marginal effect of MAN on growth, i.e., the effect on growth of a 1-unit (%-point) increase of MAN is now equal to $\alpha + \phi RELUS$ (keep in mind that MANREL = MAN x RELUS). If $\phi<0$ and $\alpha>0$, countries with low values of RELUS (i.e., developing countries) will have a relatively high and (depending on the exact parameter values) positive marginal effect. At RELUS = $-\alpha/\phi$, the marginal effect is exactly zero (note that with $\phi<0$ and $\alpha>0$, $-\alpha/\phi$ is a positive number, and if the absolute value of

ϕ > the absolute value of α, this number is also <1). For values of RELUS > $-\alpha/\phi$, the marginal effect even becomes negative. Thus, our modified engine of growth hypothesis that accounts for the effect of industrialization in catching-up growth in developing countries is that $\phi<0$ and $\alpha>0$.

Note that the interaction effect MANREL also provides a different view on the convergence effect that plays such a prominent role in the empirical growth literature (e.g., Barro and Sala-i-Martin, 1995). From this point of view, the marginal effect of RELUS on growth is equal to $\beta + \phi$MAN. Convergence or catching-up means that this overall marginal effect is negative, for which it is sufficient (although not necessary) that $\beta, \phi<0$. Then, an increase in MAN makes this effect even smaller ("more" negative), i.e., industrialization reinforces the convergence or catching-up effect. In addition to the parameter expectations on α and ϕ that we have already phrased, we therefore expect $\beta<0$.

The interaction between MAN and EDU is intended to capture the effect of absorptive capability (Verspagen, 1991; Cohen and Levinthal, 1989). Catching-up based growth through industrialization is a process that involves knowledge transfer and innovation, and the efficiency with which this can take place depends on absorptive capability on the side of the knowledge "receiver". Although other factors than just education, such as infrastructure, political stability etc., are involved (Abramovitz, 1986), we will proxy absorptive capability with EDU. The hypothesis is that a better educated workforce will make the marginal effect of manufacturing on growth higher. Hence our expectation is that the sign of the coefficient on the interaction effect of MANEDU is positive. The marginal effect of MAN on growth in the specification with both interaction effects present then becomes $\alpha + \phi$RELUS + φEDU, where $\varphi>0$ represents the idea that education is a positive influence on absorptive capability.

The marginal effect of EDU on growth is equal to $\gamma + \varphi$MAN. It seems to be a reasonable hypothesis that this effect is always positive, which suggests, in addition to $\varphi>0$, which we have already hypothesized, that $\gamma>0$.

Table 4: Determinants of growth: Estimation results with interaction terms, Hausman Taylor specification

	Base run without Interaction terms			Model with Interaction term MANREL			Model with interaction terms MANREL and MANEDU		
	(1)			(2)			(3)		
Variable	Coef	se	Sig	coef	se	Sig	coef	se	
Endogenous									
MAN	0.045	0.021	**	0.087	0.031	***	-0.020	0.043	
SER	0.022	0.016		0.018	0.016		0.012	0.016	
RELUS	-7.181	1.296	***	-4.824	1.803	***	-3.330	1.813	*
EDU	-0.220	0.159		-0.202	0.158		-0.639	0.199	***
MANREL				-0.118	0.064	*	-0.241	0.072	***
MANEDU							0.027	0.007	***
Exogenous									
OPEN	0.008	0.005		0.007	0.005		0.005	0.005	
LNPOP	-0.372	0.297		-0.312	0.288		-0.070	0.236	
	-0.740	0.401	*	-0.730	0.401	*	-0.757	0.401	*
	0.442	0.407		0.433	0.406		0.428	0.404	
D55-60	0.699	0.428		0.673	0.427		0.655	0.422	
D60-65	0.615	0.491		0.544	0.490		0.545	0.483	
D65-70	0.475	0.532		0.358	0.531		0.330	0.520	
D70-75	-1.636	0.597	***	-1.782	0.597	***	-1.811	0.582	***
D75-80	-0.519	0.670		-0.684	0.669		-0.743	0.649	
D80-85	-0.207	0.737		-0.399	0.736		-0.432	0.714	
D85-90	0.043	0.821		-0.153	0.820		-0.135	0.795	
D90-95	0.455	0.890		0.254	0.887		0.283	0.861	
D95-00	0.008	0.005		0.007	0.005		0.005	0.005	
D00-05	-0.372	0.297		-0.312	0.288		-0.070	0.236	
Time invariant									
KGATEMP	4.073	1.353	***	4.057	1.306	***	4.566	1.096	***
Constant	5.463	2.887	*	4.557	2.815		4.374	2.416	*
Rho	0.831			0.817			0.720		
# obs	790			790			790		
# countries	88			88			88		

