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February 25, 2009

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Abstract

Using the knowledge-capital model, we compare factors affecting the inbound and outbound manufacturing and services investment between Singapore and a sample of industrialized and developing countries. The nature of Singapore's two-way investment with the industrialized nations is essentially skill seeking, while with the developing countries it is low wage seeking with the exception of inbound services investment, which is skill seeking. During 1994-2003 time period, Singapore's skill abundance relative to all parent countries, increased annual average inbound investment in manufacturing and services by US$ 8.15 billion and US$ 15.19 billion respectively.

1. Introduction

In this paper we apply the KK model to compare the influence of skills on manufacturing and service sector foreign investment in Singapore. Although in the past, the KK model has been applied to study factors affecting aggregate investment stocks (Carr, Maskus and Markusen, 2001 (hereafter CMM); Chellaraj, Maskus and Mattoo, 2009 (hereafter CHMM)) it has not been tested for bilateral investment stocks in the service sector for any country.

Singapore's strategy has been to make the country an attractive investment location for foreign MNEs by emphasizing infrastructure and skills development, along with fiscal incentives (Chang, 2005; Shin, 2005; Hu, 2004). In the mid 1980s, the GOS adopted a policy of promoting and developing Singapore as a regional hub (Dobson and Chia, 1997). There were two strategic elements: developing highly specialized niches and upgrading the low productivity domestic sector. The Singapore government adopted the cluster strategy of promoting key industries in electronics, pharmaceutical, telecommunications, etc (Hattari et al., 2008). In the most recent decade Singapore has shifted from low end manufacturing toward research, innovation, and service sectors such as transport, banking and financial investments (Sung 2006). Between 1984 and 2003 Singapore rapidly closed its skills gap with most industrialized countries through training and expanding education (Anwar, 2008). Kee and Hoon (2005) argue that the rapid economic development of Singapore may be partly attributed to these policies.

In 2003, inbound direct and portfolio investment stocks in manufacturing exceeded the corresponding outbound investment stocks by a margin of over 1.6 to 1, as noted in figure 1 while the corresponding figure for services was 2:1 (figure 2). Further,

two-way investment between industrialized countries and Singapore exceeded that between developing countries and Singapore by more than 6 to 1 in manufacturing and more than 4:1 in services (figures 1 and 2). It is plausible that increasing relative Singapore skill endowments underlay the increase in outbound investment stocks, especially in developing countries for both manufacturing and services.

The paper proceeds as follows. In the next section we briefly review the KK model to motivate the analysis. In Section 3 we specify the KK model for estimation and in Section 4 we provide the econometric results. In the final section we discuss the potential economic and policy significance of the findings and offer concluding remarks.

2. The Knowledge-Capital Model

2. The Knowledge-Capital Model and Prior Empirical Literature

Since Markusen (1984) and Helpman (1984), the general-equilibrium theory of the multinational enterprise has focused on two distinct motivations for investment: to access markets in order to circumvent trade frictions (horizontal FDI) and to employ low-wage labor for assembly parts of the production process (vertical FDI, or fragmentation). In the former case, multiple plants making similar goods are located in different markets and produce either for local markets or regional exports. In the latter, headquarters are split from assembly, and goods are traded in different stages of fabrication.

2a. Theoretical Overview

These motivations may be understood consistently within the general-equilibrium knowledge-capital model of FDI, explicated in Markusen (2002). The KK approach includes three principal assumptions. First, services of knowledge-based activities, such as R&D, can be geographically separated from production and supplied to production

facilities at low cost. Second, these knowledge-intensive activities are skilled-labor intensive relative to production. These assumptions create a motive for the vertical fragmentation of production, locating R&D activities where skilled labor is abundant and production where unskilled labor is plentiful. There will also be a motive for locating production in large markets if there are plant-level scale economies.

Third, knowledge-based services have a (partial) joint-input characteristic, in that they can be utilized simultaneously by multiple production facilities. The third assumption creates firm-level scale economies and motivates horizontal investments that replicate the same products or services in different locations.

The model assumes two homogeneous goods (X and Y), two countries (h and f), and two homogeneous factors, unskilled labor (L) and skilled labor (S), which are internationally immobile. Good Y is labor-intensive and produced under constant returns to scale in a competitive industry. Good X is skilled-labor-intensive overall, has increasing returns to scale at the plant level, and is subject to Cournot competition with free entry and exit. Within a firm, headquarters services and plant facilities may be geographically separated and a firm may have plants in one or both countries. Because R&D services can be shared across plants, sector X exhibits firm-level economies of scale as well. Transport costs in trade use unskilled labor and there are fixed costs of investing in a new plant.

With this structure, there are several firm types that can arise in equilibrium. First, there may be national firms that maintain a single plant and headquarters in one country and may or may not export to the other. Second, there may be horizontal MNEs that maintain plants in both countries with headquarters located in one country. Finally, there

may be vertical MNEs that maintain a single plant in one country and headquarters in the other.

Different country characteristics favor various firm types producing or maintaining headquarters in either country. For example, national firms will be more likely in country h if it is relatively large, which encourages local production while firms would avoid investment costs in the smaller nation. National firms also dominate if the two nations are similar in size and relative endowments, tending to discourage vertical FDI, and transport costs are low or foreign investment barriers are high, reducing horizontal investment.

Horizontal MNEs become important if the nations are similar in size and relative endowments, transport costs are high and investment costs are low. In this environment firms find it advantageous to locate production capacity in both locations, taking advantage of firm-level scale economies, while selling primarily in local markets to avoid transport costs. However, if the countries vary in endowments but have similar size firms, MNEs would concentrate headquarters in the skilled-labor-abundant country and production in the skilled-labor-scarce country. Thus vertical firms headquartered in the skilled-labor-abundant countries are favored unless trade costs are high. Vertical MNEs become especially significant if one country is small and skilled-labor abundant, in which case headquarters locate there and produce in the other location. This incentive is increased if trade costs from the host country back to the parent country are low.

2b. Application to Singapore

We apply this model informally to Singapore in order to motivate our regression analysis. Throughout the period of analysis, Singapore, despite experiencing rapid

economic growth, remained small in terms of its own market size (domestic consumption) in comparison with the other countries in our sample. However, the economy dramatically increased its relative skill endowments. For example, figure 3 depicts trends over time of differences in Singapore skill endowments and average skill endowments of selected industrialized and developing countries for the period 1994-2003.[1] This reflects increases in Singapore's endowment of occupational skills relative to the average skills of partner nations. There is a general upward trend suggesting widening of skill differences between Singapore and its investment partners.

The trends in inward services FEI stocks for all industrialized economies in our sample are presented in figure 4 and show a general upward trend. However, manufacturing FEI from these countries increased until 1999 and then exhibited a downward trend. Similarly, while outbound FEI in services to all industrialized countries in our sample showed an upward trend since 1998, manufacturing FEI rose until 2000 and thereafter declined sharply (figure 5).

Regarding developing countries inbound manufacturing FEI declined between 1994 and 2003 while inbound services FEI rose sharply (figure 6). However, both manufacturing and services FEI from Singapore to the developing countries in our sample rose during the 1994-2003 period and in the case of services it increased sharply (figure 7). As Singapore became skill abundant relative to the developing countries in our sample, inbound manufacturing investment declined while services investment increased. Meanwhile, relative Singapore skill abundance has resulted in sharp increases in both manufacturing and services FEI to developing countries.

