Climbing the Technology Ladder Too Fast?
An International Comparison of Productivity in South and East-Asian Manufacturing, 1963-1993

-

Marcel P. Timmer

Groningen Growth and Development Centre
University of Groningen*

December 1999

Abstract
This paper provides a star comparison of manufacturing productivity levels in China, India, Indonesia, South Korea and Taiwan with the US as the reference country for the period 1963-1993. South Korea and Taiwan showed prolonged catch up in labour productivity with the US, whereas the other countries had long periods of relative stagnation. This is reflected in relative performance of seven detailed manufacturing branches. Physical capital per hour worked in the Asian countries is still well below the US level and there are abundant opportunities for further capital intensification. Relative total factor productivity levels in South-Korean and Taiwanese manufacturing are much lower than in the US in all manufacturing branches. The same is true for India and Indonesia compared to South Korea and Taiwan. Hence, late industrializers do not automatically benefit from the increasing global pool of technologies.

Key-words: International comparisons, productivity, manufacturing, Asia.

JEL-code: O47, O57.

* I am grateful to Eddy Szirmai and Bart Verspagen for insightful discussions.

1. Accumulationists and Assimilationists

Three decades of impressive growth in East- and South-east Asia has attracted attention from economists and policy makers alike. Boosted by the World Bank (1993) study *The East-Asian Miracle*, a large body of literature attempts to explain the ‘miracle’. The debate centres around two interrelated discussions. First of all, a huge controversy arose concerning the impact and desirability of selective micro-economic interventions by national governments. Related to this is a more quantitative discussion about the sources of rapid Asian growth: the total factor productivity (TFP) debate. This second debate is the central focus of this paper. It will be argued that the discussion has two flaws. First, the analysis of catch up and convergence is restricted to an aggregate economy level (Kim and Lau 1994, Young 1995, Collins and Bosworth 1996). This might mask diverging trends at a more desaggregated sectoral level (Bernard and Jones 1996). Therefore, this paper focuses on productivity catch up and stagnation at the level of seven manufacturing branches. Secondly, we provide comparisons of productivity *levels*, in addition to *growth* trends. Growth rates alone do not tell to what extent productivity and capital intensity gaps still exist.

Krugman started the TFP-debate by popularising the findings of Young (1995) and Kim and Lau (1994) in his famous, or rather infamous, article “The Myth of Asia’s Miracle”. Young found that TFP growth rates in East-Asia did not exceed those in advanced countries, and concluded that no technological catch up has taken place. Instead, East-Asian growth is simply explained by a rapid increase in inputs through massive investment and once-and-for-all gains from increased labour participation and improved resource allocation between sectors. In short, the so-called *accumulationists* argue that the Asian miracle was based on “perspiration” rather than “inspiration”. Growth was bound to slow down soon as Western levels of capital intensity are approached (Krugman, 1994). The recent financial turmoil and its repercussions on growth in Asia seems to support this analysis, at least at first sight.

Assimilationists like Nelson and Pack (1998) concede that East-Asian growth has been fuelled by rapid growth of the physical and human capital stock.. However, they disagree with the conclusion that “technical progress has played an insignificant role in post-war aggregate economic growth of East Asian NICs” (Kim and Lau, 1994, p.264). The core of the disagreement between accumulationists and assimilationists is the interpretation of the rapid increases in capital per worker which took place. Following neo-classical theory, accumulationists interpret capital intensification as an automatic and effortless shift along a well known global production function. Less developed countries can adopt technologies practised at the world technology frontier without the need to devote resources to the development of new technologies. In contrast, assimilationists stress the effort which is necessary to master technologies which might not be new to the world, but are unknown to the countries introducing them. Viewed this way, capital intensification is not a simple movement along a prevailing production function, but a search for an enlargement of the set of production possibilities.

Successful absorption of new technologies, and investigation of new products and new markets requires a growing group of skilled workers and entrepreneurs who learn about and learn to master new technologies already in use in more advanced countries.

This paper enlarges the empirical basis for the discussion between accumulationists and assimilationists in two directions: by taking a more desaggregate view, and by providing international comparisons of productivity levels, in addition to growth rates. Section 2 outlines the industry-of-origin approach to international comparisons as used in this study. For the period 1963-1993, a star comparison of China, India, Indonesia, South Korea and Taiwan with the US as the reference country is made. Relative labour productivity levels for aggregate manufacturing are presented in section 3. South Korea and Taiwan showed prolonged catch up with the US, whereas the other countries had long periods of relative stagnation.

Relative capital intensity levels in manufacturing are presented in section 4. Physical capital per hour worked in the Asian countries is still well below the US level and there are abundant opportunities for further capital intensification contrary to Krugman's provocative suggestions. In addition to the 'object gaps', there are also big 'idea gaps' as relative productivity in manufacturing is found to be low in all Asian countries. This finding runs counter the argument that late industrialisers can automatically benefit from the increasing global pool of technologies. The increased set of production possibilities should enable latecomers to produce more productive than early industrialisers given a particular level of capital intensity. This appears not to be the case neither for Korea and Taiwan compared to the US, nor for India and Indonesia compared to the East-Asian tigers. Opportunities offered by lateness are not easily seized as stressed by the assimilationists.

Turning to manufacturing branches, section 5 shows that catch up or relative stagnation of labour productivity in aggregate manufacturing is reflected in relative performance of most branches. However total factor productivity trends differ considerable between branches. Hence, aggregate studies mask important divergent trends at a more detailed level. Section 6 provides a discussion of possible explanations for relatively low productivity in Asian manufacturing.

