CAPITAL FORMATION AND FOREIGN DIRECT INVESTMENT IN KOREA AND TAIWAN: COPING WITH DIMINISHING RETURNS?

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Introduction

Well before the recent financial and economic crisis in Asia began, a vigorous debate emerged about the factors behind the real growth performance of Eastern Asia since the 1960s and the barriers to further growth. Originally the debate revolved around the question whether the typical neo-classical factors, i.e. those limiting the role of governments and strengthening that of markets in reallocating resources to their most efficient use, or interventionist measures, i.e. those regulating financial markets and imposing industrialization policies, have explained the region's exceptional growth performance. In 1993 the World Bank further complicated the debate by introducing a 'market-friendly' approach as a way to blend aspects of the neo-classical and revisionist viewpoints (World Bank 1993).

More recently the debate has become focused around the question whether the accumulation of capital in Eastern Asia was so rapid that the growth process became extensive and that future growth is likely to slow down because of diminishing returns to capital (Krugman 1994). Indeed, some scholars report rapid accumulation in combination with low total factor productivity growth in Asia (Kim and Lau 1994; Young 1992, 1994, 1995) but others emphasize that, despite rapid accumulation, total factor productivity (TFP) growth in Eastern Asia has been quite respectable when compared to other developing regions in the world (Nehru and Dhareshwar 1994; Sarel 1995; Collins and Bosworth 1996; Nadiri and Son 1997; Timmer 2000). In a recent paper, Easterly and Levine (1999) argue that it is TFP growth rather than capital accumulation which accounts for a substantial share of cross-country differences in per capita incomes. Others argue that the production function approach, which underlies this growth accounting work, is inappropriate as the distinction between capital accumulation and total factor productivity cannot be made so that the fundamental driving factor behind economic growth, i.e. the search process to master new capital goods and substitute capital for labour, remains hidden (Nelson and Pack 1999). The recent literature on endogenous growth also suggests that returns on capital may be higher than assumed in the Solow production function because of spillovers. The surge of foreign inflows of capital in emerging markets during the 1990s has rekindled a new interest in foreign investment as a source of important spillovers to domestic capital (Balasubramanyam, Salisu and Sapsford 1996; De Mello 1997; Borenzstein a.o. 1998).

Much of this debate has lacked clarity for several reasons, two of which are addressed in this paper. The first is related to the measurement of domestic capital stock and the second to the measurement of the relative importance of FDI in relation to domestic capital stock.

Lack of reliable data in combination with the sensitivity of the procedures seriously limits the number of countries for which one can derive robust estimates of the domestic capital stock (Nehru and Dhareshwar 1993; Sarel 1997). As a result, many studies, in particular those making use of cross-country regressions, have used investment-output ratios as a proxy for the change in capital stock. This procedure assumes that marginal and average capital-output ratios are the same. A recent study by Fukuda and Toya has emphasised that this assumption is particularly unrealistic for Eastern Asia where economies are characterized by relatively low capital-output ratios in combination with high rates of capital accumulation (Fukuda and Toya 1999).

Those scholars who constructed capital stock estimates, reverted to different procedures. Essentially, two basic methods are available, namely wealth surveys valuing the capital stock in place at user value, and perpetual inventory estimates which are obtained by cumulating investment data using assumptions of the life time of assets and their depreciation pattern. The latter approach has been applied in two international data sets aiming to include as many countries as possible, namely the World Bank data set on physical capital (Nehru and Dhareshwar 1993) and the Penn World Tables (Summers and Heston 1991). The series from both data sets involve very substantial measurement problems as the estimates are either based on indirect procedures, such as using investment/GDP ratios (Penn World Tables) or rough methods to derive a reliable benchmark estimates for the stock (World Bank data set).[1]

Section I of this paper concentrates on capital stock estimates for two East Asian countries with extraordinarily rapid economic growth over the past decades, namely the Republic of Korea (henceforth Korea) and the Republic of China, Taiwan Area (henceforth Taiwan). We review existing estimates based on wealth surveys and the perpetual inventory method and construct new stock estimates for the total economy and manufacturing using the perpetual inventory method with assumptions on asset lives and depreciation patterns that are standardized across countries (Maddison 1995).

Section II of the paper analyses the new capital stock estimates in greater detail by relating changes in capital-output ratios at various levels of capital-labour ratios (capital intensity) to changes in levels of output-labour ratios (labour productivity). This allows us to analyse the behaviour of these variables in relation to Solow's production function, which also relates capital intensity and labour productivity under the assumption of diminishing returns to capital as the elasticity of output with respect to capital represents the factor share of capital in total output (Solow 1956). Comparisons are made with estimates for the United States in order to indicate the gaps in labour productivity and capital intensity which still remain between the East Asian countries and the United States.

The second problem which we address in this paper relates to the impact of foreign direct investment on the domestic capital stock. Most studies use FDI as a percentage of domestic investment to indicate the importance of foreign investment on capital growth. However, the interpretation of this ratio is not as straightforward as it may appear. Instead, it is more meaningful to look at the share of foreign capital stock in the domestic capital stock. This will be done for Taiwan and Korea in Section III.

The estimates in this paper are for the total economy as well as for the manufacturing sector alone. The debate on the role of capital accumulation in growth often ignores the crucial differences concerning these relations at the sectoral level vis-à-vis the total economy level. The manufacturing sector in particular is likely to show different patterns as the process of capital intensification and the inflow of FDI was of greater importance there than in other sectors of the economy.

I. Estimating the physical capital stock in Korea and Taiwan

Because a worldwide standardization of the measurement of physical capital is still lacking, international comparisons of capital input are fraught with problems.[2] Ideally, capital input needs to be measured as the flow of capital services from the installed capital stock. This flow approach requires detailed data on the composition of the capital stock and rental prices of the different assets (Jorgenson and Griliches 1967). However, for most countries data on rental prices are not available so that service flows cannot be measured.[3] Therefore one has to rely on stock measures

[1] As this paper concentrates on two countries, we prefer to use methods that make use of the data to a fuller extent, thus improving international comparability of national data. Hence we refrain from using either the World Bank or Penn World Table data in the remainder of this paper.

[2] In this paper we concentrate on non-residential capital stock, i.e. non-residential buildings, and other construction (except land improvement), machinery and equipment and transport equipment.

[3] Using data on asset lifetimes a rough approximation of the service flow can be made (Timmer 2000).

and assume that capital services are proportional to the aggregate capital stock. Capital stock estimates are sometimes based on wealth surveys (see below), but more often on the perpetual inventory method (PIM), which has also been used for the estimates of Korea and Taiwan in this paper.

I.1 The perpetual inventory method

The perpetual inventory method, pioneered by Goldsmith (1951), estimates the capital stock as the sum of past real investments which have survived up to the current period. This method requires assumptions with regard to service lives and retirement patterns of assets. In this paper we compile estimates of the gross fixed capital stock for the total economy and for manufacturing, assuming that assets are discarded in one stroke at the end of their service lifetime. It is also assumed that repair and maintenance will keep the physical production capabilities of an asset constant during its lifetime. This is known as the one-hoss-shay efficiency pattern or rectangular retirement.[4] Hence the stock of asset type i at time t (K_{it}) is given by:

$$K_{it} = \sum_{t-d_i+1}^{t} I_{it} \qquad (1)$$

with I_{it} investment at constant prices in asset type i at time t and d_i the service lifetime of asset i. Use of equation (1) gives gross fixed capital stock estimates which include depreciation as defined in the national accounts. Depreciation as reported by firms is largely determined by accounting and tax conventions and much less so by the actual decline in productive capacity of the capital stock. Instead we assume that the productive capacity of each asset is constant until it is scrapped at the end of its lifetime.

An important problem in comparing perpetual inventory estimates of the capital stock across countries is that not only the depreciation patterns but also the assumptions concerning asset lives may differ substantially. For example, even within the OECD, where countries are at relatively similar levels of economic development, asset lives for non-residential structures vary between 39 years in the United States, 57 years in Germany and 66 years in Great Britain (Maddison 1995). Some of these differences may be ‘true’ differences as, among other reasons, an accelerated GDP growth can speed up the replacement of new for old assets. However, the observed differences cannot be directly related to this. Hence as a second-best approach (until internationally comparable asset lives are available) one may calculate the stock on the basis of standardized asset lives across countries. The standardization method was pioneered by Maddison (1995) for total economy estimates for France, Germany, Japan, Netherlands, Great Britain and the United States, and was replicated for manufacturing in Germany, Japan and the United States by Van Ark and Pilat (1993) and for other sectors of the economy in France, Germany, Japan, Great Britain and the United States by O’Mahony (1996). Hofman (1998) applied the standardization procedure to six Latin American countries.

I.2 Standardized capital stock estimates for Korea and Taiwan

The capital stock estimates for Korea and Taiwan in this paper are based on the standardized perpetual inventory method described above. Estimates for the total economy are provided from 1951 (Taiwan) or 1953 (Korea) up to 1995, and for manufacturing from 1960 to 1993. In general the method involves the following data requirements: gross investment series at current prices, price indices to revalue investment to constant base year replacement costs, asset service lifetimes or rates of actual depreciation, and a benchmark capital stock figure. We have constructed our benchmark capital stock figure for the beginning year of the period on the basis of our long series of investment back to the beginning of the century. The estimates and sources are presented in Appendix 1. Below we summarize the main elements of our procedures.

[4] Different types of efficiency patterns such as geometric decline or straight-line depreciation are discussed for OECD countries in for instance Ward (1976), Blades (1993) and O’Mahony (1996).

Korea, total economy
For the period 1953-1995 two series on capital formation were obtained from the Korean national accounts, one for non-residential buildings and other construction (except land improvement) and one for transport equipment and machinery and equipment. For the period 1914-1940, we obtained similar series from Pyo (1996). To bridge the period 1940-1953, we estimated capital formation on the basis of output series assuming investment-output ratios at 0.10 for the period 1940-1944, at 0.00 for 1945 and 1946, at 0.05 for 1947-1950 and at 0.00 for 1951 and 1952. After linking, the investment series was expressed in 1990 Won. As the 1940-1953 figures were not divided into series for non-residential structures and machinery and equipment, we used an average of the pre- and post- five year period share. Next we applied the perpetual inventory method by using standardized asset lives of 39 years for structures and 14 years for equipment from Maddison (1995). Moreover we discounted all pre-1953 investment by 40% to account for war damage (Maddison 1998: 66). The first cumulated benchmark estimate is provided for 1953. The estimates are adjusted from end-year to mid-year basis.