[1] We define this measure of skill differences in the next section.

2c. Prior Estimation

In CMM (2001) the initial empirical estimation of the KK model was performed, using a 1986-1994 panel dataset of bilateral country-level affiliate sales in manufacturing, involving both U.S. affiliates abroad and foreign affiliates in the United States. In their econometric work, the authors found that a convergence in income (GDP) between the United States and any investment partner (holding the sum of their incomes constant) increased affiliate sales in both directions. There was substantially greater evidence of horizontal FDI, with affiliate sales rising in host countries with skill endowments closer to those of the United States, than of vertical FDI. This result may have been due to the selection of countries, which did not include many lower-income developing nations.

This empirical evidence has been substantiated by other studies. Gao (2003) included an additional variable to account for ethnic networks and found that there is a significantly positive role in inward FDI of ethnic Chinese networks. Waldkirch (2008) studied German MNEs and found that FDI happens largely between similarly endowed countries, with little evidence of any vertical motivation. Braconier, Norback and Urban (2005) included other industrialized countries, such as Sweden, and found evidence to support the KK model.

An important criticism of the CMM approach was that pooling bilateral data could disguise the actual relationships between endowment differences and MNE activity. The reason is that the United States was the host in half the observations and the parent in the rest, implying that the sign of their skill-endowments variable (the difference between parent and host in the ratio of skilled to total labor) depended on the direction of the investment. Thus, where the United States was a skill-abundant host

(parent), an increase in skill differences implied a convergence (divergence) in endowments. This difference makes interpretation of coefficients difficult and calls for splitting the sample into inbound and outbound investment (Blonigen, Davies and Head, 2003; Blonigen, 2005).

A second criticism of such studies is the potentially inappropriate pooling of data from developing and industrialized countries. Blonigen and Wang (2004) found that the underlying factors affecting the location of FDI activity varied systematically across these country groups in a way that was not captured by prior empirical models. Thus, U.S. outward FDI to large industrialized countries is strongly attracted to countries with higher skill abundance, suggesting a horizontal motivation. However, the effect was reversed for FDI in developing countries, although the relationship was not statistically significant.[2]

The above criticisms were addressed by CHMM (2009) using aggregate bilateral foreign investment stocks data for Singapore which found strong evidence that the nature of Singapore's two-way investment with the industrialized nations has shifted into skill-seeking activities over the period, while Singapore's investments in developing countries have increased sharply and become concentrated in labor-seeking activities. The results also indicate that the size of the ASEAN market also influenced inbound foreign investment in Singapore from industrialized countries.

This research is the first attempt to estimate the KK model for the service sector for any country and also the first attempt to separately compare the impact of skills on manufacturing and service sector investments. Furthermore, as MNEs base regional

[2] See also Yeaple (2003).

headquarters in Singapore and invest in neighboring countries, the use of ASEAN GDP to account for host market size is appropriate for inbound foreign investment in both manufacturing and services. As this research incorporates both these investment objectives, a panel study of two-way FDI into and out of Singapore taking into consideration the impact of the regional market size should be of considerable interest. In addition, we also incorporate the role of the GOS in maintaining political stability, strict anti-corruption laws as well as the development of infrastructure such as roads, rails, energy, telecommunications and ports.

3. Methodology and Data

3a. Basic Specification

Following CHMM, our specification for the determinants of both manufacturing and service sector investment is as follows:

$$FEI_{ijt} = \beta_0 + \beta_1 (GDP_{it} + GDP_{jt}) + \beta_2 (GDP_{it} - GDP_{jt})^2 + \beta_3 (SK_{it} - SK_{jt}) + \beta_4 (GDP_{it} - GDP_{jt}) * (SK_{it} - SK_{jt}) + \beta_5 IC_{jt} + \beta_6 INST_{jt} + \beta_7 INFRA_{jt} + \beta_8 TC_{jt} + \beta_9 TC_{jt} * (SK_{it} - SK_{jt})^2 + \beta_{10} TC_{it} + \beta_{11} DIST_{ij} + e_{ijt} \quad (1)$$

The dependent variable is the stock of foreign equity investment (FEI) invested by country i (the parent) in country j (the host).[3] For inward investment, Singapore is always the host country and for outward investment Singapore is always the parent country. CMM (2001) employed majority-owned affiliate sales in manufacturing as their measure of investment activity. Available data do not incorporate this measure and we choose to analyze investment stocks instead. Note that focusing on stocks instead of activity flows may actually be an advantage, for the former measures reflect long-term decisions to

[3] Definitions of variables and data sources are provided in the following subsection.

invest and are less volatile, and less dependent on omitted variables, than are annual activity measures (Braconier, Norback and Urban, 2005).

(GDP_{it} +GDP_{jt}) is the sum of parent-country and host-country real gross domestic product (GDP Sum). It captures joint market size and the coefficient is expected to be positive. The next variable, the squared difference in GDP between parent and host nations captures changes in relative size, holding relative factor endowments fixed, and the theory implies that incentives for market-seeking investment should increase as countries become more similar in size. Thus, in principle there should be an inverted U-shaped relationship between FEI stock and country size differences, suggesting that the coefficient should have a negative sign. One difficulty with this interpretation is that Singapore is small relative to the other countries in the data. When one partner is small, the underlying theoretical discrimination between horizontal and vertical motivations is less sharp and it is possible to observe a positive coefficient on size differences.

The next variable is the difference in relative skill endowments between the parent and host countries. If the recipient nation is skill-abundant, implying that the skill differences variable is negative, a rise in its endowment would attract skill-seeking FDI and vice versa. On the other hand, if the recipient nation is labor abundant, implying that the skill differences variable is positive, a fall in its endowment would attract low wage seeking FDI.

The interaction terms introduced in this model are based on numerical simulation by CMM (2001). The basic result of this simulation is that the effect of differences in country size on FDI depends on whether the countries are similar in relative endowments and, if they are different in size, on whether the small country is the skill abundant

country. While coefficient β_3 captures the direct marginal impact of skill differences on investment stocks, the total marginal effect depends on other economic determinants, as suggested by the non-linearities captured in interaction terms. For example, if β_4 is negative and the parent country is larger than the host, a reduction in the difference in country size (that is, an increase in the size of the host) should reduce the sensitivity of investment stocks to skill differences. Thus, the interaction between country-size differences and skilled labor differences is expected to have a negative impact since FEI stocks should be smaller where market size differences are large, for a given difference in skills. The interaction term between host-country trade costs and squared skill differences is designed to capture the fact that such costs should encourage horizontal, but not vertical, investment, in which case they should matter less when skill differences are large. But, as CMM (2001) point out, this is not a theoretically sharp hypothesis.

Higher host-country investment costs (IC_{jt}) should reduce investment. Similarly, higher host country institutional barriers ($INST_{jt}$) and host country infrastructure impediments ($INFRA_{jt}$) should have a negative impact on FEI. To the extent that investment is driven by market-seeking incentives, higher host-country trade costs (TC_{jt}) should increase it due to tariff-jumping. However, where investment is undertaken to fragment production networks, higher trade costs can deter FEI. Parent-country trade costs (TC_{it}) should have a negative impact on FEI stocks since they make exporting output back home more costly. Finally, $DIST_{ij}$ is the distance in kilometers between Singapore and the capital cities of partner countries. Generally, one would anticipate a negative coefficient on this variable.