2. Industry-of-origin Approach to International Comparisons

The international comparisons of levels and trends in productivity in this paper are based on star comparisons with the US as the reference country. We make use of published and ongoing work in the International Comparisons of Output and Productivity project (ICOP)[1] from Szirmai and Ren (1998) on China, Timmer (1999b) on India, Szirmai (1994) on Indonesia, Pilat (1994) on South

[1] Since 1983 a substantial research effort has been undertaken to carry out industry of origin comparisons of sectoral output and productivity across countries. The International Comparisons of Output and Productivity (ICOP) project was initiated by Angus Maddison. The ICOP project now covers about 30 countries in Asia, East and West Europe, and North and South America. Information about ICOP can be obtained at http://www.eco.rug.nl/ggdc/icop.html.

Korea and Timmer (1998) on Taiwan. In the ICOP project, comparative levels and trends in labour productivity are derived as follows.

a. First, national labour productivity figures for a given benchmark year are put on a similar conceptual basis by adjusting all countries to conform to a common definition of value added and employment, and a common industrial classification.
b. Second, value added in local currency in the benchmark year is converted to a common currency using binary purchasing power parities at producer prices, so called unit value ratios (UVRs). UVRs are estimated with the industry-of-origin method for international comparisons as used and refined in the ICOP project.
c. Third, the benchmark comparison of real labour productivity is extrapolated forwards and backwards through time, on the basis of national time series of employment and value added in the countries being compared.

The basic data sources for the calculation of industry-of-origin UVRs are the manufacturing censuses of the different countries. These contain product level data on quantities and output values, allowing for calculation of unit values for each item or group of items. On the basis of a binary product matching procedure between each Asian country and the reference country in this paper, the USA, product level UVRs are derived.[2] These UVRs are subsequently aggregated into higher level UVRs by a stepwise weighting procedure. As the structure of production differs from country to country, two aggregate UVRs are calculated, one at country weights of the Asian country (Paasche index), the other at country weights of the reference country, the USA (Laspeyres index). The Fisher averages of the two UVRs are used as a summary measure. The UVRs are used to convert value added in a single deflation procedure.[3]

For the purpose of comparisons by branch of industry, industry-of-origin UVRs are preferable to the expenditure-based purchasing power parities (PPPs) as derived in the International Comparisons Project (Kravis, Heston and Summers, 1982). Expenditure PPPs are based on prices of final goods and thus include not only indirect taxes and transport and trade margins, but also the prices of imported goods, while excluding the prices of exported goods. Even when the expenditure PPPs are corrected for such factors, the problem remains that PPPs refer only to final products. Branches producing intermediate products like textiles, basic metals, pulp, wood products etc. will therefore not be covered by these final product PPPs (Jorgenson and Kuroda, 1990; Hooper and Vrankovich, 1995).[4]

---

[2] The number of product matches made in each binary comparison varies from 67 for China/US to 214 for Indonesia/US.

[3] Ideally, double deflation is preferable but data on input unit values are insufficiently available. See for a more detailed description of the ICOP industry-of-origin approach Maddison and van Ark (1988) or van Ark (1993). Timmer (1996) provides a statistical reinterpretation of the ICOP approach as a stratified sampling approach.

[4] See van Ark (1996) for an elaborate discussion.

Table 1 provides the Fisher UVRs for total manufacturing used in this paper. They are compared with ICP PPPs for total GDP and the official exchange rates. The UVR for total manufacturing is higher than the PPP for GDP, which is a common finding in ICOP studies of developing countries. The GDP PPP also includes relative prices of services which are generally much lower in developing countries than in developed countries. The exchange rate deviates considerably from the UVR and is consistently higher. Relative price levels range from 49% in the case of China/US up to 85% in the case of Korea/US.

Table 1 Alternative Currency Converters (National Currency per US$)

	Manufac-turing UVR	GDP PPP	Exchange Rate	Relative Price Level [a]
China/US (1985)	1.45	0.79	2.94	49
India/US (1983)	8.08	3.06	10.31	78
Indonesia/US (1987)	1,200	417	1,644	73
South Korea/US (1987)	700	474	823	85
Taiwan/US (1986)	29.7	23.3	35.5	84

[a] Relative price level is defined as the Fisher UVR divided by the exchange rate times 100.
Sources: Manufacturing UVR for China/US from Szirmai and Ren (1995); India/US from Timmer (1999b); Indonesia/US from Szirmai (1994); South Korea/US from Pilat (1994); Taiwan/US from Timmer (1998). GDP PPP and exchange rate from PWT 5.6 (see Summers and Heston, 1991). Taiwan PPP updated from Yotopoulos and Lin (1993).

3. Relative Productivity Levels in Manufacturing

For productivity measurement, consistency in the population of firms surveyed for data on both input and output is an essential prerequisite. Therefore we chose to take series on output and employment from one and the same source. Preferably these series are taken from the national accounts (in case of the US), or from manufacturing surveys, when consistent desaggregated national accounts series are not available (China, India, Indonesia and Korea). Only for Taiwan we were forced to use a combination of national accounts and survey data.

Manufacturing survey data in developing countries often covers only medium and large scale firms. In Indonesia, establishments with less than 20 employees, and the oil refining and liquid natural gas industry, are excluded from the survey. In India, establishments with less than 20 employees using no power, or establishments with less than 10 employees using power, are not covered. The Chinese census covers only enterprises with independent accounting systems at township level and above.[5] For these countries time series covering all manufacturing firms are not available. Note that this introduces an upward bias in labour productivity and capital intensity levels relative to the other countries studied. For South Korea and Taiwan, the figures in this paper do refer to all manufacturing firms.