Taiwan, total economy
The procedure for the estimation of the capital stock of the Taiwanese economy was similar to that used for Korea. For the period 1951-1996 two series on capital formation were obtained from the Directorate-General of Budget, Accounting and Statistics (DGBAS) for non-residential structures and for plant and equipment. For the period 1912-1938, we obtained total gross capital formation figures from Mizoguchi (1997). To bridge the period 1938-1951, we estimated capital formation on the basis of output series assuming investment-output ratios at 0.1 for the period 1939-1944, at 0 for 1945 and 1946 and at 0.05 for 1947-1950. After linking, the whole investment series was expressed in 1991 New Taiwanese dollars. As the 1938-1951 figures were not divided into series for non-residential structures and machinery and equipment, we used a average of the pre- and post- five year period share. Next we applied the perpetual inventory method, by using the standardised asset lives of 39 years for structures and 14 years for equipment from Maddison (1995). The first cumulated benchmark estimate could be provided for 1951. The estimates were adjusted from end-year to mid-year basis.

Korea and Taiwan, manufacturing
For manufacturing only one series for total capital formation (excluding residential structures) could be obtained from the post-war national accounts. To obtain an average standardized asset life for the aggregate manufacturing investment series, we used average asset lives from OECD countries at 45 years for investment in non-residential structures and 17 years for investment in equipment and vehicles (Van Ark and Pilat 1993: 42). These asset life estimates were weighted by the share in gross fixed capital formation for Taiwan in 1987, which provided an average lifetime of 25 years.[5] Investment series for manufacturing go back to 1953 for Korea and 1951 for Taiwan. We obtained investment series for the pre-1953 period (Korea) and pre-1951 period (Taiwan) using the trend in capital formation for the total economy in both countries. For Korea we applied a 40 per cent war damage adjustment.[6]

I.3 The sensitivity of the capital stock estimates
Clearly the standardization procedure is sensitive for the various assumptions involved. Assumptions concerning asset life times in particular affect the results. For example, one might argue that asset

[5] The share in gross fixed capital formation in Taiwanese manufacturing was 31% for structures and 69% for equipment in 1987 (MOEA 1987: Table 2-4).

[6] This procedure slightly differs from that used in Timmer (2000) where the pre-1953 and pre- 1951 series are derived from average growth rates for 1951/56 (for Taiwan) and 1953/57 for Korea.

lifetimes in rapidly growing Asian countries are likely to be shorter than those in more slowly growing OECD economies because of higher investment rates and a more rapid turnover of firms due to the continuing process of introducing new technologies from more advanced countries (industrial upgrading). To test this proposition we recalculated the standardized estimates for the total economy and manufacturing in Korea and Taiwan using alternative asset life assumptions.[7]

Table 1. Capital stock estimates using alternative lifetimes: Total economy and manufacturing, 1987.
(% of preferred estimate).

	Alternative lifetime assumptions (years)				
Total Economy	18+5 years	22+6 years	30+10 years	39+14 years	45+19 years (a)
Korea	73	79	94	100	104
Taiwan	65	72	89	100	107
Manufacturing	10 years	15 years	20 years	25 years	30 years
Korea	77	92	97	100	101
Taiwan	64	86	96	100	101

(a) for Korea: 42 years for non-residential structure and 19 years for plant and equipment.

Source: PIM estimates with rectangular retirement patterns, war-damage adjustment (for Korea) and alternative lifetimes for total non-residential fixed capital using investment series from Appendix 1, compared with the preferred estimates discussed in main text.

The overall conclusion from the table is that small variations in lifetimes have a limited impact on capital stock estimates for these East Asian countries. If the assumed asset lifetime for Korea and Taiwan is reduced to 30 years for structures and 10 years for plant and equipment, the total economy stock in 1987 declines with 6% and 11% respectively. The effects for manufacturing are even smaller since the faster growth of investment compared to the total economy reduces the impact of changes in asset lives. Further study on international differences in asset lifetimes is called for but in the remainder of this paper we use our preferred estimates.

I.4 Comparison of the results with previous estimates

For both Korea and Taiwan capital stock estimates, based on a mix of national wealth surveys and the perpetual inventory method exist. In a series of papers, Pyo provides estimates of gross fixed capital stock in Korea based on wealth surveys in 1968, 1977 and 1987, linked with investment from the national accounts (Pyo 1988, 1992, 1998). For linking, use is made of the polynomial-benchmark method for the period between benchmark years. For the period before the first and after the last benchmark year the perpetual inventory method is applied. Pyo's method assumes that the benchmark estimates from the wealth surveys are the best available estimates. An important advantage of this method is that depreciation of the assets can be calculated directly from the model (Pyo 1998). In his earlier work Pyo estimated gross and net capital stocks independently. In his latest report he first estimates net capital stocks, which are converted to gross stocks using interpolated net-gross conversion ratios from the wealth surveys (Pyo 1998). This revision leads to a downward adjustment of the results, especially before 1968. Kim and Hong (1997) also base their estimates on wealth survey data, but use only data for 1987 as they consider these to be more reliable than the results of previous surveys.[8]

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[7] Variations in retirement patterns have only small effects. Similarly, variations in initial year estimates have also little influence as by far the biggest part of investment in these dynamic economies has been made in the last decades. A sensitivity analysis on capital stock estimates for OECD countries is given in O'Mahaony (1996).

[8] Pyo provides a comparison of his old and new estimates (Pyo 1998: Table 12). The pre-1977 figures given in this table are based on erroneously aggregated figures in an earlier publication (Pyo 1992: Table A2). Pyo also shows that the results of Kim and Hong (1997) lead to implausibly high estimates of the capital stock in the 1960s and 1970s. For 1962, their estimate is more than three times higher than his.

Official capital stock estimates for Taiwanese manufacturing are provided by the Directorate General of Budget, Accounting and Statistics (DGBAS), using the benchmark extrapolation method (DGBAS 1999). However, capital formation in agriculture is excluded in the estimates by DGBAS.

Tables 2 and 3 compare the value of the capital stock according to our standardized estimates derived from the perpetual inventory method with those from Pyo and DGBAS respectively. In all cases our estimates are lower than the estimates based on the wealth surveys. The gap in the early years is particularly large for Taiwan, and especially for manufacturing. But for the total economy the gap is also large when one takes into account that our estimates include capital stock in agriculture, whereas the DGBAS figures do not. However, the gap between the DGBAS estimates and our figures becomes much smaller over time. This implies that our estimates show more rapid capital accumulation than the wealth-based estimates. For Korea, the gap between Pyo's and our estimates is much more constant.

Both because of reporting errors and theoretical differences, the PIM estimates inevitably differ from the wealth survey results. There are two main limitations of the PIM method (Pyo 1998). The first is the need for long historical investment series. In this paper, we show that this limitation can be overcome using historical national accounts studies. A second limitation is the need to assume particular asset lifetimes. Lifetimes might differ across countries and over time and further research is needed here. By using standardized asset lives as in this paper, international comparability is enhanced. The estimation procedure is transparent and it is possible to check the sensitivity of the results. Wealth surveys have the advantage that they measure the assets actual in use, but in extrapolating the benchmark stock assumptions concerning retirements have to be made as well. The actual nature of the survey is crucial for its usefulness for capital stock measurement (Ward 1976). Ideally, the survey should be a survey of physical assets on a case-by-case basis and it should have a complete coverage, but such surveys are complicated and prone to measurement errors. If instead the survey is based on book values, as often reported in censuses, its use is much more circumspect. Balance sheets valuations reflect a cumulation of historical prices of different time periods, depend on the depreciation accounting practices of firms which are mainly influenced by tax conventions rather than the actual decline in productive capacity, and the vintage composition of the stock is unknown. The Korean wealth survey comes close to a survey of physical assets (Pyo 1998: 19), but the official Taiwanese capital stock figures seem to be based on balance sheets.[9] Another important shortcoming of using wealth surveys is the problem of obtaining consistent methods of evaluation both across countries and over time (Ward 1976). Therefore we prefer to use our internationally consistent estimates based on the PIM method.

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[9] Comparison with the Taiwanese production census data suggests that the census is used as a benchmark. According to DGBAS, the total gross value of fixed assets in the manufacturing sector in use in 1991, excluding land, was NT$ 3,544 billion in 1986 prices (DGBAS 1991: Table 10). This figure is almost identical to the NT$ 3,537 billion given in DGBAS (1994).

Table 2. Capital stock in Korea according to this study and Pyo: Total economy and manufacturing, 1953-1996.

	Total economy				Manufacturing		
	This study	Pyo	This study/ Pyo		This study	Pyo	This study/ Pyo
	bln. 1990 Won		(%)		bln. 1990 Won		(%)
1953	8,666	11,241	77				
1963	13,108	19,518	67		2,936	3,848	76
1973	46,226	55,256	84		9,344	14,673	64
1985	224,602	297,191	76		59,855	102,137	59
1996	736,682	980,149	75		247,448	404,847	61
	Average annual growth rate (%)				Average annual growth rate (%)		
1953/63	4.1	5.5					
1963/73	12.6	10.4			11.6	13.4	
1973/85	13.2	14.0			15.5	16.2	
1985/96	10.8	10.8			12.9	12.5	

Note: All growth rates in this paper are logarithmic.
Sources: Investment series from Bank of Korea, *National Accounts* and for the pre-war period from Pyo (1996). Assumptions as explained in text. Survey estimate from Pyo (1998: Table A4).

Table 3. Capital stock in Taiwan according to this study and DGBAS: Total economy and manufacturing, 1951-1995

	Total economy				Manufacturing		
	This study	DGBAS	This study/ DGBAS		This study	DGBAS	This study/ DGBAS
	bln. 1991 Taiw. $		(%)		bln. 1991 Taiw. $		(%)
1953	326,050						
1963	490,476	645,910	76		83,078	340,038	24
1973	1,402,549	1,545,568	91		414,371	727,338	57
1985	5,339,055	5,707,863	94		1,816,015	2,316,079	78
1996	13,667,004	13,220,471	103		4,691,847	5,754,758	82
	Average annual growth rate (%)				Average annual growth rate (%)		
1953/63	4.1						
1963/73	10.5	8.7			16.1	7.6	
1973/85	11.1	10.9			12.3	9.7	
1985/96	8.5	7.6			8.6	8.3	

Note: DGBAS (1999) excludes capital in the agricultural sector of the economy.
Source: Investment series from DGBAS, *National Income in Taiwan Area*; Mizoguchi (1997). Assumptions as explained in text. Survey estimate taken from DGBAS (1999, Table 1).