This basic framework is applied to data samples involving both inbound and outbound manufacturing and services FEI stocks in Singapore. This estimation should capture the basic influences of the KK model. However, we also split the sample into inbound and outbound separately for industrialized and developing country partners and investigate foreign investment behavior for these groups separately for both services and manufacturing. Outbound and inbound investments to and from industrialized countries in both manufacturing and services are expected to be skill seeking. Outbound investment to developing countries for both manufacturing and services is expected to be low wage seeking. Although we have no particular expectation for inbound investment from developing countries into Singapore trends indicate that as Singapore became relatively more skill abundant, manufacturing investment declined and services investment increased.

3b. Data Sources and Description

The dependent variable in the KK model should be a measure of bilateral stocks of foreign direct investment. Unfortunately, Singapore only sporadically compiled outbound and inbound FDI data before 1998 for many countries. Information from 1994-2003 is available on bilateral stocks of foreign equity investment, defined as the sum of direct equity investment and portfolio equity investment. Direct equity investment incorporates all investments made in ownership entailing a measure of management control, with a minimum ownership threshold of ten percent, while portfolio investment involves financial stakes unrelated to management control. Thus, the measure we analyze, FEI stocks, is somewhat broader than FDI. However, in Singapore portfolio investment is relatively small. Stocks of such investment amounted to no more than 9.5

percent of total FEI stocks from 1994 to 2003 and averaged less than 4.0 percent. Moreover, the correlation between FEI stocks and FDI stocks from 1994 through 2003 is 0.929. The sources of the FEI data are the *Statistical Yearbook of Singapore, Foreign Equity Investment in Singapore* and *Singapore's Investment Abroad,* published by the GOS's Department of Statistics. They are converted into millions of 1990 US dollars using contemporaneous exchange rates and the US GDP deflator.

Data on the right-hand side variables come from sources detailed in CMM (2001), updated through 2003. Real GDP is measured in billions of US dollars for each country. Annual real GDP figures in local currencies were converted into dollars using the market exchange rate. Both GDP and exchange rates are from the *International Financial Statistics* of the IMF. Skilled labor abundance is defined as the sum of occupational categories 0/1 (professional, technical, and kindred workers) and 2(administrative workers) in employment in each country divided by total employment. These figures are compiled from annual surveys in the *Yearbook of Labor Statistics* published by the International Labor Organization. In cases where some annual figures were missing, the skilled labor ratios were taken to equal the period averages for each country. Our skill difference variable is the relative skill endowment of the parent country less that of the host country.

The cost of investing in the affiliate country is a simple average of several indices of perceived impediments to investment, reported in the *World Competitiveness Report* (1984-1994) and *Global Competitiveness Report* (1995-2003) of the World Economic Forum. The investment barriers include restrictions on the ability to acquire control in a domestic corporation, limitations on the ability to employ foreign skilled labor, restraints on negotiating joint ventures, strict controls on hiring and firing practices, market

dominance by a small number of enterprises, an absence of fair administration of justice, difficulties in acquiring local bank credit, restrictions on access to local and foreign capital markets and inadequate protection of intellectual property. The resulting indices are computed on a scale of zero to 100, with a higher number indicating higher investment costs. The institutional barriers are defined as the frequency of bribery and corruption in the host country and are computed on a scale from zero to 100 with zero being the least corrupt and 100 being the most corrupt. Meanwhile, the infrastructure barriers refers to the quality of infrastructure in the host country and includes the quality of railroad, ports, air transport, waterways, roads, electric supply as well as telecoms and telephones. They are also computed on a scale of zero to 100 with zero being the most efficient and 100 being the least efficient. Finally, the trade cost index is taken from the same source and is defined as a measure of national protectionism, or efforts to prevent importation of competitive products. It also runs from zero to 100, with 100 being the highest trade costs. All of these indices are based on extensive surveys of MNE managers. Finally distance is the number of kilometers of each country's capital city from Singapore.

Sixteen countries are included in the manufacturing and services sample for the period 1994-2003.[4] Overall total outbound FEI stocks to developing countries were far higher than the reverse activity. In contrast, total inbound FEI stocks from industrialized countries were much higher than Singapore's outward FEI to those nations. It is important to note that there are a number of years early in the period where either inward or outward

[4] The countries included in the sample (1994-2003) are Australia, Canada, France, Germany, the Netherlands, Japan, Switzerland, Taiwan, UK, USA, Hong Kong, China, Indonesia, Malaysia, the Philippines, and Thailand.

investment stocks were reported to be zero, almost always with developing countries. Thus, our estimation procedure is Tobit.

3c. Endogeneity and Instrumental Variables

It is evident that causation may run both ways between skill differences, which is our primary determinant of interest, and foreign investment. For example, an increase in inbound FEI may raise the level of skills in Singapore due to professional training within MNEs. Moreover, flows of investment may be accompanied by skilled engineers and managers within the firm. Thus, the skill-differences variable is likely to be endogenous to investment in some degree. To address this issue we develop instruments that plausibly are correlated with skill differences but not correlated with the regression error term.

We incorporate two classes of instruments. First is the vector of legal marriage ages for males and females in the partner country, which we take from the UN *Demographic Yearbook* and the relevant statistical yearbooks of individual countries. The idea is that as the prevalence of skills rises, countries are likely to adopt higher minimum marriage ages in response to demographic pressures. For example, France increased its marriage age for women from 15 to 18 in 2000 and India increased it from 17 to 19 in 1996. Thus, for French investment in Singapore these instruments are the marriage ages of males and females in France, whereas for Singapore's investment in India it is the corresponding Indian ages. We note that there is considerable variation across countries in legal marriage ages but not much time variation within any country in our period.

A second class of instruments relates to labor-market conditions abroad. For regressions involving bilateral FEI stocks between Singapore and the industrialized economies we employ the contemporaneous unemployment rates in China and the Philippines. The idea is that changes in aggregate labor demand in those countries should be correlated with labor-market conditions, including occupational mix, in Singapore and the developed economies, but should be exogenous to decisions to change their bilateral FEI stocks. Similarly, for bilateral skill-ratio differences between Singapore and the developing economies our instrument is the average unemployment rate of OECD countries, which is available from an on-line OECD database. The citizens of these countries also have options to go to other countries such as the US, Australia or UK if unemployment rates remain high. But, countries such as the UK, US or Australia have quotas on foreign skilled labor while Singapore does not. Hence, it is appropriate to use unemployment rates in OECD countries, China and the Philippines as instrumental variables. The Chinese unemployment rate is available from the China *Statistical Yearbook* and the Philippines unemployment rate is available from the Philippines *Yearbook of Statistics*.

3d. Regional FDI Activities

One notable feature that helps explain the structure of foreign investment is that MNEs often establish an affiliate in Singapore and then use it as a base to invest in neighboring developing countries (Low, Ramstetter and Yeung, 1998). Outward investment by foreign-controlled firms was around 60 percent of total outward investment during 1995, declining to 40 percent by 1998[5]. It declined further to 35% by

[5] Department of Statistics, Government of Singapore.

2003 due to waves of mergers and consolidations in which Singapore based corporations purchased majority stakes in foreign firms operating in Singapore (Department of Statistics, 2003). To check the robustness of the results using Singapore GDP, we re-estimate the inbound equations for industrialized countries using ASEAN GDP to account for regional investment activities for both manufacturing and total investment. Specifically, the variables GDPSUM and the square of GDP differences would change to account for ASEAN GDP. For skill differences interacted with GDP differences, we would use ASEAN GDP interacted with skill differences between Singapore and its investment partners. Meanwhile all other variables remain the same as the basic specification. Here, the focus is only on inbound investment from industrialized countries.