Table 2 presents levels of value added per worker relative to the USA for the period 1963-1993 using the industry-of-origin approach. The studied economies clearly fall into two categories: South Korea and Taiwan on the one hand, and China, India and Indonesia on the other. In 1963, Korean and Taiwanese labour productivity was 7%, respectively 11%, of that in the USA. In three decades, the Korean labour productivity relative to the US went up to 49% in 1993. In the same period, the Taiwanese level went up to 31%. In China, India and Indonesia, labour productivity was less than 11% of the US in 1993.[6]

Table 2 Gross Value Added per Worker and per Hour Worked in Total Manufacturing, 1963-1993 (US = 100)

	China[a]	India[a]	Indonesia[a]	Korea	Taiwan	US
A. per worker						
1963		7.5		7.2	11.8	100.0
1975	[b] 6.3	7.2	9.2	16.5	19.3	100.0
1987	5.7	8.4	8.1	26.5	26.6	100.0
1993	[c] 6.3	10.9	10.2	49.1	31.3	100.0
Catch up rate[d]	***-0.010	***0.011	* 0.006	***0.061	***0.029	
B. per hour worked						
1963		6.0		5.1	8.2	100.0
1975		6.0	6.9	12.0	13.7	100.0
1987	4.9	6.8	6.3	18.4	20.4	100.0
1993		8.8	8.0	35.8	24.9	100.0

[a] Chinese, Indian and Indonesian figures have incomplete coverage see section 3; [b] 1980 ; [c] 1992.
[d] Semi-logarithmic trend growth rate for 1963-1993, except Indonesia for 1975-1993, at * 90% or *** 99% significance.
Source: Updates and revisions as described in Timmer (1999b) of original studies for China/US from Szirmai and Ren (1995); Indonesia/US from Szirmai (1994); South Korea/US from Pilat (1994) and Taiwan/US from Timmer (1998).

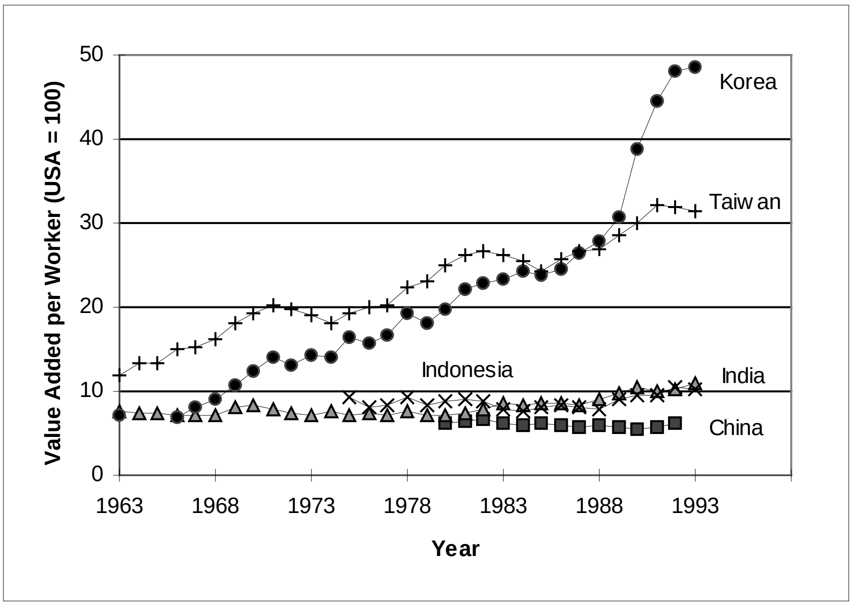
Table 2 also shows the semi-logarithmic catch up growth rate by regressing the natural logarithm of relative labour productivity on time ($\ln y_t = \alpha + \beta t$). Little stars indicate whether the trend growth β

5 For this sector, no single cut off point in terms of establishment labour force size can be given, but the average employment size of enterprises not covered by the census is six workers per establishment (Szirmai and Ren, 1998, Table A.2).

6 In 1990, adjusting for small scale establishments, labour productivity in China and Indonesia was about 5% of the US level, while the Indian relative level was only 2% (Timmer 1999b).

differs significantly from zero, that is, whether catch up or falling behind has taken place. In Korea and Taiwan rapid catch up has taken place at respectively 6.1 and 2.9 per cent per year. In contrast, the Chinese census sector has significantly fallen behind during 1980-92. In Indonesia, the medium and large scale sector experienced little catch up at 0.6 per cent per year, and all of this took place since 1989. In India, the registered sector caught up at 1.1 per cent per year during 1963-1993, but it was relatively stagnant during the 1960s and the 1970s. One could characterise the experience of these countries in the earlier periods as rapid growth without catch up. Graph 1 illustrates the catch up and stagnation patterns of the Asian countries.

Graph 1 Relative Labour Productivity Levels in Asian Manufacturing, 1963-1993 (US = 100)



Source: See Table 2.

In panel B of Table 2 the labour productivity comparison is put on an hourly basis. Hours worked per worker in Asian manufacturing are much higher than in the USA. Hence relative value added per hour is much lower than value added per worker. Taiwanese and especially Korean economic development is still based in part on exceptionally long working hours. The differentials between the Asian economies become smaller, as hours worked in Chinese, Indian and Indonesian manufacturing are lower than in the other Asian economies.

4. Relative Capital Intensity and Efficiency Levels in Manufacturing

The relatively low levels of labour productivity in the Asian countries are of course partially caused by less capital intensive production due to lower wage-rental ratios. Therefore, in this section we present estimates of relative capital intensities in the manufacturing sector. Capital stock estimates are inherently difficult to make and different approaches to their measurement are used. This is the main determinant of the widely diverging rates of TFP growth which have been estimated for Asian countries (Chen 1997, Felipe 1997). In this paper, gross fixed capital stock is estimated using the perpetual inventory method (PIM) for all countries. Essentially, a capital stock estimated by PIM is a summation of past gross investment flows. Each year new real investment is added and capital which is assumed to have been worn out after its service life time is discarded. We assume that repair and maintenance will keep the physical production capabilities of an asset constant during its lifetime (rectangular survival distribution).[7] Investments are taken from manufacturing surveys in the case of India and Indonesia, and from the national accounts in the case of South Korea and Taiwan. For Chinese manufacturing, no reliable investment series exist. Table 3 shows the estimates of capital per worker in the four Asian countries relative to the US.