II. Diminishing returns and catch-up potential: The need for structural change

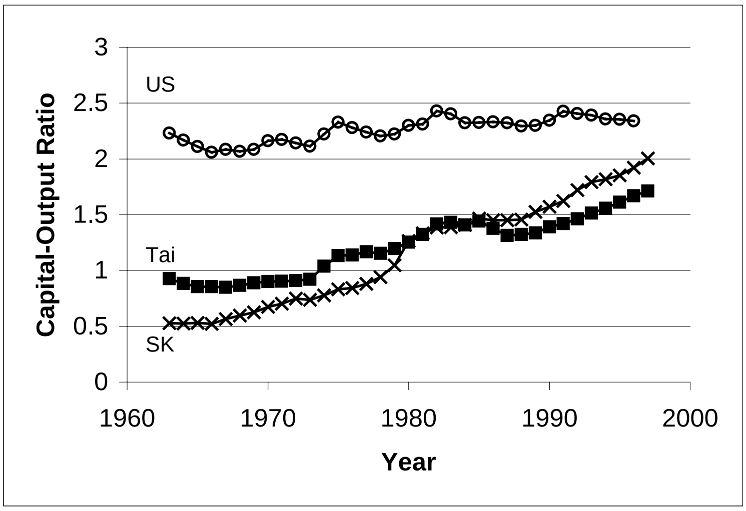
In order to put the rapid growth in the capital stock in the East Asian countries in perspective, this section looks at the pace of capital accumulation in relation to the change in labour input and output. This provides an indication of the efficiency with which the massive investment flows have been absorbed in the economy. We first focus on changes in the capital-output ratios to analyse the issue of diminishing returns to investment. The issue is then treated more in depth by taking into account labour input and relating capital intensity and labour productivity trends and levels. An international perspective is taken by comparing developments in Korea and Taiwan with those in the United States.

II.1 Diminishing returns to investment?

It has been suggested by various authors that capital accumulation in East Asia has been so rapid that decreasing returns are likely to set in. To this end we present comparative trends in capital-output ratios in international prices. Output and capital stock were converted to US dollars (prices of 1990) on the basis of purchasing-power parities for GDP and capital formation respectively. GDP is taken from the database of the Groningen Growth and Development Centre and various ICOP studies.[10] Figure 1 shows the changes in the capital-output ratio in the total economy. In the 1960s, Korea and Taiwan were characterized by strikingly low capital-output levels compared to the United States as stressed by Fukuda and Toya (1998). This indicates that capital was used in a highly productive way. As the investment process accelerated in the following decades, the capital-output ratio slowly converged towards the level of the United States. It reflects a change in the economic structure towards more capital-intensive production processes. In 1995, the amount of capital used per unit of output was still considerably lower in the East Asian countries than in the United States.

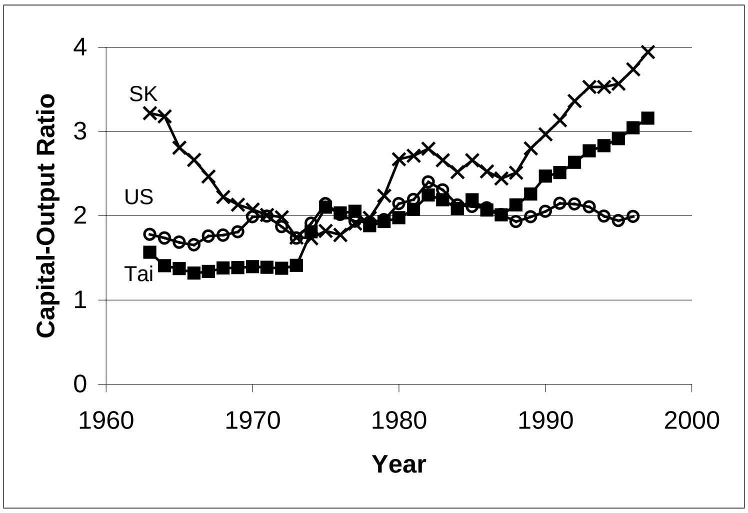
[10] For ICOP, see Van Ark (1993), Pilat (1994) and Timmer (2000). Information about the GGDC database can be obtained at http: //www.eco.rug.nl/ ggdc/Dseries.html.

Figure 1. Capital-output ratios in 1990 US dollars
Korea, Taiwan and USA, total economy 1960-1996



Source: See Tables 4 and 5

Figure 2. Capital-output ratios in 1990 US dollars:
Korea, Taiwan and USA, manufacturing 1960-1996



Source: See Tables 4 and 5

Yet the relative changes in the capital-output ratio in manufacturing were rather different as shown in Figure 2. In the early phase of industrialization in the 1960s, capital-output ratios were already high and comparable to those in the United States.[11] This contradicts the suggestion by Fukuda and Toya (1998) that the low capital-output ratios at the total economy level in East Asia are mainly due to low levels in manufacturing. On the contrary, the low capital-output ratios in the non-manufacturing sectors account for the lower total economy levels relative to the United States.

When comparing the relative trends between the total economy and manufacturing, it should be noted that all figures are converted into 1990 US dollars using purchasing-power parities. It is a stylized fact that relative price levels of developing countries relative to the United States (or any other advanced country) are higher in manufacturing than in non-manufacturing. Indeed, in 1987 the relative price level (i.e. the purchasing-power parity relative to the exchange rate) of Korea vis-à-vis the United States was 85% for manufacturing output but only 58% for the total economy. For Taiwan the difference was smaller, i.e. a relative price level of 78% for manufacturing versus 61% for the total economy (Timmer 2000). Hence, in domestic prices the difference between capital-output ratios in the total economy and manufacturing would be less but still significant.

A particularly interesting feature of Figure 2 is the development of the capital-output ratio in Korean manufacturing, first declining from a very high level in the 1960s to a minimum in the 1970s, then increasing, especially towards the end of the 1980s. The declining trend in the 1960s has also been found by Hong (1976). In Taiwanese manufacturing the ratio steadily rose since the early 1960s with a similar acceleration in the 1980s. The difference between Korea and Taiwan in the 1970s reflects the different industrial development. In both countries investments were geared towards labour-intensive exports but at the same time secondary import substitution and the establishment of heavy industries such as oil refining and basic metals was pushed much more in Korea than in Taiwan (Amsden 1989; Timmer 2000).

The rapid increase in the capital-output ratio in the late 1980s in both countries suggests that capital has been accumulated in the manufacturing sector at increasingly faster rates with little additional output growth. In 1995, the ratio in both countries was higher than in the United States. This observation lends partial support to those who argue that diminishing returns to capital will reduce further growth prospects in East Asia (Krugman 1994; Young 1995). Still, from the beginning of the 1980s onwards, the manufacturing sector in Korea and especially in Taiwan underwent radical structural changes. Rising wages and increased competition from other Asian low-cost producers caused the competitiveness in the labour-intensive industries such as textiles and wearing apparel to dwindle rapidly. As a result, manufacturing activities were quickly upgraded. The capital-output ratios suggest that this process of industrial upgrading did not translate into higher output growth rates. On the contrary, as the capital intensification of the production process proceeded, similar investment efforts generated less output growth than before when investments were in more mature and labour-intensive technologies.

However, to fully assess the impact on the growth potential of the Korean and Taiwanese economy, we need to look not only at the relation between capital and output but to take labour inputs into account as well. Initially, investments were accompanied by a rapid increase in the labour force but during the 1980s the growth of the labour force stagnated, especially in manufacturing.

II.2 The remaining potential for catch-up

Table 4 shows the non-residential capital stock per hour worked in Korea, Taiwan and the United States. Employment series for both the total economy and manufacturing are derived from national account statistics, and average hours worked from the database of the Groningen Growth and Development Centre and various ICOP studies. The table confirms the extraordinarily rapid growth of capital intensity in Korea and Taiwan, in particular since the early 1970s, both in

[11] When using the estimates by Pyo (1998), the ratio in Korea would be even higher. This provides further evidence in favour of our PIM-estimates.

manufacturing and the total economy. Before 1973 capital intensity grew more slowly in Korea. However, it should be recognized that in 1963 Korean capital intensity in manufacturing was already some 40% higher than in Taiwan. Despite the rapid growth in capital-labour ratios, the gap in capital intensity relative to the United States was still huge by 1996. For the total economy capital-labour ratios were around 30% of the level of the United States in 1996. Relative capital intensity was somewhat higher in manufacturing but still left a gap of about 50% in both countries compared to the United States.[12] This indicates that also within manufacturing, relative labour-intensive activities still dominate production. This is also true at a lower level of aggregation. Timmer (2000) found large gaps in capital intensity between the East Asian countries and the United States in all 2-digit manufacturing industries, except textiles.

To analyse the issue of diminishing returns comprehensively, we need to look not only at the capital-labour ratios but also at labour productivity ratios relative to the United States. Table 5 shows the level of value added per hour worked in Korea, Taiwan and the United States for the total economy and manufacturing. It is clear that the rapid growth in capital intensity is reflected in rapid labour productivity growth. It appears that, despite the lower level of capital intensity, the labour productivity level for the total economy has been substantially higher than in manufacturing. This implies that non-manufacturing sectors create higher productivity levels with lower capital intensity. This again points at the different relative output price levels in manufacturing and non-manufacturing sectors discussed above. Even though, when using domestic prices, manufacturing tends to create more output per working-hour with more capital per working-hour, in international prices, non-manufacturing sectors create more output per working-hour even with less capital.

[12] The levels of capital intensity in Korean manufacturing differ substantially from those presented in Timmer (2000). This is due to the differences in the labour series used. Here we used employment series from the national accounts which are about 50% higher than those found in the manufacturing census which were used by Timmer (2000). Further investigation into these differences is warranted.

Table 4. Capital per hour worked in Korea, Taiwan and United States, total economy and manufacturing, 1963-1996.