Annual GDP figures for ASEAN[6] in local currencies were converted into US dollars using the market exchange rate. Both ASEAN GDP and exchange rates are from the *International Financial Statistics* of the IMF.

4. Results

First the basic framework is applied to the inbound and outbound FEI data for all sectors for manufacturing and services. Our instrumental-variables procedure is to run the first-stage regressions of relative skill differences on the instrumental variables discussed above for each sample and use the predicted values to estimate second-stage tobit regressions. With few exceptions, the Sargan test[7] indicated that the variables are

[6] Sum of the GDPs of Singapore, Malaysia, Indonesia, Thailand, the Philippines, Vietnam, Cambodia and Laos. Time series data for Myanmar and Brunei Darussalam were not available for all years and hence were excluded from the ASEAN GDP.

[7] A Sargan test for over-identifying restrictions is used to test for the validity of instruments. The instruments adopted are valid if the p value is greater than 0.1.

uncorrelated with the residuals and serve as appropriate instruments. The first-stage equations are available upon request.

4a. Basic Specification

The second-stage Tobit regression results for inward manufacturing FEI stocks in Singapore for the period 1994-2003 presented in Table 1 indicate that the effect of joint market size, measured by the sum of GDP, is positive and significant, and the coefficient on squared difference in real GDP is negative (though insignificant), the expected outcome under the KK model. However, the squared difference in real GDP for inward services investment in the third column is positive and significant, not as expected under the KK model. These findings suggest that while incoming manufacturing investments follow the inverted-U shape in size differences, services investments seem to rise with differences in GDP. It may be that larger parent countries, such as the United States and Japan, are more likely to invest disproportionately in the various service sectors as their GDP rises. Outbound manufacturing and services investment from Singapore rise with market size and falls with GDP size differences, as anticipated, although in the case of the latter, the squared GDP skilled differences are insignificant.

Host investment costs for inbound and outbound manufacturing are negative and significant at the five percent level and for outbound services at the one percent level, while host trade costs are positive and significant at the one percent level only for inbound services. Parent trade costs are also negative and significant at the one percent level for inbound services only. Meanwhile, institutional barriers are an impediment in all four equations while the infrastructure barriers are an impediment to only outbound investment for both manufacturing and services. This is not surprising as infrastructure,

especially public transport infrastructure in Singapore is highly developed even compared to many industrialized countries such as the United States and the index has not varied much from year to year. Finally, distance does not appear to have any impact on inbound stocks for either manufacturing or services but it significantly reduces outbound aggregate investment in both sectors.

Our main interest lies in the impact of relative skill endowments. The direct coefficients on relative skill differences are negative and significant at the one-percent level for only the services inbound sample but not for manufacturing. However, results for outbound regressions indicate that an increase in Singapore's skills compared to the countries in which it invests tends to significantly increase FEI stocks in both sectors. Thus, an increase in this variable would suggest a rising relative skill endowment in Singapore, which induces a rise in both manufacturing and services outbound FEI stocks. This finding supports the view that Singapore's investment abroad is concentrated in labor-intensive assembly manufacturing and low skill services industries.

As noted earlier, the total impact of skill differences depends also on the interaction coefficients. Thus, the change in FEI as a result of change in skill differences is derived as follows:

$$\partial FEI/\partial(SK_{it} - SK_{jt}) = \beta_3 + \beta_4 (GDP_{it} - GDP_{jt}) + 2*\beta_9 (TC_{it} * (SK_{it} - SK_{jt})) \quad (2)$$

The interaction between GDP differences and skill differences is negative and significant for inbound FEI for both manufacturing and services. It is negative and insignificant for outbound manufacturing FEI and positive and insignificant for outbound services FEI. A negative and significant coefficient in the case of inbound manufacturing and services FEI suggests that as Singapore increases in size relative to the host countries, it reduces

sensitivity of inbound investment stocks to skill differences for both manufacturing and services. Plugging in the means for the entire aggregate inbound sample in Table 1 into equation (2), we get the following results for inbound manufacturing:

$\partial FEI/\partial(SK_{it} - SK_{jt})$=-7867 -0.0003(1348640) + 2*(-46.19)(18.34*-0.07202) =

-US$ 8149.57 million

Plugging in the means for the entire aggregate inbound sample in Table 1 into equation (2), we get the following results for inbound services:

$\partial FEI/\partial(SK_{it} - SK_{jt})$=-14381 -0.0004(1348640) + 2*(103.49)(18.34*-0.07202) =

-US$ 15193.80 million

Over the 1994-2003 period, as host Singapore became skill abundant relative to all parent countries in our sample, average inbound manufacturing and services FEI stocks from these countries annually increased by US$ 8.15 billion and US$ 15.19 billion respectively. Singapore's increasing skill abundance relative to all parent countries in our sample accounted for 32% and 37% of average inbound manufacturing and services FEI stocks from these countries respectively. Note, finally, that the interaction terms between squared skill differences and trade costs are insignificant for all four equations.

Table 2 and 3 offer a different cut of the data by considering aggregate manufacturing and services inbound and outbound FEI stocks respectively broken down into investment with industrialized and developing countries. For manufacturing (Table 2), variations in joint market size are insignificant for FEI stocks to and from both developing and industrialized countries. The coefficient on squared differences in GDP is positive and significant only for investment from developing countries, but insignificant for others.

In the case of industrialized partners, the direct impact of skill differences on outbound FEI is negative and significant but insignificant for inbound stocks. In contrast, this coefficient is significantly positive for both inbound and outbound manufacturing investment with developing countries, indicating that this investment has a vertical orientation. As Singapore's skill endowments rose compared to those in neighboring developing economies, outbound manufacturing FEI stocks grew larger and vice versa. Meanwhile, as Singapore became relatively skill abundant, developing countries reduced their manufacturing investment in Singapore.

For services (Table 3), variations in joint market size are insignificant for FEI stocks from developing countries, while they are positive and significant in all other equations. The coefficient on squared differences in GDP is positive and significant for inbound investment from industrialized countries, but negative and significant for outbound FEI stocks. For inbound and outbound services investment from developing countries the coefficients are negative but insignificant.

The impact of skill differences on inbound and outbound FEI is negative and significant at the one percent level in the case of industrialized partners. However, for outbound investment into developing countries it is positive and significant. For inbound investment from developing countries, the coefficient is negative and significant at the five percent level. Thus, the results for inbound service sector stocks from developing countries are markedly different from those of manufacturing. Whereas for manufacturing the skill-difference variable is positive and significant at the one percent level, for the service sector it is negative and significant at the five percent level. Service sector skill scarcity in parent developing countries such as Malaysia, appear to increase

skill seeking investment in Singapore. However, it should be remembered that inbound services investment stocks from developing countries to Singapore are small and furthermore, the results should be interpreted with caution as the service sector samples for bilateral investment with both industrialized and developing countries are also very small.

Section 4(b). Re-specifying the GDP variable to account for ASEAN Market Size

As discussed earlier, MNEs also invest in Singapore to re-invest in neighboring developing countries. For instance, MNEs establish regional headquarters in Singapore and re-invest in neighboring countries such as Indonesia. Thus, inward investment into Singapore is also likely to take into consideration the entire market size of the ASEAN region. To account for the ASEAN market size, and to establish the robustness of the results using the Singapore market size discussed earlier, we recast the market size variable to include the regional FEI activities for both manufacturing and services. We re-estimate the industrialized country inbound equations separately by using the ASEAN GDP measures to account for regional FEI activities.