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

The Hausman-Taylor results for the model with interaction effects are documented in Table 4. Note that we have also estimated a similar model with interaction effects on SER instead of MAN (in that model, no interaction effects on MAN were included, although MAN itself was present). This estimation yielded no significant effect of SER on growth, which is why we do not document the detailed results (these are available on request). We also estimated a version of the model in which OPEN was used as an additional interaction variable with MAN. Again, we do not document these estimations (results available on request), because this interaction term was never significant. The first column in Table 4 reproduces the base run of Table 3, i.e., a model without interaction effects. The second column in Table 4 includes only the interaction term MANREL, the third column includes both MANREL and MANEDU. We do not document a regression that includes only MANEDU and not MANREL. These results are available on request, and do not differ substantially from column 3).

When the interaction terms are included in the model, they are always significant. This justifies, in a statistical sense, their presence in the model. Moreover, the sign on the interaction effects is as expected (negative for MANREL and positive for MANEDU). In column 2, i.e., with only MANREL present, the signs on MAN and RELUS are also as expected, and significant. In the last column, MAN on its own is not significant, but EDU and RELUS are, although EDU has a negative sign, which is against our expectations.

In order to obtain a full picture of the impact of these variables on growth, we need to look at the full marginal effects, i.e., including both the interaction and the direct effects. We therefore provide a visualization of the marginal effects of RELUS and EDU in Figures 1 and 2. These marginal effects depend on MAN, which is why this variable is on the horizontal axis of the figures. The solid line indicates the marginal effect itself; the dashed lines indicate the 95% confidence interval around this marginal effect. This confidence interval has been calculated on the basis of a *z*-test statistic that results from the variance-covariance matrix of the coefficients that are estimated in the regression, as well as the particular value of MAN on the horizontal axis (in the calculation of the confidence interval, this value of MAN is considered as non-stochastic). We use the last column in Table 3 to calculate these results (the graph for the marginal effect of RELUS does not differ substantially if we use the results in the second column).

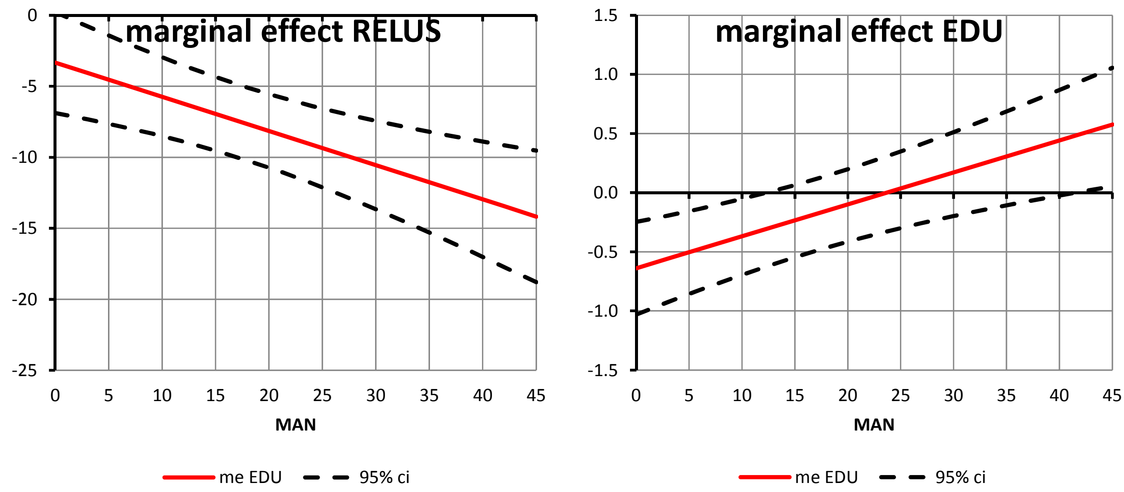

Figure 1. The marginal effect of RELUS and EDU on GR (based on estimations in column 3 of Table 4)

The marginal effect of RELUS on growth is always negative, and significant, i.e., irrespective of the value of the manufacturing variable. This indicates that there is always a catching-up bonus, no matter whether the country is industrialized or not. However, this bonus does increase with the degree of manufacturing. For every 10% points industrialization, the catch-up bonus increases by about 2.5% points (the exact slope of the line is -0.24).