In 1993, workers in Indian and Indonesian manufacturing had about 23% of the capital per worker in the US at their disposal. In Indonesia, relative intensity shows a declining trend since 1975. The investment boom triggered by the opening up of the Indonesian economy in 1986 has been accompanied by a huge labour influx mainly in the labour intensive export industries. Indian relative intensity levels have shown no significant catch up for three decades (1963-93). In both South Korea and Taiwan relative capital intensity levels have rapidly increased at about 5 per cent per year. Catch up took place from very low levels in the sixties, and in 1993 the gap with the US is still far from closed. In 1993, capital stock per hour worked in Korea is 62% of the US, while 38% in Taiwan. This indicates that abundant opportunities for further capital intensification and catch up still exist, contrary to the suggestions of accumulationists.

Table 3 Capital Intensity in Total Manufacturing, 1963-1993 (US = 100)

	India[a]	Indonesia[a]	Korea	Taiwan	US
A. per worker					
1963	19.3		15.8	8.5	100.0
1975	17.0	30.1	21.0	22.4	100.0
1987	20.1	21.8	44.0	29.9	100.0
1993	22.9	22.7	84.7	47.4	100.0
Catch up rate[b]	-0.002	***-0.020	*** 0.053	*** 0.048	
B. per hour worked					
1975	14.2	22.7	15.3	15.8	100.0
1987	16.1	16.9	30.6	22.9	100.0
1993	18.4	17.8	61.7	37.7	100.0

[a] Indian and Indonesian figures have incomplete coverage see section 3;
[b] Semi-logarithmic trend growth rate for 1963-1993, except Indonesia for 1975-1993.
Significance at * 90% or *** 99% level.

[7] See Timmer (1999a) for details of estimating capital stock in Indonesian manufacturing.

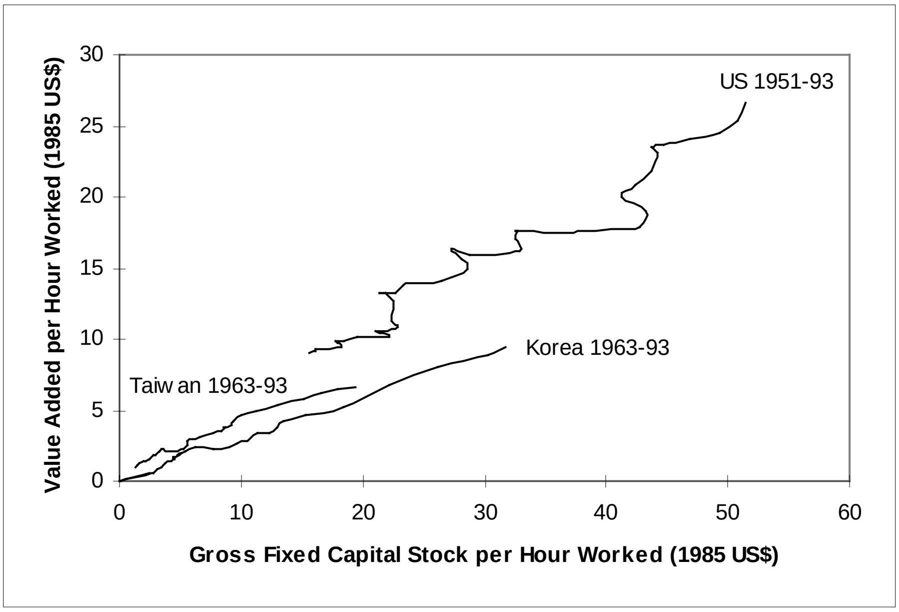
Graph 2 provides an insightful analysis of the productivity with which capital is used. It traces the historical relationship between capital intensification and labour productivity for the US and the Asian countries, all expressed in 1985 US dollars. The paths for Korea, Taiwan and the US in panel A show that capital intensity has been steadily increasing through time (except for some temporary setbacks in the US). As expected, the relation between capital intensification and labour productivity is positive for all three countries. The graph reinforces the fact that large gaps in capital intensity still exist. In 1993, capital per hour worked in Taiwan manufacturing was lower than in the US in the early sixties, and Korea had not yet surpassed the level in US manufacturing in 1975.

The permanent 'lead' of the US over South Korea and Taiwan in graph 2 is also interesting. This indicates that the US manufacturing sector generated much more output per hour worked *in the past*, when using the same amount of capital per hour worked as in South Korea and Taiwan *today*. The finding indicates that developing countries do not automatically benefit from the increasing global pool of technologies. As the world technology frontier shifts because of innovations and maturing of older technologies, South Korea and Taiwan today have a much larger set of technologies to choose from than the US in earlier times. The advantages to backwardness are portrayed in the possibility for less developed countries to adopt these technologies without the need to devote resources to the development of these technologies themselves (Gerschenkron 1952). Hence, one would expect that South Korea and Taiwan today could generate at least as much output as the US in the past with the same amount of capital per hour worked. However, productivity is much lower as indicated in graph 2 and consequently technologies do not spill over automatically as stressed by assimilationists. The graph shows that South Korea and Taiwan today still lag behind the technological level in US manufacturing of at least more than two decades ago. Note that one does not need to invoke the concept of a production function for this interpretation. By comparing South Korea, Taiwan and the US at different points in time but at similar capital intensity levels, one abstains from the troublesome decomposition of technical change and capital intensification which is so much criticised by assimilationists (Nelson 1973).