	Korea		Taiwan		United States	
	Total Economy	Manufac-Turing	Total Economy	Manufac-turing	Total Economy	Manufac-Turing
	1990 US dollars		*1990 US dollars*		*1990 US dollars*	
1963	1.20	2.67	1.76	1.93	41.31	25.17
1973	2.68	3.07	3.59	4.02	49.92	33.13
1985	8.90	9.47	10.74	10.94	63.54	51.01
1996	21.86	31.24	23.64	29.83	69.94	65.42
	Average annual growth rate (%)		Average annual growth rate (%)		Average annual growth rate (%)	
1963/73	8.0	1.4	7.1	7.3	1.9	2.7
1973/85	10.0	9.4	9.1	8.3	2.0	3.6
1985/96	8.2	10.9	7.2	9.1	0.9	2.3

Sources: Capital stock from Tables 2 and 3. Converted into 1990 US dollars on the basis of purchasing-power parities for investment calculated from Penn World Tables, Version 5.6. Employment from national accounts: Korea: EPB, *Annual Report on the Economically Active Population*; Taiwan: DGBAS, *Statistical Yearbook of the Republic of China* and *Monthly Bulletin of Manpower Statistics*; United States: BEA, *National Income and Product Accounts of the United States*. Working-hours total economy from GGDC Total Economy Database and manufacturing from Pilat (1994) for Korea and USA and from DGBAS, *Monthly Bulletin of Earnings and Productivity* for Taiwan.

Table 5: Value added per hour worked in Korea, Taiwan and United States, total economy and manufacturing, 1963-1996.

	Korea		Taiwan		United States	
	Total economy	Manufac-Turing	Total economy	Manufac-turing	Total Economy	Manufac-turing
	1990 US dollars		*1990 US dollars*		*1990 US dollars*	
1963	2.28	0.83	1.90	1.23	18.52	14.19
1973	3.63	1.76	3.90	2.85	23.60	19.10
1985	6.07	3.56	7.45	5.00	27.33	24.19
1996	11.38	8.36	14.17	9.80	30.35	32.91
	average growth rates (%)		*average growth rates (%)*		*average growth rates (%)*	
1963/73	4.7	7.6	7.2	8.4	2.4	3.0
1973/85	4.3	5.8	5.4	4.7	1.2	2.0
1985/96	5.7	7.8	5.8	6.1	1.0	2.8

Sources: Output from Bank of Korea, *National Income in Korea 1975*; *National Accounts*, various issues, linked with OECD, *National Account Statistics, 1997*; for Taiwan from DGBAS, *National Income in Taiwan Area of the Republic of China, 1994;* United States from BEA, *National Income and Product Accounts of the United States*. Converted into 1990 dollars on the basis of 1990 Geary Khamis purchasing-power parities from Maddison (1995) for total economy. For manufacturing on the basis of unit value ratios from Pilat (1994) for Korea and from Timmer (2000) for Taiwan. Employment and hours as in Table 4.

Figures 3 and 4 show the relationship between the non-residential capital stock per hour worked and GDP per hour worked in 1990 dollars for the total economy and manufacturing respectively in a graphical format. These graphs may be seen as representing a neo-classical production function of the type:

$$Y/L = A\ F(K/L)$$

with Y = value added, K = capital, L = labour and A = technology level.

According to this equation the change in labour productivity is a function of the change in capital-labour ratios and technical change. The traditional neo-classical growth model of Solow (1956) suggests that capital accumulation will go together with diminishing returns so that the Y/L - K/L relationship is reflected in the concave nature of the lines in Figures 3 and 4. Alternatively, Y/L can also increase because of technical change, which means a continuous upward shift of the lines in Figures 3 and 4. An impressionistic observation of Figure 3 suggests that for the total economy a continuous upward shift of the production function, i.e. technical change driving labour productivity growth, is a clear possibility. This possibility, in combination with the remaining large gaps in capital intensity and labour productivity, suggests that despite rising capital-output ratios there is still scope for further catch-up growth. Disentangling the effects of capital accumulation and total factor productivity more precisely goes beyond the scope of this paper and is a topic of further research (Pilat 1994; Timmer 2000).

The findings in this section suggest that continued growth in East Asia on the basis of expansion of inputs is not 'inevitably subject to diminishing returns' (Krugman 1994: 63). The finding that gaps in capital intensity between the United States and the East Asian countries are still large suggests that there is still much scope for further investment-driven growth. The rising capital-output ratios suggest that this process needs to be complemented with changes in the industrial stucture, introduction of new technologies and improvements in the credit allocation mechanisms. This need is reinforced by the currency crisis in 1997 and 1998. Foreign direct investment can play an important role in this process by augmenting the domestic investment effort and through associated technology spillovers.

Figure 3. Labour productivity and capital intensity: total economy, 1990 US dollars.

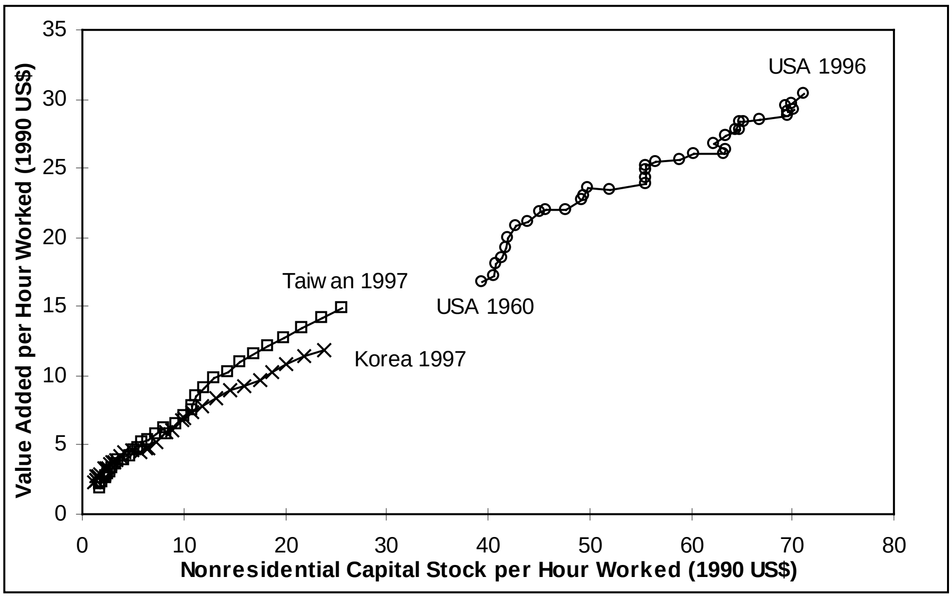
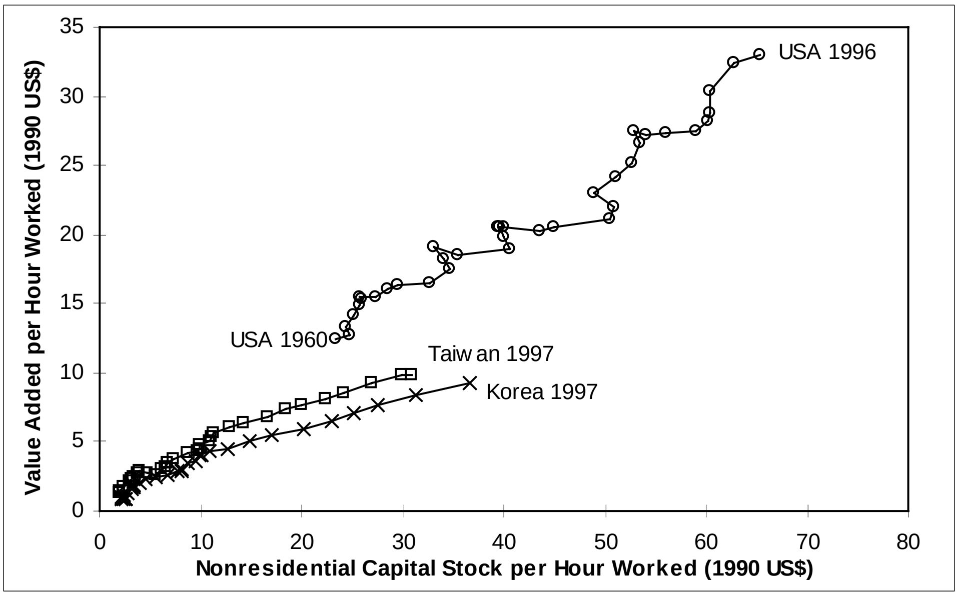


Figure 4. Labour productivity and capital intensity: manufacturing, 1990 US dollars.



III. Foreign direct investment as a contributor to productive capital

Foreign direct investment (FDI) has played an important role in the economic development process of Eastern Asia since the heyday of colonial rule in the region. Clearly the nature of foreign capital flows has changed from maximizing revenues from exports during the period of colonization to strengthening the industrial process since the 1960s (Lindblad 1998).

Beforehand, it should be emphasized that FDI accounts for only a small share of the total foreign capital inflow in Korea and Taiwan. For example, in the early 1960s net foreign capital, i.e. inflows minus outflows, accounted for 50-75% of gross domestic investment in Korea and 40-50% of investment in Taiwan. In both countries around 75-85% of such inflows consisted of bilateral loans, in particular from the United States. Over time the share of all foreign capital in total domestic investment declined whereas the share of private loans relative to public capital increased. In Taiwan net foreign capital turned strongly negative during the 1980s as Taiwanese firms started to invest abroad. FDI as a percentage of total net foreign capital increased over time, but on average it was less than 20% in Taiwan and only 7% in Korea between 1961 and 1986 (Stallings 1990). Our focus is on FDI because these are most strongly associated with simultaneous technology flows and as such a potential source of spillovers, due to advanced production techniques, new management and organisational practices and marketing networks (Blomström and Kokko 1998).[13]

According to the IMF definition, FDI refers to investment made to acquire lasting interest in enterprises operating outside the economy of the investors. FDI can be in the form of equity capital, reinvested earnings and provision of intercompany loans.[14] When using FDI statistics two important distinctions must be made. Gross flows differ from net flows in so far that according to the latter concept outward FDI is netted with inward FDI. As Korea and Taiwan have become major outward investors in recent years, this distinction is important. Here we use the gross flows. A second distinction is made between approved and disbursed flows. The latter refers to FDI flows which are realised, while the former refers to planned flows approved by the recipient government. In this paper we look at disbursed FDI flows into Korea and Taiwan. Hence it refers to all realised FDI flows into the two countries.

A third distinction that might be made, but is not pursued here, is the origin of FDI inflows. The incidence of technology spillovers is probably higher in FDI from industrialized countries but much less so in FDI from other countries at roughly the same level of technological development. In Korea in 1980, about 90% of the FDI stock originated from developed areas, but in Taiwan this was only 65% as Hong Kong and Singapore also invested heavily in this economy (United Nations 1992).