As expected, the marginal effect of EDU on growth increases with industrialization. However, this effect is mostly insignificant, i.e., most of the time the confidence interval around the solid line embraces the horizontal axis (zero marginal effect). At low values of manufacturing, the marginal effect of education is even negative, and significant. This is inconsistent with our expectations. To be precise, the marginal effect of 1 year of schooling (EDU) on growth is negative (positive) for values of MAN that are smaller (larger) than 24% (where the solid line crosses the x axis). The marginal effect of EDU becomes significantly negative at values of MAN that are lower than about 12%. With the particular distribution of the MAN variable, this implies that about 27% of all observations show a significantly negative marginal effect of EDU. This picture of the impact of education on development may be hard to accept. But this result must be seen in light of the fact that we have found very little effect of EDU on growth in any regression so far. In Table 3, for example, the fixed effects and Hausman-Taylor estimations yielded negative and non-significant effects of EDU on growth. We may thus have to accept that our regressions have little to say about the direct impact of human capital on growth. This does not detract, however, on the role of human capital as a factor in absorptive capability, which only depends on the coefficient on MANEDU, and this is significant and positive as expected.

The last marginal effect that we need to consider from Table 4 is that of MAN itself. This marginal effect depends on RELUS and EDU. We choose to visualize this effect by constructing a RELUS – EDU flat plane, and dividing this plane into two parts, of which one corresponds to a positive marginal effect of MAN, and the other to a negative marginal effect of MAN. This is done in Figure 2. The solid line divides the RELUS – EDU plane into the two parts.[8] Above (left of) this line, the marginal effect of MAN is positive, below (to the right) of the line, the marginal effect is negative. The dashed lines again represent the 95% confidence interval around the solid line. As before, EDU and RELUS are considered as non-stochastic variables, and the confidence interval is determined using a *z*-test based on the entire variance – covariance matrix of the estimation. The dots in the figure represent actual observations. Whenever an observation is above (below) the highest (lowest) dotted line, the observation represents a case where manufacturing contributed positively (negatively) to growth, according to our regressions.

[8] To be precise, the solid line in Figure 2 is described by the equation $EDU = -(\alpha + \phi\ RELUS)/\varphi$.