The results presented in Table 4 indicate that the effect of joint market size with ASEAN countries on inbound services FEI is positive and significant at the five percent level while it is insignificant for inbound manufacturing investment. The coefficients on squared difference in real GDP are insignificant in both equations.

The investment-cost in the host country and both parent and host trade-cost indexes are insignificant for both manufacturing and services. However, while barriers to investment and infrastructure impediments significantly reduce manufacturing investment from industrialized countries, they have no impact on services investment.

Finally, there is one major difference between the results for the sample with Singapore GDP presented in Tables 2 and 3 and the sample with ASEAN GDP presented in Table 4. Distance has a positive and significant impact on inward manufacturing FEI stocks when ASEAN GDP is used suggesting that distant countries such as the US and Canada invest more heavily in Singapore manufacturing than those that are nearer, most likely to have an easier access to markets in the ASEAN region by avoiding higher transport costs. However, distance had an insignificant impact on service sector FEI.

Relative skill differences are negative and significant at the one percent level for the service sector samples and but insignificant for the manufacturing sector samples. This suggests that while service sector investment is sensitive to changes in skill differences, manufacturing investment is not sensitive to such changes. This may be because Singapore is attracting both high end and low end manufacturing investment. While high end manufacturing investment stays on in Singapore, the low end investment passes through Singapore on its way to neighboring countries. During 2003 manufacturing accounted for about forty percent of all outbound investment (manufacturing plus services investment) by foreign MNEs with regional headquarters in Singapore, mostly to neighboring countries[8]. However, inbound services investment stocks from industrialized countries were nearly three times that of manufacturing investment. This suggests that a majority of the inbound services investment stays on in Singapore while majority of the manufacturing investment coming into Singapore is re-invested in neighboring countries. Finally, the interaction between ASEAN GDP differences and Singapore skill differences as well as the interaction between Singapore

[8] Singapore Department of Statistics, 2003

skill differences squared and trade costs for both manufacturing and services are insignificant

5. Implications and Concluding Remarks

Singapore's rapid growth in skill endowments supported a significant rise in horizontal outward FEI with the industrialized world for both manufacturing and services. However, while increase in skill endowments increased inbound services FEI from industrialized countries, the effect on inbound manufacturing FEI was insignificant. Second, over the period Singapore's skill share rose considerably in relation to those in neighboring developing countries. This tendency supported a clear vertical orientation in outward investment for both manufacturing and services, from Singapore to Asian developing economies, particularly in ASEAN, as regional headquarters operations in the former sought lower-wage labor for production in the latter. Based on the results using ASEAN market size, some of this trend could be ascribed to incoming investments from industrialized countries in skill-intensive regional headquarters services in Singapore, which in turn re-invest in ASEAN. Third, a rise in Singapore skills relative to developing countries decreases inward investment in manufacturing while it increases investment in services, indicating that as far as services are concerned, investment by parent developing countries such as Malaysia in Singapore, is essentially skill seeking. Finally, evidence using ASEAN GDP indicates that distance increases investment into Singapore from industrialized countries for both manufacturing and services. MNEs from industrialized countries further away from Singapore such as the USA appear to invest more in Singapore relative to countries nearer to Singapore such as Australia most likely to avoid higher transport costs.

These findings have important resonance for policy issues. As part of its economic development policy, the government of Singapore followed the "complementary strategy" of rapidly building its skills base while remaining open to investment from abroad. Our results indicate the policy has been successful as MNEs, particularly from the developed economies, increasingly invest in skill-intensive activities in Singapore services. Many international firms also use skill-abundant Singapore as a base from which to invest in neighboring ASEAN developing countries. However, for services, skill seeking investment from developing countries could also be a symptom of larger skilled shortages in those countries.

More fundamentally, to the extent that foreign direct investment contributes to economic transformations, Singapore's success in building its labor skills improved both its own growth prospects and the economic development of its developing-country investment partners, such as Malaysia, Thailand and Indonesia. Thus, from the point of view of both developing countries, particularly in ASEAN, and Singapore itself, the need for continued skills development in Singapore should be emphasized. However, our results also indicate that skills development and retention in the service sector should also be emphasized among Singapore's developing country investment partners.

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Table 1. Second-Stage Tobit Results for Singapore's Manufacturing Bilateral Inbound and Outbound Investment with Year Fixed Effects, 1994-2003

Regressors	**Manufacturing Inbound**	**Manufacturing Outbound**	**Services Inbound**	**Services Outbound**
GDP Sum	0.0003**	0.0003***	0.0014***	3.22e-07**
	(1.99)	(3.77)	(8.43)	(1.97)
GDP Diff. Squared	-6.68e-12	-1.28e-11**	6.95e-11***	-7.26e-12
	(-0.17)	(-1.97)	(3.98)	(-0.72)
Skill Diff.	-7867	8565***	-14381***	18168***
	(-1.08)	(3.03)	(-4.58)	(4.51)
GDP Diff.*Skill Diff.	-0.0003***	-0.0002	-0.0004***	0.0001
	(-3.99)	(-1.02)	(-3.40)	(1.21)
IC Host	-88.37**	-12.67**	-0.21	-39.47***
	(-2.07)	(-2.10)	(-0.00)	(-4.66)
INST Host	-466.26**	-15.46***	-1994.74***	-16.40***
	(-2.02)	(-3.25)	(-4.58)	(-2.73)
INFRA Host	2.96	-60.54***	13.68	-434.72***
	(0.14)	(-6.75)	(0.75)	(-6.85)
TC Host	31.28	-0.22	67.79***	-18.38
	(0.98)	(-0.05)	(3.48)	(-1.44)
TC Host*Squared Skill Diff.	-46.19	18.29	103.49	102.52
	(-0.17)	(0.28)	(0.88)	(1.02)
TC Parent	12.74	76.06	-29.56***	192.75
	(1.02)	(1.91)	(-2.98)	(1.76)
Distance	0.25	-0.22***	0.03	-0.10***
	(1.88)	(-7.86)	(0.45)	(-2.75)
Intercept	6419	449	10776***	-1537
	(1.75)	(0.44)	(3.89)	(-0.95)
Observations	160	160	160	160
Sargan P Value	0.10	0.12	0.12	0.11
Log Likelihood	-1376	-1122	-1350	-1185

Table 2. Second-Stage Tobit Results for Singapore's Manufacturing Investment with Industrialized and Developing Countries with Year Fixed Effects, 1994-2003