FDI in Korea

For estimates of FDI flows in Korea we made use of the *International Direct Investment Statistics Yearbook* published by the OECD for the period from 1985 to 1995. The flows are based on arrivals less capital withdrawn. These flows are linked by a series for 1970-1984 from UNCTC

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[13] Still, if one adheres to the screening theory of international capital markets, foreign capital might be more productive than domestic capital as investment projects financed by (private) foreign capital are more stringently screened. One might also argue that in the particular case of Korea and Taiwan, the large amounts of capital aid provided by the United States in the 1950s had high spillovers as well because it was tied to technical assistance in planning economic reforms (Amsden 1989).

[14] Flows of FDI are notoriously hard to measure so that there is a high degree of incomparability of FDI statistics from different countries. This is due to three main reasons. First, countries differ in their definition of foreign direct investment. Second, they differ in their methods of data collection. And, third, corporate accounting practices and valuation methods differ between countries. As a general rule the most important characteristic of FDI which distinguishes it from portfolio investment is that it is undertaken with the intention of exercising control over the enterprise (United Nations 1992: 39).

(1992). This linking is justified as both series use the same concept of FDI but, unfortunately, the latter series is only available for the total economy. To estimate flows into manufacturing, we applied the share of the manufacturing sector in total flows derived from stock figures in the same publication. The current flows have been deflated by the domestic investment price index (Appendix 2).

In most studies the impact of FDI is analysed by expressing FDI as a percentage of gross fixed capital formation in the domestic economy. Doing so, it appears that, at least in quantitative terms, FDI has never been important in Korea. The ratio of the FDI flows to gross fixed capital formation (GFCF) in non-residential capital peaked in 1973 at about 6% but declined afterwards to less than 2% in the 1980s at the time when domestic investment boomed. For manufacturing the FDI flow ratio was of course higher, peaking in 1973 at 16% but never exceeding the level of 4% after 1974. This ratio is often interpreted as an indicator of the portion of domestic capital formation undertaken by foreigners. However, one has to be careful with this interpretation. Investment in the sense of FDI is rather different from the concept of total investment used in the National Accounts. In addition to newly established investments, FDI also includes the acquisition of existing assets in the host country and is as such not fully comparable with gross domestic capital formation according to the National Accounts definition which measures only additions to the existing stock of domestic capital. In fact, the major part of FDI into Taiwan and Korea consists of equity rather than reinvested earnings or intercompany loans. A high ratio of FDI to GFCF may indicate little more than a high rate of foreign take-overs without anything happening to new investment.

Therefore, as argued by Ramstetter (1996), a more meaningful indicator of the importance of FDI is calculated by using the share of foreign multinationals in total output or, as here, the share of FDI stock in the total gross domestic fixed capital stock. For the measurement of FDI stock we used a similar procedure as for our estimates of the total capital stock, i.e. we added annual FDI flows to a benchmark FDI stock for 1970 for the total economy and for 1971 for the manufacturing sector. The benchmarks are taken from UNCTC (1992) (Appendix 2) and based on cumulating FDI flows since 1962.

FDI in Taiwan

Data on FDI in Taiwan are more difficult to obtain than for Korea. The first basic source is the *Statistics on Chinese and Foreign Investment* published by the Investment Commission of the Ministry of Overseas and Economic Affairs (MOEA) which publishes the *Statistics on Overseas Chinese and Foreign Investment*. This source is used by most researchers as it provides detailed time series on inward and outward FDI flows by sector and by country. However, a major disadvantage of this source is that it only collects data on approved FDI, not on actually disbursed FDI. An alternative is to use data collected by the Central Bank of China in the *Balance of Payments* which provides data on disbursed FDI that unfortunately is not broken down by sector. In addition, these series are shorter than those from MOEA. We therefore choose to use data on approved FDI from MOEA which are corrected by a ratio of disbursed to approved FDI. This ratio is based on data of FDI flows to Taiwan disbursed from Japan and the United States. Disbursed flows from these two countries are divided by approved flows from these countries as recorded by the MOEA year by year.[15] The average ratio for the period 1982-1993 is 0.66 (Appendix 2). This ratio is then used to transform the data on approved FDI from MOEA into

[15] Disbursed FDI from Japan and the United States constitute about 55% of total approved FDI in Taiwan during the period 1952-1993. Although one would expect that there is a lag between approval of FDI and the actual disbursement of this approved amount, a simple correlation analysis reveals that there is a high correlation between approved and disbursed flows in the same year (0.90 for Japan, 0.73 for the United States) which is much higher than the correlation between approvals and lagged disbursement. Hence we take the ratio of approved and disbursed amounts in the same year.

disbursed flows for both total and manufacturing FDI.[16] As for Korea we calculated stocks of FDI by cumulating previous flows. For Taiwan we could use data going back to 1952 (Appendix 2).
In Figure 5 we show the ratio of FDI stock to non-residential gross fixed domestic capital stock for both the total economy and the manufacturing sector in Korea. This gives an indication of the portion of the domestic capital stock which is under foreign control.[17] It shows clearly that the FDI stock was most important in the 1970s and declined in importance afterwards. Looking at the actual shares one can conclude that FDI has never been important in quantitative terms, neither for the economy as a whole nor for the manufacturing sector. It never constituted more than 6.5% of the non-residential capital stock in the manufacturing sector in 1975, declining to a mere 2 % in the 1990s. Instead the process of rapid economic growth in Korea in the past decades, and especially in the booming 1980s, was overridingly based on national investment efforts.

In Figure 6 we show the corresponding figures for Taiwan. It clearly shows that the importance of foreign firms dramatically increased during the period 1960-1973. The share increased from less than 1% to almost 6% in the total economy. It was especially important in the manufacturing sector where the ratio increased from 2% to more than 14%. After 1973, the importance of foreign firms in terms of capital stock declined and more or less stabilized in the 1980s at about 4% for the total economy and 8% for manufacturing.[18]

When we compare the Taiwanese experience with that of Korea, the simultaneity of the peaks in importance of FDI in the beginning of the 1970s stands out clearly. In both countries the importance of FDI declined rapidly afterwards and stabilized in the 1980s. The most important difference between these two East Asian countries concerns the importance of FDI in absolute terms. In Taiwan FDI constitutes a larger share in the domestic capital stock than in Korea, not only in the 1970s but also in the 1990s. Korea was characterized by a larger distrust and a higher degree of regulation of FDI. Until the beginning of the 1980s, Korea pursued an extremely cautious policy towards FDI (Hill 1990). In contrast to Korea, Taiwan offered a hospitable environment for FDI providing foreign investors with infrastructure and fiscal incentives since the early 1950s. FDI took off in the early stage of export-oriented growth in the 1960s, stimulated by the establishment of the first Export Processing Zones in 1966.[19] The electrical machinery branch in particular took up most of the FDI in this period.[20]

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[16] Alternatively, one might take the lower estimate by Schive based on unpublished data of about 0.45 (Schive 1988: 383). This indicates that our ratio might be too high, probably caused by the fact that Japanese and American investors realized more of their proposed projects than other investors in Taiwan. However, we also compared our estimates for disbursed FDI with those according to the balance of payments. Trends and levels are roughly comparable. Accumulating the data for 1976-1993 shows that our estimates are 14% higher than the balance of payments figures, which is within reasonable limits (Appendix 2.4).

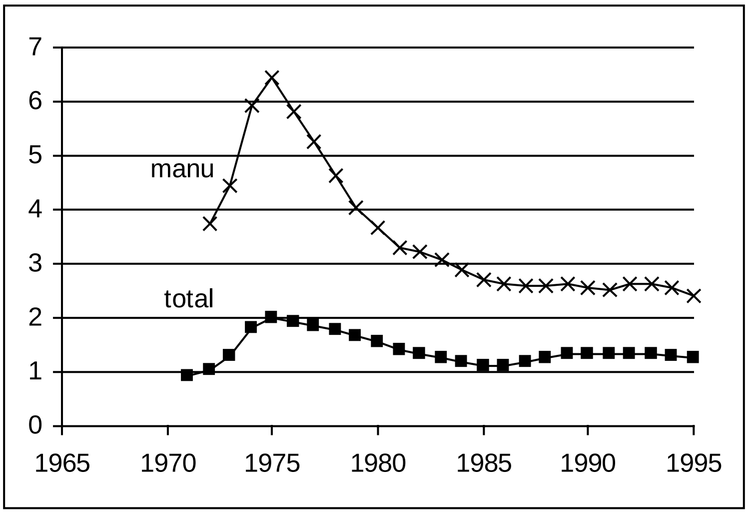
[17] Even this interpretation is tricky. First of all, FDI is not only directed towards acquisition of fixed capital only, but also includes non-fixed assets. Hence one should divide by the total capital stock rather than by the fixed capital stock. More importantly, a firm does not have to be totally foreign-owned to be under foreign control. Most of the time only a part of the shares of a firm will render a foreign investor an effective voice in the management of the enterprise. If this is frequently the case, the ratio of FDI stock to total domestic capital stock will be an underestimate of the part of the domestic capital stock which is actually under foreign management. A rough estimate using data from Schive (1988: Table 2) shows that in Taiwan about 60% of the assets of firms classified as foreign was in foreign hands in 1985.

[18] A sizeable amount of FDI into Taiwan consists of investments by overseas Chinese, blurring the distinction between 'domestic' and foreign firms. Investment from this group was actively encouraged by the government (Hill 1990). In 1980, 35% of accumulated FDI consisted of overseas Chinese investment but this share rapidly declined to 15% in 1993 (MOEA 1993).

[19] But certainly not solely directed to these zones (Schive 1988).

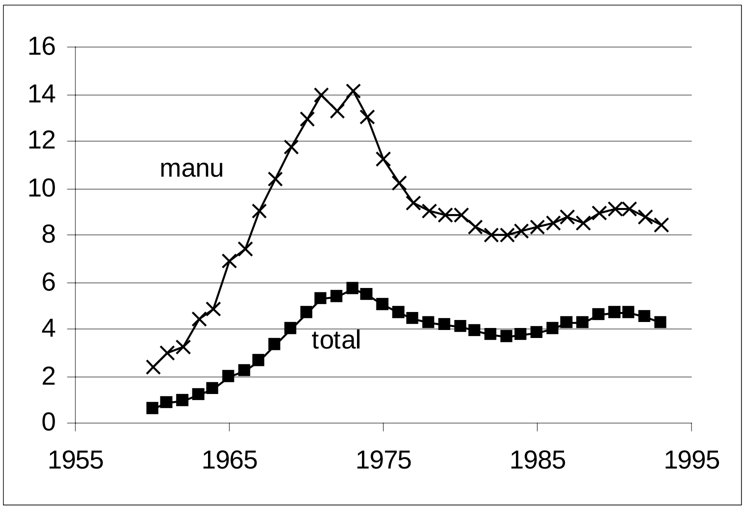
[20] About 50% of the total accumulated (approved) stock in manufacturing in 1970 (MOEA 1993).