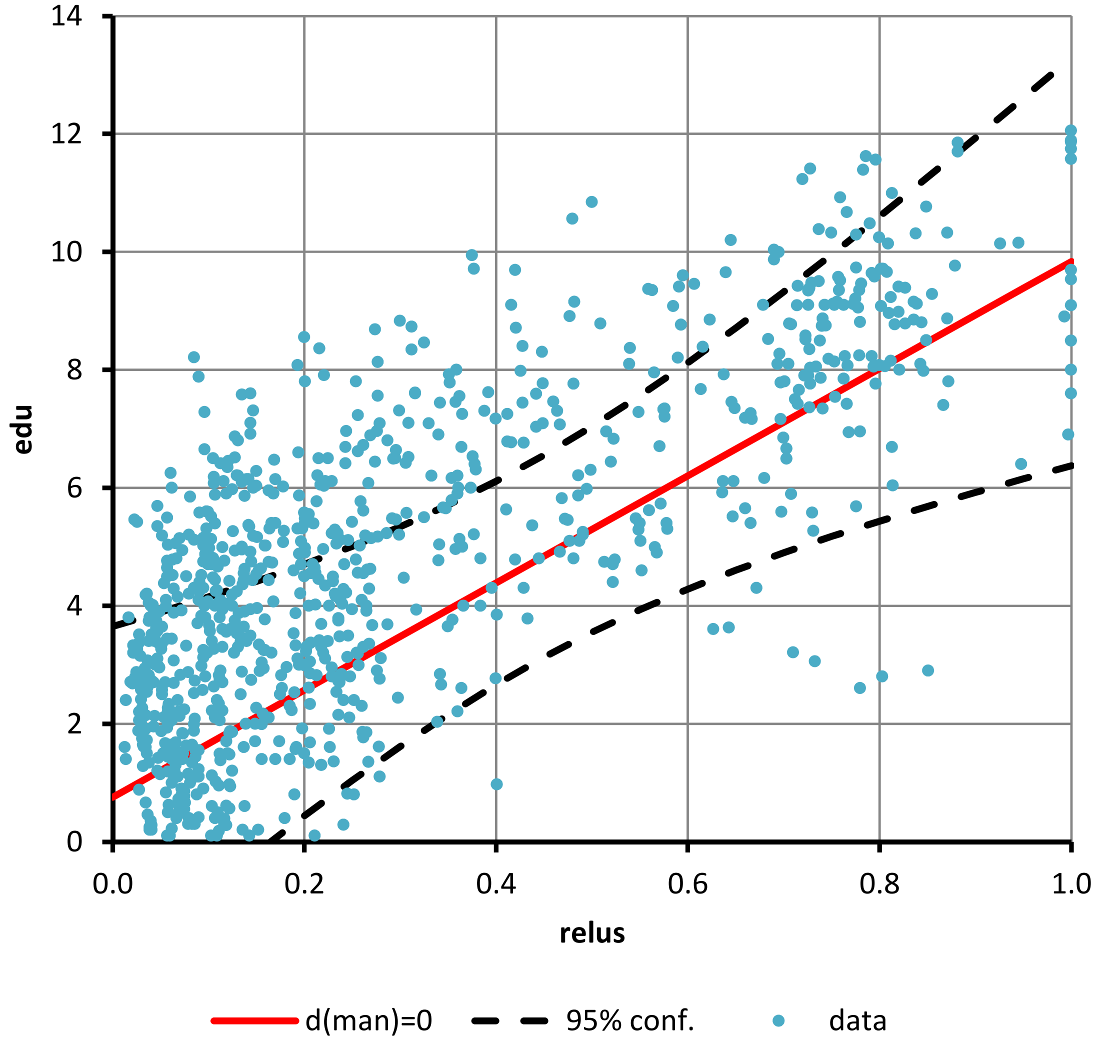

Figure 2. The marginal effect of MAN on GR (based on estimations in column 3 of Table 4)

The upward-sloping nature of the line in Figure 2 implies that especially countries with low levels of development (i.e., high catching-up potential) and high human capital, will show a positive effect of manufacturing on growth. This is fully in line with our theoretical expectations. We see a fairly large number of observations above the highest dotted line, but also a large number of observations between the dotted lines (i.e., insignificant marginal effect of manufacturing). Only a small number of observations show a negative and significant marginal effect of manufacturing. Thus, the results in Figure 2 generally support the engine of growth hypothesis, although mostly in the "extended" form of equation 1.

Figure 2 also sheds light on the interpretation of the negative (and significant) coefficient of MAN in the last column of Table 4. In itself, such a negative sign may appear to go against our theoretical expectations, because it indicates that, without considering the effect of RELUS and EDU, the effect of manufacturing on growth is negative. However, as the figure shows, this is "compensated" by even very modest values of EDU and catching-up potential.

It is also interesting to look at a number of individual countries, especially those that are prominent cases in the literature about industrialization and development, and investigate where they fit in Figure 1. We will briefly orient this exercise by geographical region. In Asia, Korea and Taiwan, both famous cases that were part of the "Asian Miracle," were above the threshold level of education specified by the confidence interval in Figure 2 for the entire period, i.e., since 1950. The combination of catching-up bonus and education in these two countries was such that from 1950s onwards, they had a strong positive marginal effect of industrialization on growth. Hong Kong, another country that was part of the Asian Miracle, passed the threshold in 1970, but fell below the threshold again in 1990 (by then it was so highly developed that the catching-up bonus for manufacturing became small). Japan started above the threshold, but fall below it in 1970. The Philippines passed the threshold in 1965, China in 1970, Malaysia in 1975, Indonesia in 1990 and India in 2000.

In Latin America, we do not find any major countries that were already above the threshold level of education in 1950. Chile was the first to pass the threshold in 1965; other countries were later: Argentina in 1975, Colombia in 1980, Mexico in 1985, and Brazil in 1995. In Africa, countries generally take even longer to rise above the threshold level of education during our period of investigating. Ghana (1975), South Africa (1980), Botswana (1985), Kenya (1985), Egypt (1990), Tanzania (1990), Nigeria (1995), and Uganda (1995) are examples. Most European and other developed countries are below the threshold value of education, indicating that for advanced economies the share of manufacturing has become less important for growth. Nevertheless, some countries rise above the threshold level towards the very end of the period studied (e.g., Sweden in 1990 and Germany in 2000).