Regressors	Developing Countries Inbound	Developing Countries Outbound	Industrialized Countries Inbound	Industrialized Countries Outbound
GDP Sum	-0.0005 (-1.73)	-0.002 (-1.77)	-0.0004 (-0.85)	-0.00001 (-0.79)
GDP Diff. Squared	5.66e-10*** (4.44)	5.63e-09 (1.55)	8.24e-11 (1.11)	5.04e-13 (0.26)
Skill Diff.	2236*** (14.68)	5375** (2.11)	-19412 (-1.47)	-13731*** (-2.72)
GDP Diff.*Skill Diff.	-0.0001** (-1.96)	-0.0007 (-1.07)	-0.0002 (-1.09)	-0.0002*** (-2.81)
IC Host	-40.38*** (-15.20)	-8.38 (-0.94)	-108.34 (-0.97)	0.92 (0.52)
INST Host	-318.25*** (-12.45)	-12.41*** (-2.83)	-1014** (-2.02)	-7.59** (-2.22)
INFRA Host	0.00 (0.00)	-5.46 (-0.58)	-78.73 (-1.59)	-21.28*** (-2.75)
TC Host	2.92*** (3.16)	-20.28 (-1.42)	37.50 (1.07)	3.21*** (2.63)
TC Host*Squared Skill Diff.	68.37*** (4.24)	240.70 (1.49)	-2964 (-1.15)	141.43*** (3.57)
TC Parent	-0.07 (0.11)	-7.87 (-0.93)	42.13 (1.67)	-14.40** (-1.96)
Distance	-0.13*** (-13.34)	-0.50*** (-4.06)	-0.70*** (-3.05)	-0.03*** (-3.90)
Intercept	5152*** (14.57)	3836*** (5.04)	10734 (1.49)	1039*** (3.13)
Observations	50	50	100	110
Sargan P Value	0.09	0.07	0.08	0.11
Log Likelihood	-226	-348	-968	-583

Table 3. Second-Stage Tobit Results for Singapore's Services Investment with Industrialized and Developing Countries with Year Fixed Effects, 1994-2003

Regressors	Developing Countries Inbound	Developing Countries Outbound	Industrialized Countries Inbound	Industrialized Countries Outbound
GDP Sum	-0.0002 (-0.07)	3.02e-07** (2.13)	0.0024*** (6.11)	0.0003*** (3.19)
GDP Diff. Squared	-4.74e-09 (-1.84)	-4.75e-10 (-0.39)	7.00e-11*** (3.12)	-1.90e-11*** (-2.11)
Skill Diff.	-9259** (-1.96)	20825*** (6.04)	-14902*** (-2.57)	-15533*** (-5.33)
GDP Diff.*Skill Diff.	-0.0005** (-2.29)	0.005 (0.05)	-0.001** (-2.12)	0.0005 (1.33)
IC Host	-32.04** (-2.20)	-158.44*** (-4.12)	28.31 (0.33)	-23.22*** (-2.65)
INST Host	4.98 (0.71)	-1099*** (-4.57)	-973.16*** (-3.51)	-117.85*** (-6.28)
INFRA Host	-31.72** (-2.00)	-2600*** (-5.26)	-1.42 (-0.05)	-382.75*** (-6.59)
TC Host	-8.97 (-0.37)	31.95** (1.99)	52.23** (2.07)	32.14*** (4.38)
TC Host*Squared Skill Diff.	108.32 (0.39)	-14.20 (-0.06)	-2852.55** (-2.47)	-317.71 (-1.25)
TC Parent	16.07 (1.14)	2.05 (0.29)	8.28 (0.58)	-298.25*** (-4.29)
Distance	-0.75*** (-3.63)	-1.10*** (-7.22)	-0.14 (-1.19)	-0.43*** (-8.45)
Intercept	4574.68*** (3.44)	22317*** (4.21)	10806*** (2.95)	11162*** (5.97)
Observations	50	50	110	110
Sargan P Value	0.08	0.09	0.12	0.14
Log Likelihood	-374	-349	-943	-770

Table 4. Second-Stage Tobit Results for Singapore's Total and Manufacturing Inbound Investment Using ASEAN GDP with Year Fixed Effects,

Regressors	**Industrialized Countries Manufacturing Inbound 1994-2003**	**Industrialized Countries Services Inbound 1994-2003**
GDP Sum OECD	-0.0008 (-1.09)	0.0007** (2.43)
GDP Diff. Squared OECD	-5.00e-11 (-1.09)	-3.83e-10 (-0.31)
Skill Diff.	-13817 (-1.42)	-14304*** (-2.55)
GDP Diff. OECD*Skill Diff.	-0.0016 (-1.30)	-0.0001 (-0.11)
IC Host	12.66 (0.61)	-167.55 (-1.74)
INST Host	-1177*** (-4.14)	-825.04 (-1.63)
INFRA Host	-27.85** (-2.05)	28.98 (0.65)
TC Host	43.85 (1.67)	7.14 (0.21)
TC Host*Squared Skill Diff.	-547.42 (-0.76)	-1868.14 (-1.54)
TC Parent	10.81 (0.32)	32.76 (1.18)
Distance	0.18*** (2.54)	-0.37 (-0.97)
Intercept	13021*** (3.69)	13936** (2.00)
Observations	110	110
Sargan P Value	0.09	0.08
Log Likelihood	-864	-946

Figure 1. Singapore Manufacturing Foreign Equity Investment Stocks by Sources and Destination, 2003 (Million 1990 US $)

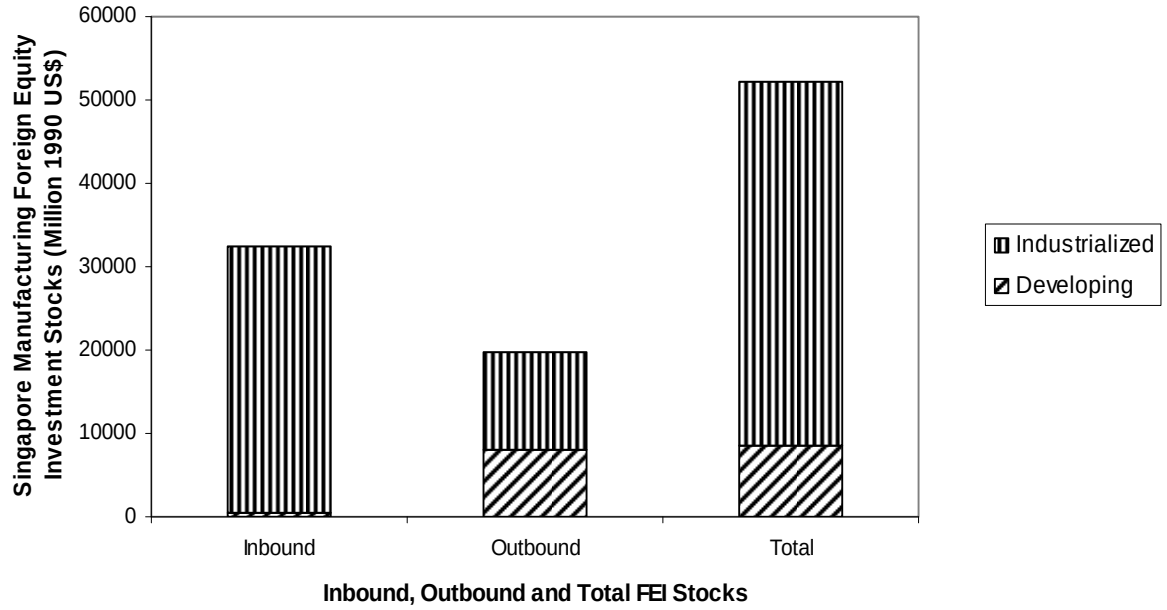


Figure 2. Singapore Services Foreign Equity Investment Stocks by Sources and Destination, 2003 (Millions of 1990 US$)