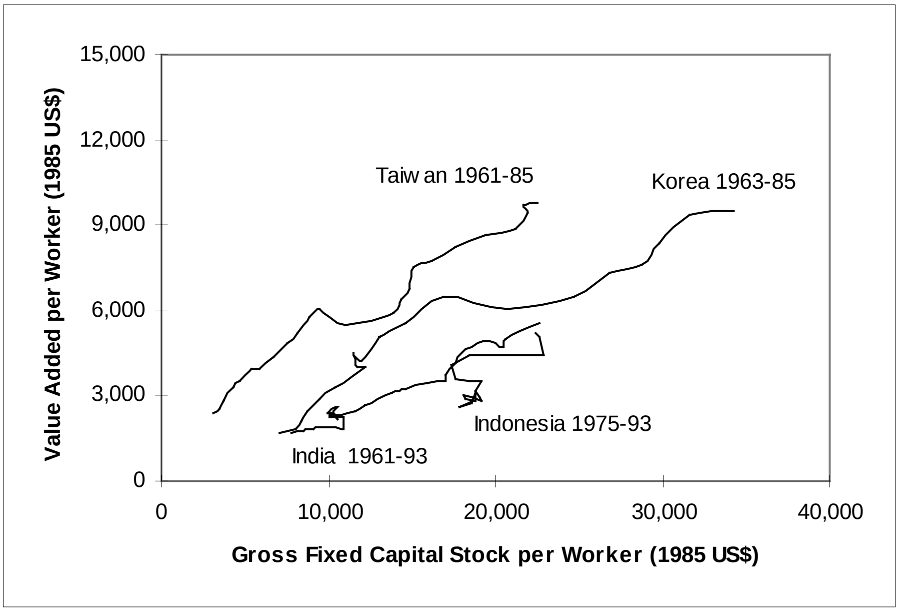
In graph 2B the development paths of India and Indonesia are traced and compared with the early experience of Taiwan and Korea at a per worker basis. In the same way as South Korea and Taiwan were outperformed by the US, India and Indonesia are outperformed by Korea and in particularly Taiwan. This is true for all capital-labour combinations explored in India and Indonesia. When in the past the Taiwanese manufacturing sector operated at intensity levels used in India and Indonesia today, labour productivity was much higher. Again, the increased set of production possibilities should enable India and Indonesia to be more productive than Taiwan and Korea. It can be concluded that the opportunities offered by lateness are not easily seized. We will return to possible reasons for the found low productivity in Asian manufacturing compared to the US in section 6.

Graph 2 Capital Intensity versus Labour Productivity in Manufacturing

A. South Korea, Taiwan and US, per hour



B. Asian countries, per worker



Source: Timmer (1999b)

5. Catch up and Stagnation in Manufacturing Branches

Aggregate patterns of manufacturing catch up and relative stagnation may be mirrored by similar movements at a more desaggregated level, or may mask diverging trends. To see whether this is the case, we estimated relative labour productivity for seven manufacturing branches for 1963-1993 in a similar way as we did for aggregate manufacturing using branch specific unit value ratios. The results are presented in Table 4. Catch up trends for the period under consideration are given as well. They are either significantly positive (+) or negative (-), or insignificant (0). As our focus is on long term trends, we take 3-year averages to smooth out business cycles which are more visible at a detailed level of analysis than at the aggregate level of the previous section. Looking at the rows of the most recent years for each country in table 4, one may conclude that the general level of labour productivity in the manufacturing sector is reflected in the relative performances of its various branches. In all branches, relative labour productivity is much higher in Korea and Taiwan than in China, India and Indonesia.[8] Even so, also in Korea and Taiwan gaps with the US still exist, especially in food manufacturing.

In the sixties, all manufacturing branches in Korea and Taiwan started from very low relative levels of labour productivity. Aggregate catch up during 1963-1993 is reflected in significant catch-up tendencies in all seven branches. Catch up in the machinery and metal branches are particularly noteworthy. In China, five out of the seven branches show significant falling behind in labour productivity levels between 1980-92 as does aggregate manufacturing. Especially in the textile branch the decline is dramatic. Only food manufacturing shows clear catch up. In India, the catch-up trend in aggregate manufacturing is mirrored by developments in the four capital intensive branches. The three traditional light branches show insignificant trends in relative labour productivity. In Indonesia, five branches participate significantly in catch up while chemicals and electrical machinery show a modest, but significant decline in relative labour productivity.

[8] Note that the data for China, India and Indonesia covers only medium and large scale firms. This introduces an upward bias in labour productivity relative to South Korea, Taiwan and the US. At a branch level, the bias is important for labour intensive traditional activities such as manufacturing of wood products, wearing apparel and leather, but the bias is negligible for large scale modern industries like chemicals, basic metals and electrical machinery.

Table 4 Gross Value Added per Worker
in Seven Manufacturing Branches, 1963-1993 (three year averages, US = 100)

	1 Food	2 Tex	3 Chem	4 Metal	5 Mach	6 Elec	7 Other	Total
China, IAE at township and above								
1980-82	6.2	11.9	7.4	12.2	3.6	10.4	4.3	6.4
1990-92	9.0	8.0	6.1	11.1	3.2	10.4	4.0	5.8
Catch up trend [a]								
1980-92	***+	***-	**-	*-	*-	0	*-	***-
India, registered sector								
1963-65	5.2	17.1	8.1	9.9	10.7	8.6	11.7	7.4
1977-79	3.3	14.0	8.1	9.0	13.6	8.4	7.2	7.3
1991-93	6.2	18.3	11.9	10.7	12.7	10.1	12.4	10.4
Catch up trend [a]								
1963-93	0	0	**+	***+	***+	***+	0	***+
Indonesia, medium and large scale sector								
1977-79	6.6	11.4	10.4	9.6	13.7	27.5	7.2	8.6
1991-93	9.1	18.4	9.9	19.3	22.7	26.7	10.3	10.0
Catch up trend [a]								
1975-93	**+	***+	*-	***+	*+	*-	***+	*+
South Korea, full								
1963-66	5.2	8.8	7.2	7.8	3.8	9.5	4.8	7.1
1977-79	11.1	24.6	22.4	27.4	24.0	16.6	10.9	18.0
1991-93	23.2	49.9	51.4	81.0	65.1	60.3	38.4	47.0
Catch up trend [a]								
1963-93	***+	***+	***+	***+	***+	***+	***+	***+
Taiwan, full								
1963-65	7.3	16.8	23.5	5.4	4.4	10.3	8.5	12.8
1977-79	10.8	40.4	29.6	20.3	20.3	20.4	18.9	21.9
1991-93	18.5	64.9	43.2	35.2	23.5	36.0	20.5	31.8
Catch up trend [a]								
1963-93	***+	***+	***+	***+	***+	***+	***+	***+