It is also interesting to reflect on the large number of observations where the marginal effect of manufacturing is insignificant. Economic growth is a complex phenomenon which is not driven by a single universal causal factor. Nevertheless, it is striking that the statistical analysis does bring out the importance of manufacturing in several of the famous cases of accelerated catch up such as those of South Korea and Taiwan.

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, and proceed by estimating the model with slope shift dummies for each of the periods to see whether the effects over manufacturing change over time.[9] The Hausman Taylor results are reproduced in Table 5.

On first sight, the effects of adding period slope shift dummies in column 1 are quite dramatic. While the coefficient of manufacturing was positive and significant in the base run in Table 3, it now becomes insignificant for 1950-1970 and 1990-2005. The share of services in the second period now also has a significant effect on growth, and the effect of education in the first period is significantly negative. It is also interesting to note that openness, which so far has not been significant, has a significant and positive sign in the last period. We also have a significant and negative sign for country size (LNPOP) in the first period.

[9] Note that by applying slope-shift dummies, rather than estimating the model separately for each of the 3 periods, we assume that the country effect is fixed over the entire period 1950 – 2005.

Table 5: Estimations for three periods, 1960-75, 1975-1990, 1990-2005

	No interaction terms			With interaction term MANREL			With MANREL and MANEDU		
	(1)			(2)			(3)		
Variable	coef	se	Sig	coef	se	sig	coef	se	
Endogenous									
man 60-75	-0.029	0.033		0.029	0.042		-0.082	0.052	
man 75-90	0.056	0.032	*	0.114	0.044	**	0.007	0.064	
man 90-05	0.035	0.032		0.110	0.045	**	-0.066	0.101	
ser 60-75	-0.001	0.022		-0.013	0.023		-0.005	0.023	
ser 75-90	0.104	0.024	***	0.098	0.024	***	0.098	0.024	***
ser 90-05	0.007	0.021		-0.003	0.021		-0.005	0.021	
relus 60-75	-5.381	1.498	***	-0.206	2.578		3.131	2.743	
relus 75-90	-12.39	1.656	***	-7.811	3.127	**	-4.869	3.473	
relus 90-05	-11.00	1.628	***	-6.376	2.900	**	-2.563	3.354	
edu 60-75	-0.580	0.197	***	-0.560	0.197	***	-1.422	0.320	***
edu 75-90	-0.234	0.178		-0.258	0.182		-0.713	0.305	**
edu 90-05	-0.160	0.174		-0.114	0.175		-0.656	0.338	*
manrel 60-75				-0.209	0.090	**	-0.428	0.110	***
manrel 75-90				-0.200	0.114	*	-0.318	0.137	**
manrel 90-05				-0.266	0.126	**	-0.441	0.169	***
manedu 60-75							0.048	0.014	***
manedu 75-90							0.024	0.013	*
manedu 90-05							0.030	0.018	*
Exogenous									
open 60-75	0.008	0.007		0.010	0.007		0.009	0.007	
open 75-90	0.003	0.007		0.002	0.007		0.000	0.006	
open 90-05	0.013	0.006	**	0.009	0.006		0.007	0.006	
lnpop 60-75	-0.716	0.381	*	-0.680	0.380	*	-0.434	0.347	
lnpop 75-90	-0.619	0.376		-0.646	0.375	*	-0.345	0.343	
lnpop 90-05	-0.494	0.366		-0.535	0.365		-0.257	0.336	
D65-70	-0.587	0.393		-0.553	0.392		-0.644	0.391	*
D70-75	0.779	0.406	*	0.811	0.406	**	0.700	0.403	*
D75-80	1.283	0.439	***	1.321	0.439	***	1.145	0.434	***
D80-85	-5.346	2.382	**	-4.591	2.418	*	-5.061	2.473	**
D85-90	-5.295	2.406	**	-4.585	2.442	*	-5.088	2.496	**
D90-95	-7.493	2.463	***	-6.799	2.497	***	-7.287	2.551	***
D95-00	-6.520	2.515	**	-5.811	2.546	**	-6.295	2.599	**
D00-05	-3.487	2.310		-2.716	2.333		-1.702	2.708	
Time invariant									
Kgatemp	5.660	1.679	***	5.706	1.676	***	5.714	1.489	***
Cons	10.871	3.720	***	9.810	3.730	***	9.248	3.451	
Rho	0.897			0.897			0.868		
# obs	790			790			790		
# countries	88			88			88		