Figure 5. Stock of foreign direct investment as a percentage of non-residential gross fixed domestic capital stock in Korea, 1971-1995.



Source: Appendices 1 and 2

Figure 6. Stock of foreign direct investment as a percentage of non-residential gross fixed domestic capital stock in Taiwan, 1960-1993.



Source: Appendices 1 and 2

In a survey on the importance of FDI for Taiwanese development, Schive (1988) stresses that although the contribution of FDI to capital formation might be small, the importance of foreign firms should not be understated. In Taiwan these firms were geared into labour-intensive export activities and as such made a major contribution when their relative contribution is expressed in terms of value added, employment or exports. Foreign affiliates in Taiwanese manufacturing accounted for about 16% of total manufacturing employment in the 1970s (Schive 1988: Table 6). However, when these foreign firms are weighted by the actual ownership share of foreigners their contribution drops to about 10% of employment. This is comparable to our estimated share of FDI in the total capital stock. This is also true for Korea, albeit to a lesser extent. In 1974 foreign affiliates accounted for 10% of value added in the manufacturing sector, increasing to 16% in 1977 but declining to 11% in 1986 (Ramstetter 1996: Table 6). In any case, the figures indicate that foreign firms might be more important than appears from the share of FDI.

Going beyond the quantitative picture drawn by comparing shares of FDI stock in the total capital stock, many studies stress the importance of FDI as a vehicle of technology transfers which makes it different from domestic investment. Although the capital transfer involved in FDI might be relatively small, the technology and managerial skills transferred through FDI are often of a much greater importance than suggested by the size of capital flows. These spillovers consist of the introduction of new technologies which can either be embodied in machinery or consist of disembodied technical knowledge. Often it also involves marketing knowledge and helps to alleviate export marketing problems of domestic firms, for example through production under a foreign brand name. This so-called ‘original equipment manufacturing’ was very important in the establishment of first the garment and later the electrical machinery sector in Korea and Taiwan (Hobday 1995). Externalities can also occur because of demand creation by foreign firms through local sourcing of parts and components. The importance of these spillovers can only be quantified using econometric techniques, which will be the next step in our research.

However, as the contrasting cases of Latin America and East Asia demonstrate, the positive spillover effects of FDI are highly dependent on the institutional framework under which FDI takes place. At least three important conditions were fulfilled in East Asia, but much less so in Latin America. First, various studies have shown that before new technologies can be productively absorbed, the level of human skills must be sufficiently developed. Second, there must be interaction between domestic and foreign firms, for example through subcontracting or a high mobility of workers. Third, the foreign firms must operate in the international market rather than relying on production for a protected domestic market as in Latin America (Hill 1990; De Mello 1997). In a recent cross-country regression these points have been stressed again. Borenzstein and associates (1998) found that FDI contributes more to growth in per capita income than domestic investment but only when the host country has reached a minimum threshold stock of human capital.[21] Balasubramanyam, Salisu and Sapsford (1996) found that the growth-enhancing effects of FDI are stronger in those countries which pursue an outward-oriented trade policy.

In any case both Taiwan and Korea have strongly relied on other sources for foreign technology acquisition as well. A major vehicle for transfer of technology in these two countries was large imports of capital goods. Much of the literature on Korean industrial development indicates that for basic standard technologies in mature industries, formal vehicles have not been important. Reverse engineering, defined as learning through the purchase and operation of capital goods but also through assistance from vendors and buyers and study of the technological literature delivered the majority of the crucial information on new technologies. Only at later stages of industrial development, when more advanced technologies are aimed at, do formal agreements gain in importance (Enos 1989).

[21] These cross-country studies treat both FDI and domestic investment as investments in the sense of the national accounts, thus ignoring the difference discussed above.

Conclusion

In this paper we first reconstructed the non-residential capital stock of Korea and Taiwan, and then compared capital-output ratios, capital-labour ratios and labour productivity levels with those in the United States for both the total economy and manufacturing.[22] With respect to the capital-output ratios we find a continuous increase over time for the total economy. In manufacturing we found a strong rise in capital-output ratios since the 1980s. At the same time we found that there are still large gaps between the East Asian countries and the United States in terms of capital-labour ratios and labour productivity. This indicates that, despite the deteriorating performance of capital goods, opportunities for further growth on the basis of accumulation are still far from exhausted. However, this requires continuous changes in the industrial structure, introduction of new technologies and improvements in the credit allocation mechanisms. Foreign direct investment can play an important role in this process by augmenting the domestic investment effort and through associated technology spillovers.

Secondly, we investigated the extent at which FDI accounted for the rise in the capital stock of Korea and Taiwan, and the extent to which it might have been a cause of rapid technological progress. Overall, we found fairly low shares of FDI in the capital stock, peaking during the 1970s and then following a declining trend in the 1980s. The latter is an unfortunate development in the light of declining returns to capital and the need for new technological impetus. FDI can be a major source of growth as it can create important technology spillovers in the economies. The main contribution of this paper has been to provide a better database to analyse these issues in more detail, for example by using growth accounting and regression techniques to assess the sources of growth in a more formal way.

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Appendix Table 1.1 Nonresidential Gross Fixed Capital Formation and Nonresidential Gross Fixed Capital Stock in South Korea, Total Economy

	Gross Fixed Capital Formation (GFCF), bln. 1990 Won			Gross Fixed Capital Stock (GFCS), bln. 1990 Won			GFCS in 1990 mln. US$
	Structures	Equipment	Total	Structures	Equipment	Total	
1913	58	33	92				
1914	67	32	99				
1915	73	24	97				
1916	67	25	91				
1917	83	42	125				
1918	102	72	174				
1919	106	79	185				
1920	116	43	159				
1921	133	47	181				
1922	189	46	235				
1923	181	52	234				
1924	151	56	207				
1925	184	50	233				
1926	221	74	295				
1927	251	101	352				
1928	250	134	384				
1929	281	160	441				
1930	272	184	456				
1931	245	142	387				
1932	233	135	368				
1933	295	163	458				
1934	381	225	606				
1935	438	276	714				
1936	498	212	709				
1937	492	189	681				
1938	580	227	807				
1939	658	369	1,028				
1940	692	490	1,182				
1941	803	395	1,198				
1942	798	393	1,191				
1943	810	399	1,209				
1944	775	382	1,156				
1945	0	0	0				
1946	0	0	0				
1947	226	112	338				
1948	244	120	364				
1949	262	129	391				
1950	282	139	421				
1951	0	0	0				
1952	0	0	0				
1953	266	88	354	6,976	1,690	8,666	13,334
1954	280	125	405	7,207	1,539	8,746	13,457
1955	369	158	527	7,490	1,415	8,904	13,701
1956	317	218	535	7,788	1,366	9,154	14,085
1957	420	231	651	8,101	1,353	9,454	14,547
1958	432	212	644	8,465	1,341	9,805	15,087
1959	497	189	686	8,863	1,427	10,289	15,832
1960	415	217	632	9,244	1,629	10,873	16,731

1961	523	229	752	9,616	1,819	11,435	17,595
1962	706	303	1,009	10,119	2,016	12,135	18,672
1963	887	399	1,286	10,816	2,292	13,108	20,170
1964	861	306	1,167	11,590	2,564	14,154	21,779
1965	1,135	379	1,514	12,467	2,865	15,331	23,590
1966	1,400	802	2,203	13,593	3,455	17,048	26,232
1967	1,640	1,059	2,699	14,963	4,342	19,305	29,704
1968	2,303	1,384	3,687	16,775	5,457	22,232	34,208
1969	3,272	1,678	4,950	19,397	6,846	26,243	40,380
1970	3,309	1,604	4,913	22,533	8,299	30,832	47,441
1971	3,197	1,974	5,171	25,642	9,864	35,506	54,633
1972	3,304	2,199	5,503	28,734	11,729	40,463	62,260
1973	4,178	2,652	6,830	32,272	13,954	46,226	71,127
1974	3,968	3,181	7,149	36,100	16,667	52,767	81,192
1975	4,443	3,484	7,927	40,024	19,777	59,801	92,015
1976	5,307	4,717	10,024	44,602	23,611	68,213	104,960
1977	6,616	6,312	12,928	50,242	28,775	79,017	121,583
1978	7,789	9,387	17,176	57,073	36,273	93,346	143,631
1979	8,846	10,875	19,720	64,985	46,061	111,047	170,867
1980	8,725	8,859	17,584	73,322	55,338	128,660	197,968
1981	8,639	8,900	17,539	81,524	63,287	144,811	222,819
1982	9,977	8,937	18,914	90,349	70,984	161,333	248,242
1983	11,936	9,695	21,631	100,830	78,769	179,599	276,348
1984	13,497	11,312	24,808	113,314	87,631	200,945	309,193
1985	14,225	11,860	26,085	127,175	97,428	224,602	345,594
1986	13,934	14,677	28,611	141,187	108,609	249,796	384,359
1987	16,467	17,483	33,950	156,246	122,264	278,510	428,541
1988	18,301	19,766	38,067	173,479	137,971	311,450	479,226
1989	21,147	22,567	43,713	193,039	155,805	348,844	536,764
1990	25,028	26,845	51,873	216,042	176,410	392,452	603,863
1991	28,284	30,088	58,372	242,698	199,361	442,059	680,193
1992	29,102	29,767	58,868	271,257	221,439	492,696	758,109
1993	31,419	29,722	61,140	301,244	241,052	542,297	834,428
1994	33,650	36,726	70,376	333,454	264,409	597,863	919,929
1995	36,613	42,521	79,134	368,243	295,153	663,396	1,020,762
1996	39,920	46,094	86,013	406,140	330,541	736,682	1,133,527
1997	42,245	40,868	83,112	446,796	364,706	811,502	1,248,653

Sources and notes: Total gross capital formation (excluding residential and land improvement) for 1914-1940 Pyo (1996) and for 1953-1997 from Bank of Korea, *National Accounts* (various issues). Capital formation from 1940-1953 on the basis of output series assuming investment-output ratios at 0.10 for the period 1939-1944, at 0.00 for 1945 and 1946, at 0.05 for 1947-1950 and at 0.00 for 1951 and 1952. Output from Maddison (1995), *Monitoring the World Economy, 1820-1992* (OECD Development Centre). After linking, the whole investment series was expressed in 1990 Won. 1940-1953 figures were divided into series for nonresidential structures and machinery and equipment using an average of the pre- and post-war period share of 67 per cent for structures. Investment was accumulated by using the standardized asset lives of 39 years for structures and 14 years for equipment from Maddison (1995). Moreover we discounted all pre-1953 investment by 40 per cent for war damage (Maddison, 1998, Table 3.10, p. 66). Stocks adjusted to mid-year. Estimates were converted to US dollars on the basis of PPPs for investment obtained from Penn World Tables 5.3 (see Summers and Heston, 1991).