[a] Semi-logarithmic trend: positive (+), negative (-) at *90%, **95% or ***99% significance or insignificant (0).
[b] Coefficient of variation based on results for thirteen branches.
Source: Timmer (1999b)

One might conclude that in general the catch up process in all economies is broad based and not limited to a small number of branches, just as falling behind in China appears to be a manufacturing wide phenomenon. This pattern is consistent with the notion of conditional convergence. The conditions for less developed countries to catch up with more advanced countries are typically not branch specific. Conditions mentioned in the literature range from education and schooling activities to the removal of institutional and socio-cultural barriers to the acquisition and diffusion of new technology (Abramovitz 1989, Barro 1991). These forces all operate at the economy-wide or manufacturing level, and much less so at branch level.

Using PIM estimates of capital stocks in a neo-classical production function framework, an indication of relative total factor productivity levels can be given. Relative TFP levels have been calculated first for a benchmark year using a Cobb-Douglas production function with constant returns to scale. The benchmark is extrapolated using national Tornqvist indices of TFP. The results are given in Table 5. It shows that in all countries and all branches, productivity has been, and still is, much lower than in the US. Only in Korea do all branches show sustained catch up in TFP during 1963-1990, but in the latest period productivity is still 60% of the US or below. In Taiwan there is relative stagnation at the aggregate manufacturing level from 1963 to 1993. However, only in the chemical sector a relative decline is recorded, while the food sector is stagnating. The other five branches all show significant catch up to 60% of the US level in the beginning of the 1990s. For Taiwan, the aggregate outcome does mask substantial variation in movements of relative branch TFP, unlike we found for labour productivity. The same is true for India and Indonesia. Relative TFP stagnation in aggregate manufacturing in India during 1973-93 is the result of counteracting small increases and decreases in relative branch TFP. In Indonesia, strong catch up is found for four branches during 1975-93. However, relative efficiency in the chemicals branch, and to a lesser extent in the electrical machinery branch, has declined. Hence there appear to be branch specific sources of relative TFP improvements.

If one adheres to the neo-classical interpretation of relative TFP as the relative level of technology[9], our findings suggest that the accumulationists are wrong in suggesting that no or only modest technological change has taken place in Asia. The aggregate level of analysis taken in most studies, such as Kim and Lau (1994) and Collins and Bosworth (1996), masks important differences in sectoral movements within the Asian countries. Looking at the manufacturing sector in Korea, TFP growth rates are particularly high, as also found (but not stressed) by Young (1995). This catch up trend is reflected in detailed branch performance. In Taiwan, manufacturing as a whole does not show catch up in TFP with the US, but this is caused by a severe falling behind of the chemicals sector and stagnation in food manufacturing, while all other branches show significant catch up trends. Also in India and Indonesia there are branches which fall behind, coupled with other branches which show clear increases in their relative level of technology.

[9] At best, TFP only measures *disembodied* technological change, at worst it is nothing more but a measurement residual including scale effects, changes in technical and allocative efficiency, changes in the quality of inputs, changes in utilisation rates, structural change and the like (Chen 1997).

Table 5 Total Factor Productivity in Seven Manufacturing Branches, 1963-1993 (three year averages, US = 100)

	1 Food	2 Tex	3 Chem	4 Metal	5 Mach	6 Elec	7 Other	Total
India, registered sector								
1977-79	16.2	25.6	23.4	16.0	24.2	14.7	15.9	16.9
1991-93	23.0	23.3	24.4	13.0	19.8	14.4	20.6	17.0
Catch up trend [a] 1973-93	***+	***-	0	***-	*-	0	***+	0
Indonesia, medium and large scale sector								
1977-79	13.7	19.2	34.6	26.3	23.9	50.6	9.5	17.7
1991-93	25.2	25.4	24.6	39.2	30.1	46.1	14.7	19.5
Catch up trend [a] 1975-93	***+	***+	***-	***+	0	**-	***+	*+
South Korea, full								
1963-66	16.3	22.8	24.1	32.3	11.4	34.3	11.8	21.6
1977-79	24.1	42.9	54.8	42.0	37.1	39.8	23.2	36.4
1988-90	21.7	34.3	39.9	60.0	51.3	59.0	40.3	38.8
Catch up trend [a] 1963-90	***+	***+	***+	***+	***+	***+	***+	***+
Taiwan, full								
1963-65	23.9	39.0	85.7	29.3	10.3	33.1	22.0	40.2
1977-79	19.0	51.8	66.5	39.6	31.4	39.3	33.3	39.8
1991-93	21.2	58.8	59.5	46.1	31.7	57.4	28.6	40.0
Catch up trend [a] 1963-93	0	***+	***-	***+	***+	***+	***+	0

[a] Semi-logarithmic trend: positive (+), negative (-) at *90%, **95% or ***99% significance or insignificant (0).
[b] Coefficient of variation based on results for thirteen branches.
Source: Timmer (1998b)

Table 6 gives alternative evidence for the important technological changes that have taken place in the Asian countries. Table 6 shows the number of goods of which production started before, or after, 1970. It shows that since 1970 the Asian countries rapidly increased the range of product technologies in use as the number of consumer, intermediate and capital goods produced has increased dramatically. The diversification of activities, including a shift towards higher technology products, is surely a sign of the process of technological upgrading that has taken place in these countries. The accumulationists' dictum that technical progress has played an insignificant role in Asian growth is readily dismissed.