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

However, we have seen in the previous section that the “extended” engine of growth hypothesis may be more realistic than the simple version. In other words, it is important to examine the interaction between manufacturing and other determinants of growth, so we proceed to add the interaction terms MANREL and MANEDU in columns 2 and 3, again with slope dummies for all three periods. As before, all interactions terms that we add are significant, and have the expected sign (i.e., for all three subperiods). The positive impact of services in the second subperiod is robust to the inclusion of the manufacturing interaction effects, and so is the negative country size effect in the first subperiod (it is now also significant in the second subperiod). Openness is no longer significant in the regressions with manufacturing interaction effects.

We proceed to look at the marginal effects of manufacturing on growth for the three subperiods, based on column 3 of Table 5. In order to save space, we do not discuss the marginal effects of RELUS and EDU as in Figure 1. In Figure 3, we present a similar analysis as in Figure 2, for all three subperiods of the estimations in Table 5. As expected on the basis of the regression results, the lines in Figure 3 have the same basic (upward-sloping) shape as in Figure 2. For each of the subperiods, we have a majority of observations that lie within the confidence interval, i.e., there is no significant effect of manufacturing on growth for these observations. However, there are also a substantial number of observations for which the marginal effect is positive, i.e., those that lie above the upper dashed line. Only in the first subperiod do we find some observations that lie below the lower dashed line, i.e., those that have a negative effect of manufacturing on growth.

In terms of a comparison between the subperiods, it is noteworthy that in the last subperiod, i.e., after 1990, only countries with very low levels of GDP per capita (below RELUS = 0.2) seem to have a positive impact of manufacturing on growth. Before 1990, there were also a number of countries with RELUS between 0.2 and, say, 0.5, that had a significant impact of manufacturing on growth. Obviously, this result is related to the position of the solid lines in the diagram, i.e., the joint effect of the estimated coefficients of MAN, MANEDU and MANREL in column 3 of Table 5.