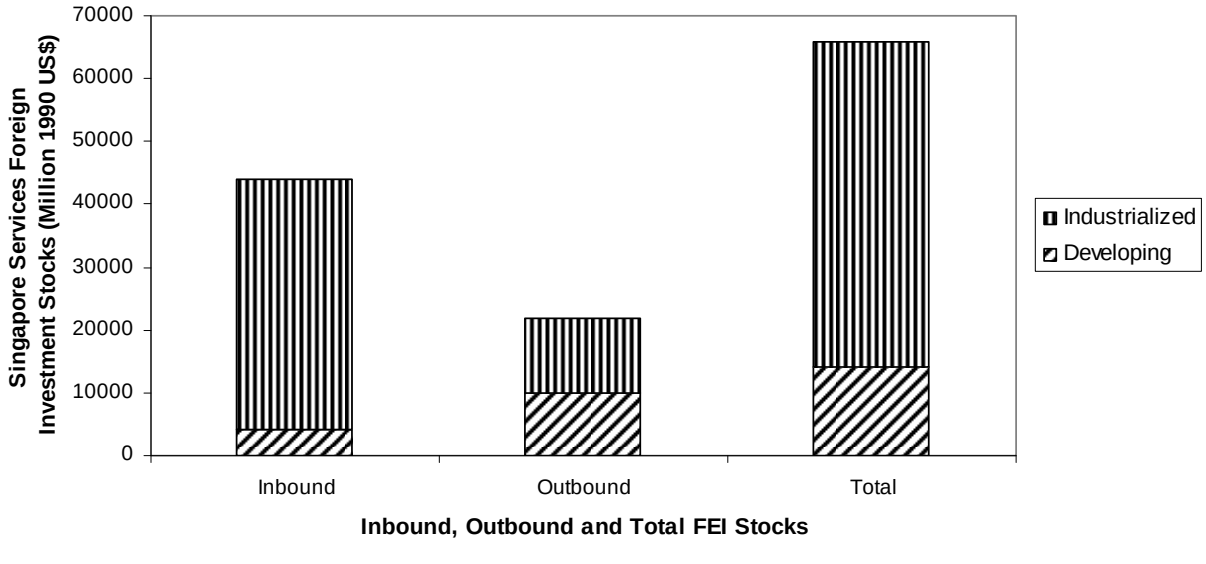
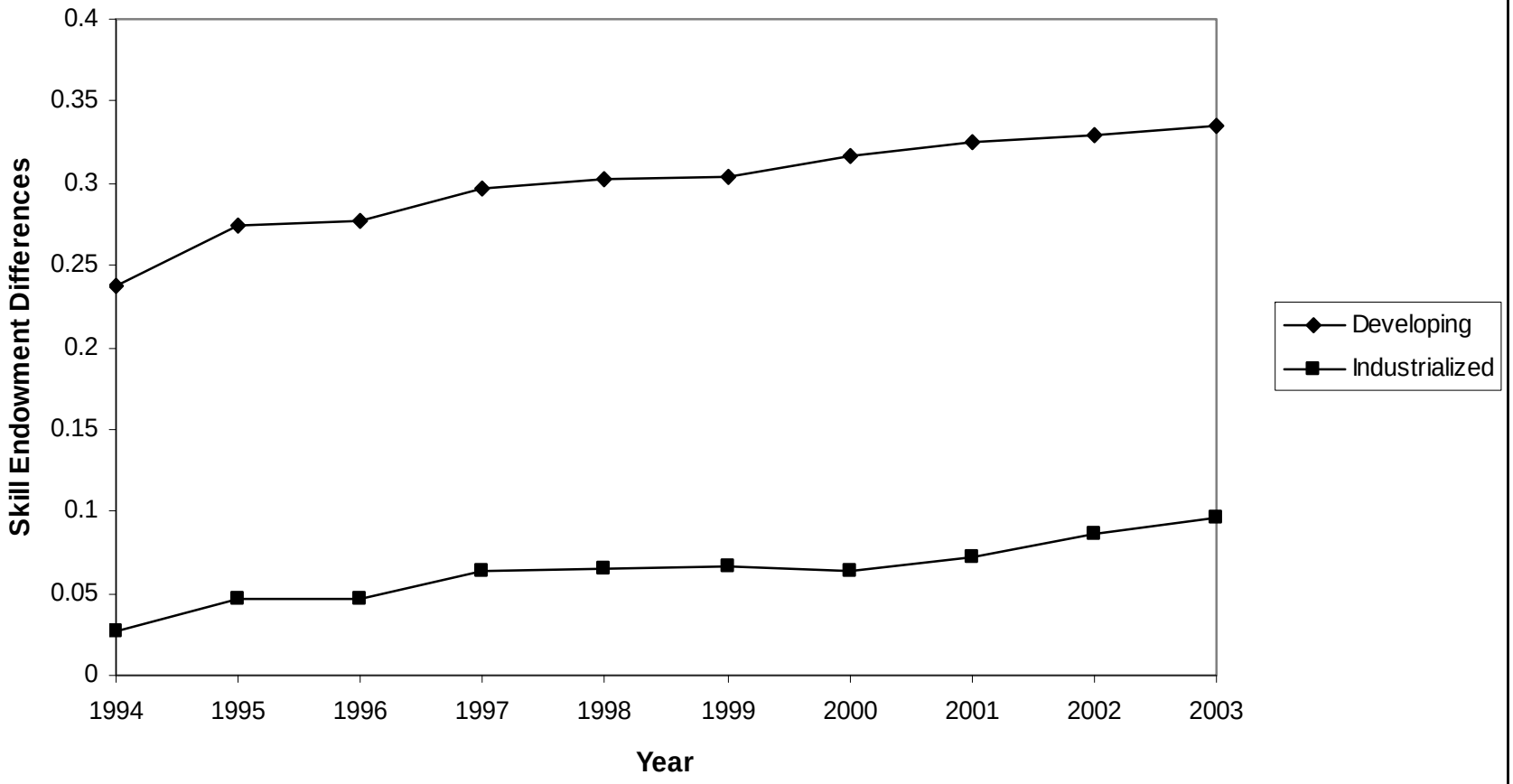


Figure 3. Differences in Singapore Skill Endowments and the Average Skill Endowments of Industrialized and Developing Countries, 1994-2003



Skill differences = (Singapore Skill Labor/Labor Force)-(Partner Skill Labor/Partner Labor Force)

Figure 4. Trends in Singapore Inbound Manufacturing and Services FEI Stocks from Selected Industrialized Countries, 1994-2003 (Million 1990 US$)