Table 6 Scope of Industrial Activities in Four Asian Countries, 1970 and 1987

	Consumer goods		Capital goods		Intermediate goods	
	1970	1987	1970	1987	1970	1987
China	10	36	1	17	23	49
India	29	47	16	21	57	74
Indonesia	36	63	1	6	18	43
South Korea	49	63	12	31	39	78

Note: Column 1970 gives the number of goods of which production started before December 1970. Column 1987 gives the number of goods of which production started inbetween January 1971 and December 1987. In total 83 consumer good categories, 43 capital good categories and 107 intermediate good categories are distinguished.
Source: UNIDO (1990) *Industry and Development, Global Report 1990/91*, Table 1.4.

6. Climbing the Technology Ladder: How Fast Can You Go?

On the basis of the results presented in this paper, one may conclude that the TFP-debate has been misdirected. First of all, capital intensities in the Asian economies are still much lower than in the US, and opportunities for further intensification are abundant. Secondly, studies have been performed at too aggregate a level. Looking at detailed manufacturing branches, it has been shown in this paper that a number of branches in all countries do show significant catch up with US TFP levels, while other branches do not. Aggregate studies mask substantial divergence at a more detailed level. Moreover, product level evidence shows that the number of technologies in use in the South and East-Asian countries have increased dramatically over the past three decades.

Consequently, the TFP-debate between accumulationists and assimilationists should not be about whether or not technological change in Asia has taken place. Assimilationists are right to stress that technological change did take place. All the same, accumulationists have a point in arguing that there is a problem nevertheless as TFP levels are particularly low in the Asian countries. If one does not accept the possibility of seperating factor substitution and technological change, or TFP, as assimilationists are wont to do (the identification problem, Nelson 1973), it still remains to be explained why the level of output per worker generated in Taiwanese and Korean manufacturing today is much lower than that generated in US manufacturing *when it was operating at the same levels of capital intensity at least two decades ago*. In the same way India and Indonesia operate today at capital-labour ratios which were used in Taiwan and Korea in the seventies, but labour productivity is much lower. Big idea gaps still exist between these countries. This runs counter the idea that latecomers can costless choose from at least as large a pool of technologies as earlier industrialisers. This result is surprising, giving that the use of manufacturing technologies is generally much less sensitive to particular country's social and physical circumstances than for example agricultural technologies (Evenson and Westphal, 1995). Moreover, opportunities for global diffusion of manufacturing technologies are high given the flows of foreign investment and competitive pressures from international trade.

On average, firms in South- and East-Asia are still predominantly engaged in lower technology activities and products which might generate less output per unit of input than activities of US firms. This is a convincing argument for explaining the relative inefficiency of the countries today compared with the US today, but less so when they are compared with the US in the past as in this study. Many of the pioneering technologies used in the US in the past are now matured and used in developing countries. It is not clear why these technologies are operated with lower productivity. Part of it might be due to the very fact that the technologies in use in developing countries are mature and used in a international competitive market. Hence the room for mark-up pricing of output is much more limited than it was for the US in the past.

A more convincing argument is that the growth of the “soft” component of investments, which includes managerial methods and information, lags behind the “hard” component in rapid growing countries. Automation in the manufacturing sector is increasingly shifting beyond the level of transformation (machine co-ordination) to transfer (system co-ordination). This will increasingly require advances in organisational techniques. Domestic diffusion of knowledge and new technologies is inadequate in many developing countries as suggested by Pack (1987) and Pack and Westphal (1986). Together with a lagging development of the institutional environment, the financial system and infrastructural services the full potential productivity of capital goods might not be realised. The recent Asian financial crises illustrates the detrimental effects of an uneven development between the soft and hard components of investment.

A more evolutionary explanation stresses the very nature of climbing the technology ladder and the role of learning. Shifting resources to new products or new production processes has both a static *level* and a dynamic *growth* effect on productivity. The dynamic effect of technological change is often linked to learning by doing. In the 1930s, Kuznets and Burns, studying US economic growth, found that output growth rates of particular products or industries were almost invariably subject to retardation.[10] This was attributed to diminishing possibilities for further productivity improvements as production and experience accumulates (bounded learning by doing). Hence new technologies will have higher productivity growth than more mature technologies, and only a continuous appearance of new industries and technologies prevents aggregate productivity growth to decline.

At the same time the shift to new technologies has a static effect on TFP levels. The direction of this effect is unclear. In the context of trade liberalisation, neo-classicals argue that the induced resource shift according to comparative advantage has a positive static effect by improving allocative efficiency. But there is abundant evidence that the introduction of new technologies invariably involves “set-up” costs associated with adaptation and adjustment problems and consequently

---

10 Abramovitz 1989, p.30 *vv*.

inefficient use, at least in the starting phase.[11] Hence the TFP level of the newly introduced technology might well be lower than the technologies already in use. However, if there exist learning spill-overs between technologies, besides technology specific learning effects as described above, part of the cost components will return in externalities.

According to this ‘model’ of climbing the technology ladder, low TFP growth arises in two situations: by climbing the technological ladder too slowly, or too fast. In the first case, it becomes progressively harder to achieve equal productivity gains with the same technologies, and growth will slow down. In the second case, the premature movement up the technological ladder results in fast productivity growth in new industries which displace each other rapidly. However, in the aggregate this is more than counteracted by the decline in the level of TFP each time a new industry is entered and (localised) learning has to start all over again. Young (1992) suggest that this is the case for Singapore which fell victim to its own ambitious targeting policies. And many others fear that Indonesia’s leapfrogging into aeroplane development has similar negative effects. Whether a country is climbing too slow or too fast is hard to assess, and certainly deserves a detailed sectoral analysis. As a short cut, one might argue that long term success in a competitive export market is a better judge than TFP measurement. In that respect, East-Asia’s industrialisation has been fast, but certainly not too fast.