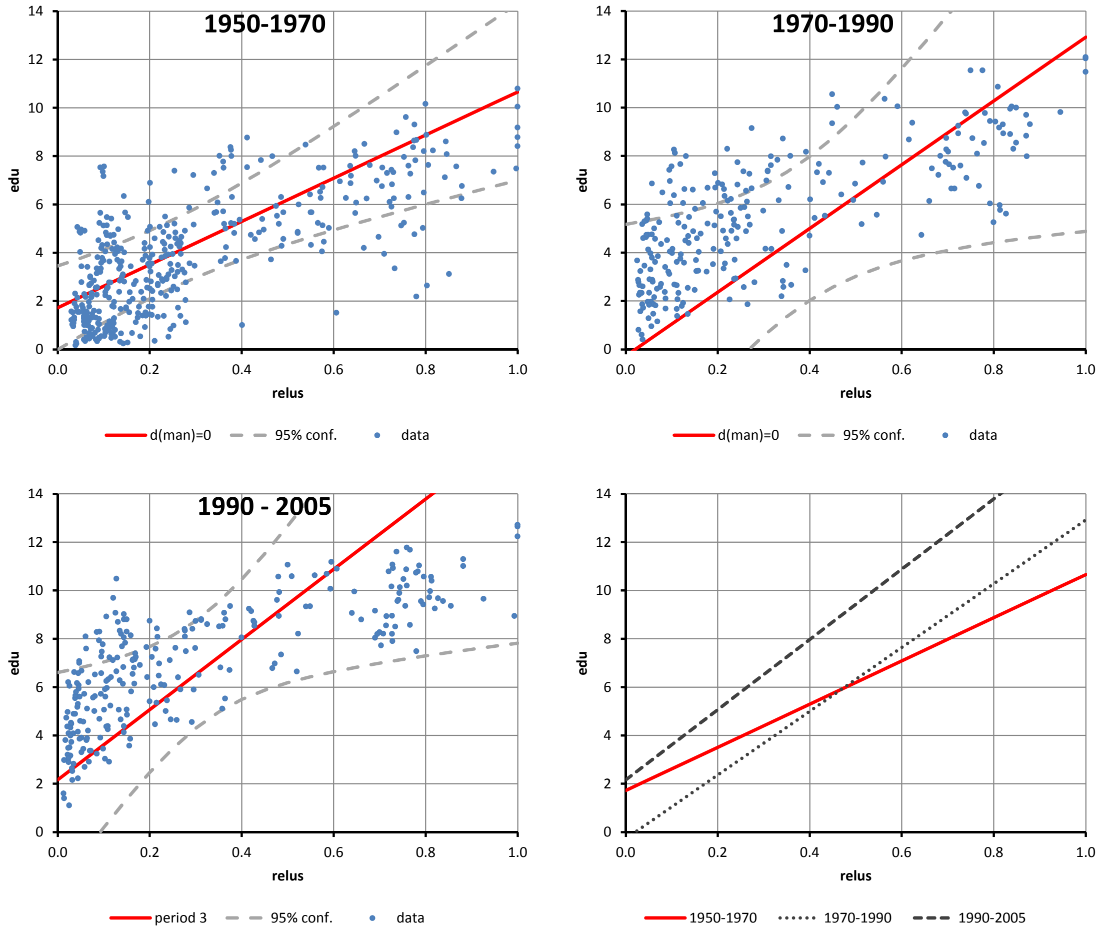

Figure 3: Marginal effects of manufacturing, subperiods

The bottom-right quadrant of Figure 3 summarizes the curves in one diagram. This compares "how easy" manufacturing as a growth strategy was in the three subperiods (the more the curve shifts to the right-lower corner of the diagram, the "easier" it becomes to grow by industrializing). From 1950-1970 to 1970-1990, the change in the position is essentially a rotation (around the point RELUS=0.5, EDU=6) that "favours" the least developed countries. For RELUS < (>) 0.5, the education threshold for a positive marginal effect of manufacturing becomes slightly lower (higher). A somewhat more dramatic effect occurs in the period 1990-2005, when the curve shifts upward. This makes an industrialization-based growth strategy "harder" than during the earlier subperiods. As a result of this shift, the "middle-income" observations (RELUS between 0.5 and 0.2) now fall within the confidence interval, rather than outside, as before. It seems global conditions have changed in a way that especially affects these middle-income countries.

8 Summary and conclusions

In this paper we have analysed a novel panel data set with information about the shares of manufacturing and services in GDP for a sample of 88 countries for the period 1950-2005. We regressed average five year growth rates on shares of manufacturing and services, and a set of control variables. The aim of the analysis was to test the hypothesis that manufacturing acted as an engine of growth, which would suggest that expanding the share of manufacturing in GDP is the key to more rapid growth and economic development.

For the total sample, we find a moderate positive impact of manufacturing on growth in line with the engine of growth hypothesis. No such effects are found for services. Splitting our sample into the subperiods 1960-1970, 1970-1990 and 1990-2005 we only find a direct effect of manufacturing on growth for 1970-1990. Services also have a positive effect on growth during this period.

We also find interesting interaction effects of manufacturing with education and income gaps. The interaction between education and manufacturing has a positive and significant effect on growth in all periods, and the interaction between manufacturing and relative GDP per capita is negative, again for all subperiods. In other words, there is a positive effect of manufacturing on growth in developing countries with a highly educated workforce. These results based on the interaction effects support the extended version of our engine of growth hypothesis, which states that manufacturing is especially effective as a growth strategy at early phases of development, but also critically depends on absorption capability (in our case, human capital).

In a comparison of the subperiods, it seems that since 1990, manufacturing is becoming a somewhat more difficult route to growth than before. Ever greater amounts of human capital are required to achieve the same positive marginal effects of expanding the manufacturing sector, and the catching-up bonus seems to have become smaller. This has especially led to a number of countries at intermediate levels of development no longer benefitting from manufacturing as an engine of growth.

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, thus achieving a more satisfactory analysis of the role of openness (which in our results is hardly ever significant in explaining growth). 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, especially within the service sector. In particular, we need to distinguish between market services and non-market services and within industry between mining, manufacturing, construction and utilities. Finally, in a subsequent analysis we would like to include policy variables and indicators of institutional characteristics in the analysis.

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