Appendix Table 1.2 Nonresidential Gross Fixed Capital Formation and Nonresidential Gross Fixed Capital Stock in Taiwan, Total Economy

	Gross Fixed Capital Formation (GFCF), mln. 1991 NT$			Gross Fixed Capital Stock (GFCS), mln. 1991 NT$			GFCS in 1990 mln. US$
	Structures	Equipment	Total	Structures	Equipment	Total	
1912	3,177	849	4,026				
1913	2,818	439	3,257				
1914	2,314	394	2,708				
1915	1,858	384	2,242				
1916	1,919	348	2,268				
1917	3,448	538	3,986				
1918	2,793	508	3,301				
1919	4,138	847	4,986				
1920	6,579	867	7,445				
1921	5,924	982	6,906				
1922	4,834	675	5,509				
1923	4,841	743	5,585				
1924	3,955	570	4,525				
1925	5,475	745	6,220				
1926	5,456	898	6,355				
1927	6,474	1,051	7,525				
1928	7,767	1,377	9,144				
1929	8,291	1,360	9,651				
1930	7,265	1,560	8,825				
1931	7,104	1,289	8,393				
1932	8,807	1,259	10,066				
1933	9,579	1,554	11,133				
1934	10,314	2,198	12,512				
1935	13,269	2,816	16,085				
1936	14,247	2,974	17,221				
1937	10,564	3,099	13,663				
1938	11,411	3,633	15,043				
1939	13,481	4,494	17,975				
1940	13,432	4,477	17,909				
1941	14,777	4,926	19,702				
1942	15,864	5,288	21,151				
1943	10,814	3,605	14,419				
1944	7,427	2,476	9,902				
1945	0	0	0				
1946	0	0	0				
1947	4,710	1,570	6,280				
1948	5,097	1,699	6,796				
1949	5,518	1,839	7,357				
1950	5,973	1,991	7,964				
1951	7,337	2,783	10,120	273,794	38,937	312,731	
1952	8,779	4,160	12,938	278,854	39,043	317,897	
1953	11,654	4,974	16,628	286,504	39,546	326,050	12,115
1954	12,086	4,848	16,934	296,288	39,972	336,260	12,494
1955	10,404	4,279	14,683	305,645	39,834	345,479	12,837
1956	11,018	5,921	16,939	313,672	39,828	353,499	13,135
1957	10,121	6,353	16,474	321,120	41,518	362,639	13,474
1958	12,392	7,723	20,115	328,911	45,516	374,428	13,912

1959	14,997	9,371	24,368	337,248	52,825	390,073	14,494
1960	18,769	10,428	29,196	347,880	62,724	410,604	15,256
1961	19,153	12,277	31,431	361,462	73,292	434,754	16,154
1962	22,297	11,301	33,598	377,350	83,447	460,797	17,121
1963	25,077	13,019	38,096	396,638	93,838	490,476	18,224
1964	28,455	15,011	43,466	418,690	105,937	524,627	19,493
1965	29,736	23,115	52,852	442,320	122,614	564,934	20,991
1966	34,764	31,097	65,861	468,606	146,248	614,854	22,845
1967	42,166	38,862	81,029	499,950	176,661	676,612	25,140
1968	50,172	46,661	96,833	538,091	214,512	752,603	27,964
1969	53,667	56,034	109,700	582,232	261,296	843,528	31,342
1970	54,302	73,919	128,221	629,032	321,172	950,204	35,306
1971	57,600	94,585	152,186	677,028	399,287	1,076,315	39,992
1972	70,091	113,064	183,155	731,680	496,074	1,227,755	45,618
1973	72,636	130,785	203,421	793,097	609,452	1,402,549	52,113
1974	82,001	153,130	235,131	858,624	741,510	1,600,134	59,455
1975	116,709	164,760	281,470	944,221	889,103	1,833,324	68,119
1976	128,531	162,158	290,689	1,054,436	1,040,773	2,095,208	77,849
1977	146,938	149,732	296,671	1,181,183	1,184,558	2,365,741	87,901
1978	160,022	173,566	333,588	1,322,217	1,332,192	2,654,409	98,627
1979	170,747	212,233	382,980	1,474,145	1,506,028	2,980,173	110,731
1980	184,580	261,437	446,017	1,637,705	1,715,757	3,353,462	124,601
1981	181,567	280,945	462,512	1,805,458	1,951,968	3,757,426	139,611
1982	184,863	279,846	464,709	1,975,334	2,189,602	4,164,936	154,752
1983	181,788	278,575	460,362	2,149,539	2,417,465	4,567,004	169,691
1984	194,208	279,031	473,238	2,333,823	2,631,291	4,965,114	184,484
1985	203,696	239,452	443,148	2,532,774	2,806,280	5,339,055	198,378
1986	210,091	268,717	478,808	2,737,313	2,956,540	5,693,853	211,561
1987	246,986	344,289	591,275	2,960,949	3,141,118	6,102,067	226,728
1988	277,737	402,569	680,306	3,218,003	3,372,590	6,590,593	244,880
1989	307,768	483,570	791,338	3,505,010	3,656,714	7,161,724	266,101
1990	351,629	524,174	875,803	3,828,053	3,997,128	7,825,180	290,752
1991	416,769	548,503	965,271	4,204,194	4,377,521	8,581,715	318,862
1992	459,567	653,339	1,112,905	4,632,145	4,816,792	9,448,938	351,084
1993	522,251	667,796	1,190,047	5,111,184	5,284,460	10,395,645	386,260
1994	593,028	714,258	1,307,287	5,657,579	5,738,653	11,396,232	423,438
1995	641,714	796,995	1,438,709	6,264,239	6,223,089	12,487,328	463,979
1996	645,289	857,285	1,502,574	6,897,171	6,769,833	13,667,004	507,811
1997	676,282	1,031,064	1,707,346	7,546,700	7,434,797	14,981,497	556,652
1998	721,803	1,152,470	1,874,273	8,232,047	8,247,762	16,479,809	612,323

Sources and notes: Total gross capital formation (excluding residential and land improvement) for 1912-1938 Mizoguchi (1997), and for 1951-1998 from DGBAS, *National Income in the Taiwan Area of the Republic of China* (1998). Capital formation from 1938-1951 on the basis of output series assuming investment-output ratios at 0.10 for the period 1939-1944, at 0.00 for 1945 and 1946 and 0.05 for 1947-1950. Output from Maddison (1995), *Monitoring the World Economy, 1820-1992* (OECD Development Centre). After linking, the whole investment series was expressed in 1991 Taiwanese dollars. Pre-1951 figures were divided into series for nonresidential structures and machinery and equipment using an average of the pre- and post-war period share of 75 per cent for structures. Investment was accumulated by using the standardized asset lives of 39 years for structures and 14 years for equipment from Maddison (1995). Stocks adjusted to mid-year. Estimates were converted to US dollars on the basis of PPPs for investment obtained from Penn World Tables 5.3 (see Summers and Heston, 1991).

Appendix Table 1.3 Nonresidential Gross Fixed Capital Formation and Nonresidential Gross Fixed Capital Stock in South Korea and Taiwan, Manufacturing

	South Korea			Taiwan		
	GFCF in 1990 bln. Won	GFCS in 1990 bln. Won	GFCS in 1990 mln. US$	GFCF in 1991 mln. NT$	GFCS in 1991 mln. NT$	GFCS in 1990 mln. US$
1935				3,200		
1936				3,426		
1937				2,717		
1938	185			2,992		
1939	236			3,575		
1940	271			3,562		
1941	275			3,918		
1942	273			4,207		
1943	277			2,868		
1944	265			1,969		
1945	0			0		
1946	0			0		
1947	78			1,249		
1948	83			1,352		
1949	90			1,463		
1950	97			1,584		
1951	0			2,104		
1952	0			2,209		
1953	81			3,760		
1954	81			4,083		
1955	144			2,434		
1956	182			3,699		
1957	197			4,079		
1958	186			4,667		
1959	154			4,762		
1960	165			6,537	71,547	2,658
1961	163			6,853	74,929	2,784
1962	219			6,677	78,623	2,921
1963	285	2,936	4,518	7,943	83,078	3,087
1964	281	3,093	4,759	12,498	90,015	3,345
1965	388	3,275	5,039	15,144	100,268	3,726
1966	661	3,635	5,594	19,069	113,634	4,222
1967	656	4,129	6,354	28,999	133,606	4,964
1968	881	4,733	7,282	34,082	161,609	6,005
1969	1,000	5,511	8,479	37,386	194,924	7,243
1970	826	6,344	9,762	48,624	236,945	8,804
1971	1,067	7,291	11,218	51,432	286,973	10,663
1972	825	8,214	12,638	64,697	344,413	12,797
1973	1,532	9,344	14,377	77,820	414,371	15,396
1974	1,721	10,918	16,799	97,851	500,799	18,608
1975	2,270	12,857	19,783	118,325	607,363	22,567
1976	3,071	15,499	23,848	111,002	720,183	26,759
1977	4,348	19,208	29,555	93,332	820,194	30,475
1978	5,865	24,274	37,350	87,114	907,432	33,717
1979	6,364	30,308	46,635	114,742	1,004,439	37,321
1980	4,547	35,651	54,856	143,947	1,130,525	42,006