[11] This is the standard argument for infant industry protection.

References

Abramovitz, M. (1989), *Thinking about growth*, Cambridge University Press, Cambridge.

Ark, B. van (1993), *International Comparisons of Output and Productivity*, Monograph series no. 1 Groningen Growth and Development Centre, Groningen.

Ark, B. van, (1996), "Issues in Measurement and International Comparison of Productivity - An Overview", in: *Industry Productivity. International Comparisons and Measurement Issues*, OECD, Paris, pp. 19-47.

Barro, R.J. (1991), "Economic Growth in a Cross Section of Countries." *Quarterly Journal of Economics*, vol.106, pp.407-44.

Bernard, A.B. and Jones, C.I. (1996), "Comparing Apples to Oranges: Productivity Convergence and Measurement Across Industries and Countries." *American Economic Review*, vol.86, no.5, pp.1216-38.

Chen, Edward K.Y. (1997), "The Total Factor Productivity Debate: Determinants of Economic Growth in East Asia", in: *Asian-Pacific Economic Literature*, 11(1), pp. 18-38.

Collins, S.M. and B.P.Bosworth (1996), "Economic Growth in East Asia: Accumulation versus Assimilation", in: W.C. Brainard and G.L.Perry (eds.) *Brookings Papers on Economic Activity, 1996*, vol.2, pp.135-203.

Felipe, J. (1997) Total Factor Productivity Growth in East Asia: A Critical Survey, *EDRC Report Series* Number 65, Asian Development Bank, Manila.

Gerschenkron, A. (1952), *Economic Backwardness in Historical Perspective*, in: Gerschenkron, A. (1962), *Economic Backwardness in Historical Perspective*, Harvard University Press, Cambridge, Mass.

Hooper, P. and E. Vrankovich (1995), "International Comparisons of the Levels of Unit Labor Costs in Manufacturing", *International Finance Discussion Papers*, Number 527, Board of the Governors of the Federal Reserve System, Washington D.C., Oktober 1995.

Jorgenson, D.W. and M. Kuroda (1990), "Productivity and International Competitiveness in Japan and the United States, 1960-1985", in: C.R. Hulten (ed.), *Studies in Income and Wealth*, 51 , University of Chicago Press, Chicago.

Kim, J-I. and L.J. Lau, (1994), `The Sources of Economic Growth of the East Asian Newly Industrialized Countries', *Journal of Japanese and International Economies*, 8, 235-271.

Kravis, I.B., A. Heston and R. Summers (1982), *World Product and Income*, John Hopkins, Baltimore.

Krugman, P. (1994), "The Myth of Asia's Miracle", *Foreign Affairs*, vol. 73(6), pp. 62-78.

Maddison, A. and B. van Ark, 1988, *Comparisons of Real Output in Manufacturing*, Policy, Planning and Research Working Papers WPS5 , World Bank, Washington D.C..

Nelson, R.R. (1973), "Recent Exercises in Growth Accounting: New Understanding or Dead End?", *American Economic Review*, vol.63, pp.462-8.

Nelson, R.R. and H. Pack (1998), “The Asian Miracle and Modern Growth Theory”, *Policy Research Working Paper* 1881, World Bank, Washington DC.

Pack, H. (1987), *Productivity, Technology and Industrial Development. A Case Study in Textiles.* New York: World Bank, Oxford University Press.

Pack, H. and L.E. Westphal, (1986), “Industrial Strategy and Technological Change: Theory versus Reality” in: *Journal of Development Economics*, vol. 22, pp.87-128.

Pilat, D. (1994), *The Economics of Rapid Growth. The Experience of Japan and Korea*, Edward Elgar Publishers, Aldershot.

Summers, R. and Heston, A. (1991), “The Penn World Table (Mark 5): an Expanded Set of International Comparisons, 1950-1988.” *Quarterly Journal of Economics*, vol.106, pp.327-68.

Szirmai, A. (1994), “Real Output and Labour Productivity in Indonesian Manufacturing, 1975-90”, *Bulletin of Indonesian Economic Studies*, 30 (2), 49-90.

Szirmai, A. and R. Ren (1998), “China's Manufacturing Performance in Comparative Perspective” in: CEPII, *Throwing Light on the Chinese Economy*, Paris, forthcoming.

Timmer, M.P. (1996), *On the Reliability of Unit Value Ratios in International Comparisons*, Research memorandum GD-31, Groningen Growth and Development Centre, Groningen.

Timmer, M.P. (1998), *Catch Up Patterns in Late Industrialisers. An International Comparison of Manufacturing Productivity in Taiwan, 1961-1993*, Research memorandum GD-40, Groningen Growth and Development Centre, Groningen.

Timmer, M.P. (1999a), “Indonesia’s Ascent on the Technology Ladder: Capital Stock and Total Factor Productivity in Indonesian Manufacturing, 1975-1995”, *Bulletin of Indonesian Economic Studies*, April 1999.

Timmer, M.P. (1999b), *The Dynamics of Asian Manufacturing. A Comparative Perspective, 1963-1993*, ECIS Dissertation Series Nr. 3, Eindhoven University of Technology, forthcoming with Edward Elgar, April 2000.

World Bank (1993), *The East Asian Miracle. Economic Growth and Public Policy*, Oxford University Press, New York.

Yotopoulos, P.A. and Lin, J. (1993), “Purchasing Power Parities for Taiwan.” in: *Journal of Economic Development*, vol.18(1).

Young, A. (1992), “A Tale of Two Cities: Factor Accumulation and Technical Change in Hong Kong and Singapore” in: *NBER Macroeconomics Annual*, Cambridge.

Young, A. (1995), “The Tyranny of Numbers: Confronting the Statistical Realities of the East Asian Growth Experience”, *Quarterly Journal of Economics*, 110, pp.641-680.