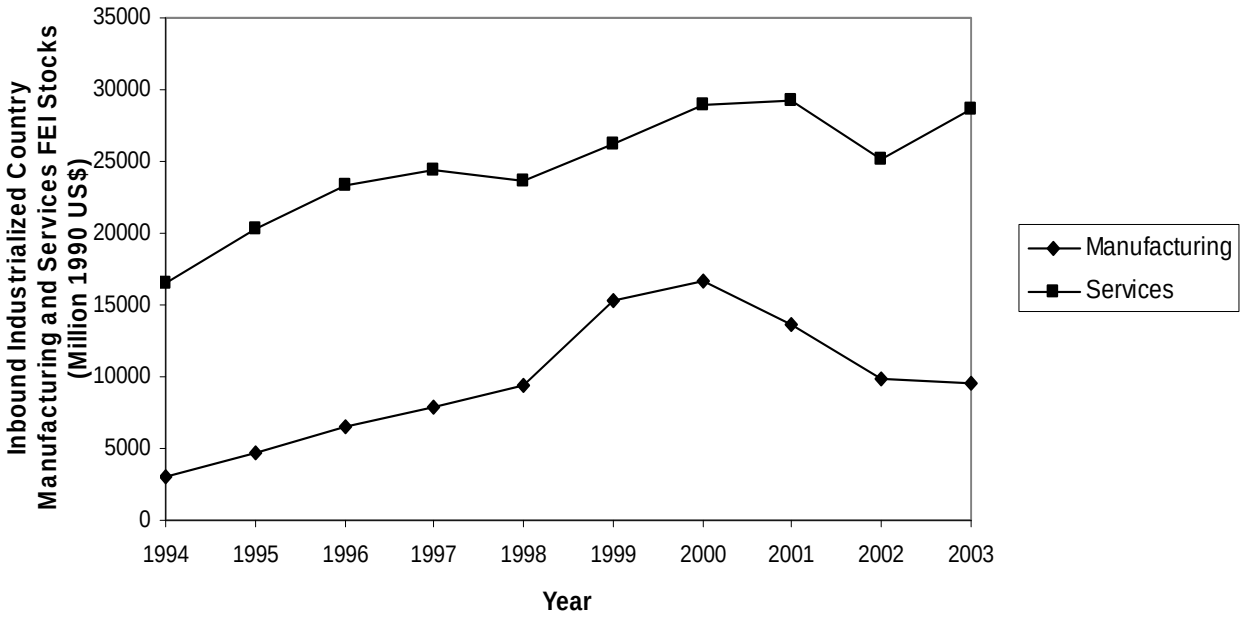
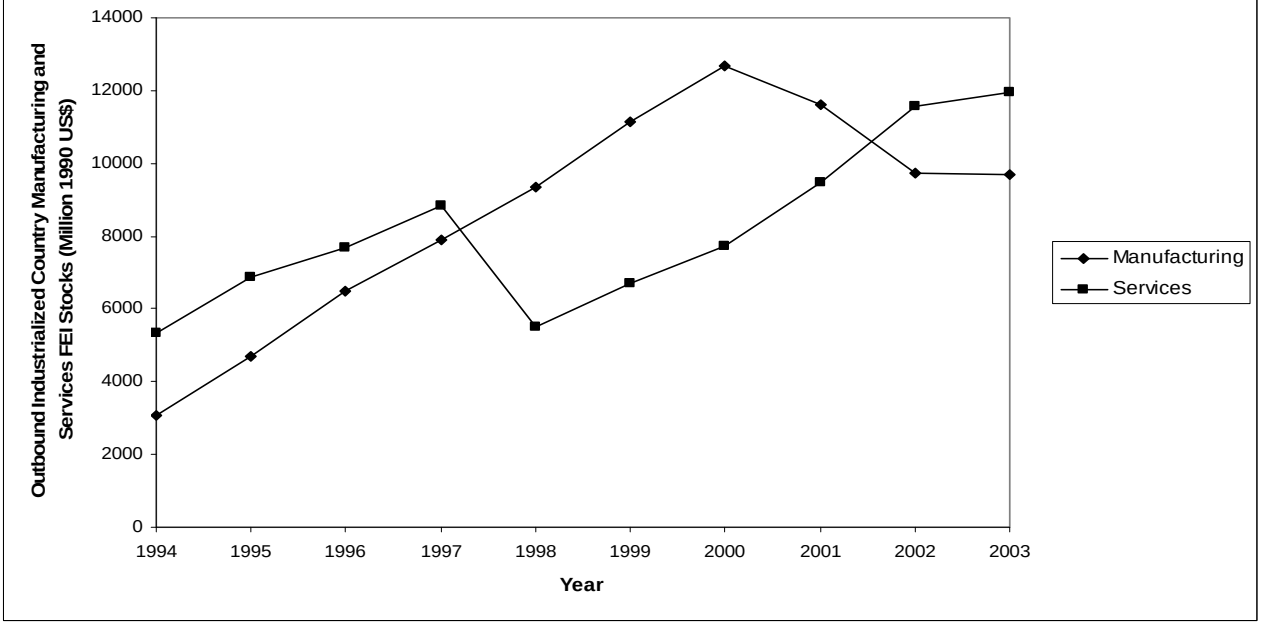


Figure 5. Trends in Singapore Outbound Manufacturing and Services FEI Stocks to Selected Industrialized Countries, 1994-2003 (Million 1990 US$)



FEI is the total manufacturing and total services FEI from and to all industrialized countries in our sample

Figure 6. Trends in Singapore Inbound Manufacturing and Services FEI Stocks from Developing Countries, 1994-2003 (Million 1990 US$)

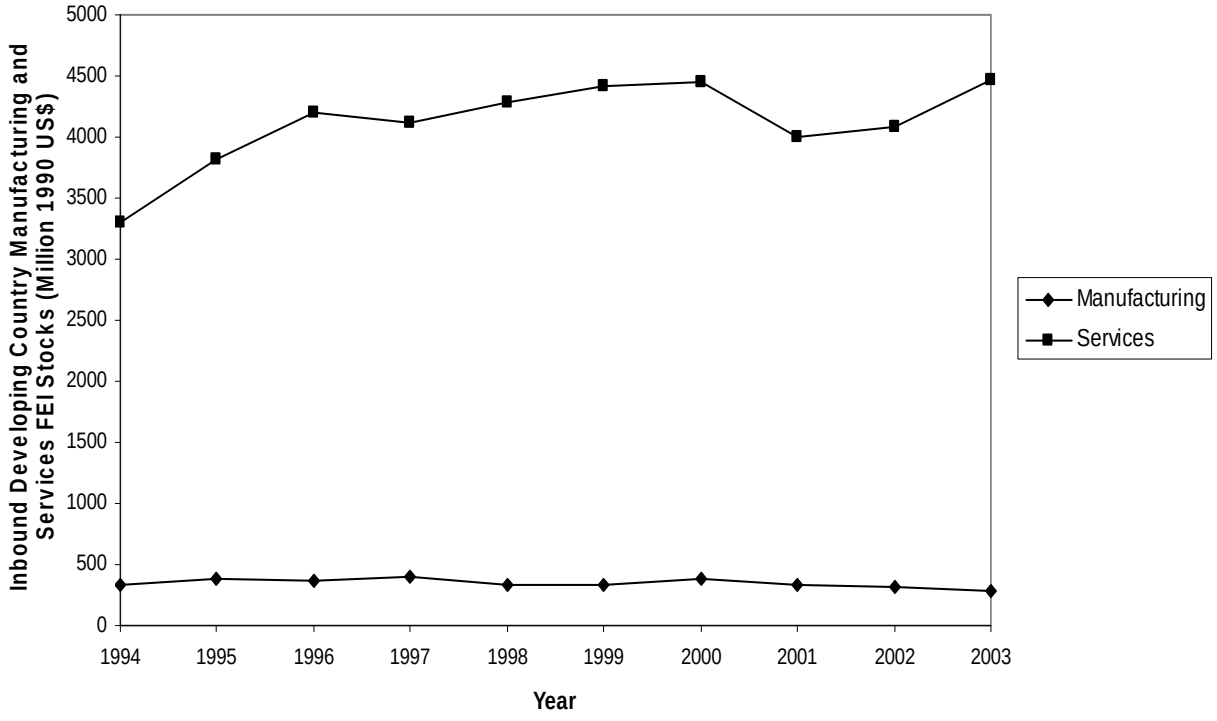


Figure 7. Trends in Outbound Manufacturing and Services FEI Stocks to Developing Countries, 1994-2003 (Million 1990 US$)