1981	4,202	39,862	61,336	151,978	1,275,421	47,389
1982	4,360	43,954	67,631	128,669	1,411,855	52,459
1983	4,498	48,191	74,151	125,661	1,534,647	57,021
1984	6,106	53,323	82,047	159,823	1,672,675	62,150
1985	7,277	59,855	92,099	138,157	1,816,015	67,476
1986	9,033	67,847	104,396	187,484	1,972,141	73,277
1987	12,603	78,474	120,748	220,953	2,169,594	80,613
1988	14,357	91,702	141,101	243,525	2,394,523	88,971
1989	16,273	106,734	164,231	251,988	2,632,059	97,797
1990	18,920	123,996	190,791	252,347	2,870,406	106,653
1991	19,991	142,927	219,921	266,761	3,112,853	115,661
1992	17,673	161,101	247,884	294,380	3,369,390	125,193
1993	16,891	177,614	273,294	296,212	3,633,145	134,993
1994	22,117	196,178	301,857	367,318	3,929,176	145,992
1995	26,816	219,731	338,099	429,405	4,284,532	159,196
1996	30,511	247,448	380,746	485,281	4,691,847	174,330
1997	30,831	277,173	426,484	622,355	5,187,601	192,750
1998				686,798	5,770,918	214,424

Sources and notes: Total gross capital formation (excluding residential and land improvement) for 1953-1997 (Korea) from Bank of Korea, *National Accounts* (various issues) and for 1951-1998 (Taiwan) from DGBAS, *National Income in the Taiwan Area of the Republic of China* (various issues). Pre-1953/1951 estimates of capital formation were obtained using trend of total economy series (see Appendix Tables 1.1 and 1.2). After linking, the whole investment series was expressed in 1990 Won and 1991 Taiwanese dollars. Investment was accumulated by using the standardized asset lives of 25 years for all nonresidential capital, based on Van Ark and Pilat (1993). Moreover for South Korea we discounted all pre-1951 investment by 40 per cent for war damage (Maddison, 1998, Table 3.10, p. 66). Stocks adjusted to mid-year. Estimates were converted to US dollars on the basis of PPPs for investment obtained from Penn World Tables 5.3 (see Summers and Heston, 1991).

Appendix Table 2.1 Disbursed Flow and Stock of Foreign Direct Investment in South Korea, 1970-1995, in million 1990 Won

	Flow of FDI			Stock of FDI		
	Total	Manu-facturing	Manufac-turing as a % of total	Total	Manu-facturing	Manufac-turing as a % of total
1970				322,724		
1971	101,653			424,377	306,077	0.72
1972	174,848	108,963	0.62	599,225	415,041	0.69
1973	353,879	230,770	0.65	953,103	645,811	0.68
1974	241,281	182,120	0.75	1,194,385	827,931	0.69
1975	111,509	74,992	0.67	1,305,893	902,923	0.69
1976	163,849	107,837	0.66	1,469,743	1,010,759	0.69
1977	179,745	110,203	0.61	1,649,488	1,120,962	0.68
1978	196,986	100,242	0.51	1,846,474	1,221,204	0.66
1979	178,228	88,246	0.50	2,024,703	1,309,450	0.65
1980	16,290	9,575	0.59	2,040,993	1,319,025	0.65
1981	139,775	93,063	0.67	2,180,768	1,412,088	0.65
1982	88,086	65,304	0.74	2,268,854	1,477,392	0.65
1983	89,804	54,598	0.61	2,358,658	1,531,991	0.65
1984	145,210	78,395	0.54	2,503,868	1,610,386	0.64
1985	268,689	178,987	0.67	2,772,558	1,789,373	0.65
1986	516,945	243,608	0.47	3,289,502	2,032,981	0.62
1987	601,017	335,990	0.56	3,890,520	2,368,971	0.61
1988	702,166	423,912	0.60	4,592,686	2,792,882	0.61
1989	608,694	363,882	0.60	5,201,380	3,156,764	0.61
1990	640,102	425,782	0.67	5,841,482	3,582,547	0.61
1991	816,382	670,399	0.82	6,657,864	4,252,945	0.64
1992	544,160	428,453	0.79	7,202,025	4,681,398	0.65
1993	491,101	339,802	0.69	7,693,125	5,021,200	0.65
1994	643,967	234,730	0.36	8,337,092	5,255,930	0.63
1995	821,368	364,549	0.44	9,158,459	5,620,479	0.61

Source: Flow in current prices for 1985-97 from OECD, *International Direct Investment Statistics Yearbook,* various issues, 1970-84 from UNCTC, *World Investment Directory 1992, vol I, Asia and the Pacific*, p.235 and 239. Deflated by implicit deflators for non-residential GFCF in total economy and for GFCF in manufacturing from Bank of Korea, *National Accounts 1990* and OECD *National Accounts* 1984-1996, vol II. Stocks are calculated by accumulating flows combined with a benchmark stock in 1970 for total economy and 1971 for manufacturing. The benchmark stocks are from UNCTC, *World Investment Directory 1992, vol I, Asia and the Pacific*, p.239. These benchmarks at current prices are based on accumulated arrivals less capital withdrawn since 1962. Benchmark stocks are deflated by implicit deflators for capital stock from Pyo (1990).

Appendix Table 2.2 Disbursed Flow and Stock of Foreign Direct Investment in Taiwan, 1952-1993, in million 1991 NT$

	Flow of FDI			Stock of FDI		
	Total	Manu-	Manufac-	Total	Manu-	Manufac-
1952	56	42	76%	56	42	
1953	271	90	33%	327	132	
1954	139	111	79%	466	243	
1955	244	164	67%	710	407	
1956	246	174	71%	956	581	
1957	97	46	47%	1,054	627	
1958	141	89	63%	1,195	716	
1959	77	33	43%	1,272	749	
1960	1,251	971	78%	2,523	1,721	
1961	1,219	491	40%	3,742	2,212	
1962	463	305	66%	4,205	2,517	
1963	1,646	1,149	70%	5,852	3,666	
1964	1,761	705	40%	7,612	4,370	
1965	3,465	2,541	73%	11,078	6,912	
1966	2,400	1,529	64%	13,478	8,440	
1967	4,648	3,623	78%	18,126	12,064	
1968	7,127	4,721	66%	25,253	16,785	
1969	8,297	6,035	73%	33,550	22,821	
1970	10,640	7,774	73%	44,190	30,594	
1971	12,222	9,442	77%	56,412	40,037	
1972	9,140	5,553	61%	65,553	45,590	
1973	14,016	12,879	92%	79,569	58,469	
1974	7,837	6,557	84%	87,406	65,026	
1975	5,072	3,456	68%	92,478	68,482	74%
1976	5,897	4,835	82%	98,375	73,317	75%
1977	6,651	3,550	53%	105,026	76,866	73%
1978	7,965	4,843	61%	112,991	81,710	72%
1979	10,323	6,992	68%	123,315	88,701	72%
1980	12,417	11,237	90%	135,731	99,938	74%
1981	10,363	6,668	64%	146,094	106,606	73%
1982	10,662	6,317	59%	156,756	112,923	72%
1983	11,709	9,625	82%	168,465	122,548	73%
1984	16,095	14,124	88%	184,560	136,672	74%
1985	20,649	15,510	75%	205,209	152,182	74%
1986	21,371	15,611	73%	226,580	167,794	74%
1987	32,650	22,050	68%	259,231	189,843	73%
1988	23,879	14,851	62%	283,110	204,694	72%
1989	43,927	29,674	68%	327,037	234,368	72%
1990	41,411	26,103	63%	368,447	260,470	71%
1991	31,479	21,978	70%	399,926	282,449	71%
1992	23,866	12,381	52%	423,792	294,830	70%
1993	20,128	11,386	57%	443,919	306,216	69%

Source: Disbursed FDI flows in current prices from data on approved FDI from Investment Commision, MOEA (Dec 31, 1993) *Statistics on Overseas Chinese and Foreign Investment* multiplied by average ratio of disbursed and approved investment into Taiwan from Japan and USA (see Appendix Table 2.3). Deflated with implicit deflator for non-residential GFCF in total economy and for GFCF in manufacturing from DGBAS, *National Income in Taiwan Area of the Republic of China*, 1994. Stocks are calculated as accumulated flows since 1952.

Appendix Table 2.3 Comparison of Disbursed and Approved FDI from Japan and USA into Taiwan (1,000 US$), 1982-1993

	Disbursed FDI (1)	Approved FDI (2)	Disbursed FDI / (1)/(2)
1982	121,000	244,365	0.50
1983	173,000	296,809	0.58
1984	164,000	356,827	0.46
1985	116,000	486,765	0.24
1986	371,000	402,856	0.92
1987	712,000	878,743	0.81
1988	563,000	605,775	0.93
1989	671,000	1,048,494	0.64
1990	668,000	1,420,248	0.47
1991	884,000	1,147,327	0.77
1992	400,000	641,526	0.62
1993	465,000	513,073	0.91
1982-93	5,308,000	8,042,808	0.66

Source: Disbursed FDI from OECD, *International Direct Investment Statistics Yearbook*, various issues. Approved FDI from Investment Commision, MOEA (Dec 31, 1993) *Statistics on Overseas Chinese and Foreign Investment,* Tables 4 and 7.

Appendix Table 2.4 Comparison of Disbursed FDI according to the Balance of Payments Statistics and Estimated from Statistics on Approved FDI, Taiwan, 1976-1993, in 1,000 US$

	FDI according (1)	Estimated (2)	(2)/(1)
1976	67,382	93,398	139%
1977	48,382	108,175	224%
1978	111,226	140,526	126%
1979	126,281	217,021	172%
1980	166,275	307,522	185%
1981	151,242	261,187	173%
1982	104,011	250,792	241%
1983	149,021	266,936	179%
1984	200,881	368,751	184%
1985	339,905	463,601	136%
1986	325,900	508,427	156%
1987	714,412	936,361	131%
1988	958,294	780,438	81%
1989	1,603,817	1,596,001	100%
1990	1,330,000	1,519,097	114%
1991	1,271,000	1,173,701	92%
1992	879,000	964,461	110%
1993	917,000	800,856	87%
1976-93	9,464,027	10,757,250	114%

Source: Balance of Payments statistics for 1976-89 from UNCTC, *World Investment Directory 1992, vol I, Asia and the Pacific*, p.299. Converted into US$ with exchange rate from DGBAS, *National Income in Taiwan Area of the Republic of China*, 1994, Table 16. 1990-93 from DGBAS, *Monthly Bulletin of Statistics*, November 1994, Table L-7. Estimated FDI from data on approved FDI from Investment Commission, MOEA (Dec 31, 1993) *Statistics on Overseas Chinese and Foreign Investment* multiplied by average ratio of disbursed and approved investment for Japan and USA from