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# *The role of foreign capital in domestic manufacturing productivity: empirical evidence from Asian economies*

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The paper empirically examines the relative contribution of foreign and domestic machinery and equipment on manufacturing productivity in seven Asian economies. A Cobb–Douglas production function is used to test whether foreign machinery is more productive than domestic machinery. The study is based on a pooled cross-sectional time-series model, including seven countries – Hong Kong, Singapore, South Korea, Malaysia, Indonesia, the Philippines and India – for the years 1975 to 1990. The results support the hypothesis that a country's stage of development, skill-level of its labour force, and the technology embodied in capital play a crucial role in determining the relative impact of foreign and domestic capital on manufacturing productivity.

## I. BACKGROUND

The impact of foreign investment on the economic growth of developing countries is usually considered to be positive. the benefits associated with foreign investment have driven developing economies to implement extensive liberalization policies that encourage inflows of foreign machinery and equipment. The extent to which sophisticated foreign equipment impacts productivity and economic growth, however, depends on its effective utilization. Labourers in developing economies tend to be less skilled and technically adept than workers in more developed countries. The effective implementation of foreign machinery in the production process of developing countries is dependent on the skill-level and productive capabilities of domestic labourers in these countries.

Technology embodied in machinery also determines how productive physical capital is in developing economies. Technology embodied in machinery acts as 'the lever of riches' (Mokyr, 1990). Developing economies, usually labour-abundant and capital-scarce, have low levels of capital accumulation, which are subject to rapidly diminishing returns. Foreign capital, imported from developed countries, provide developing economies with additional capital resources. Whether technology embodied in foreign capital is 'appropriate' or 'inappropriate' for the production techniques and resource availability in developing economies is crucial to the impact of foreign machinery on domestic productivity.

Past studies have analysed the relative impact of foreign and domestic capital on domestic manufacturing productivity using various production functions. Green and Levine (1976), Weitzman (1979), Toda (1979), and Brada and Hoffman (1985) all estimated the contribution of imported Western machinery and domestic machinery to the growth of the Soviet Union from 1960 to 1980. Green and Levine, and Weitzman used a Cobb–Douglas production function framework, Toda used a combined Cobb–Douglas/CES production function, while Brada and Hoffman used a translog production function Karake (1990) estimated the impact of foreign and domestic capital on Egypt's economic growth, from 1952 to 1985. Karake used a linear production function with inputs of Western imported capital, East-European imported capital, and domestic capital. Terrell (1992) estimated the productivity of Western and domestic capital in eight Polish industries from 1961 to 1983, using a translog production function.

This paper uses a Cobb–Douglas production function to examine empirically the relative output elasticity with respect to foreign and domestic capital. It uses a pooled cross-sectional time-series model which includes seven Asian countries – Hong Kong, Singapore, South Korea, Malaysia, Indonesia, the Philippines and India – over a period of 16 years (1975 to 1990).

## II. THE PHENOMENON OF CONSTANT RETURNS TO SCALE

The base model estimated in this study uses the microeconomic concept of a simple neoclassical production function with two inputs, labour and capital. The model has the following assumptions. The production function is differentiable. Capital is heterogeneous and is disaggregated into domestic capital and foreign capital, which are treated as separate inputs with different qualitative characteristics. Investment in foreign and domestic capital, rather than the stock of foreign and domestic capital is used to represent the two types of capital – due to non-availability of reliable data on stock of foreign and domestic capital for the sample countries. For this reason, the production function can be regarded as a 'pseudo' production function.

$Y_{it} = A_{it} f(KD_{it}, KF_{it}, L_{it})$ represents the production function of the manufacturing sector[1] incorporating the effect of technology, where output, $Y$, is determined by three inputs – domestic capital investment ($KD_{it}$), foreign capital investment ($KF_{it}$), and labour ($L_{it}$). $A_{it}$ is a constant, representing technological progress or total factor productivity (TFP). Expressing the above production function in a log form yields the equation

$$\ln Y_{it} = \sum_{i=1}^{7} \gamma_i d_i + \alpha_1 \ln KD_{it} + \alpha_2 \ln KF_{it} + \beta \ln L_{it} + \varepsilon_{it} \tag{1}$$

where the coefficients $\alpha_1$, $\alpha_2$, and $\beta$ are the output elasticities of the factor inputs of domestic capital investment ($KD$), foreign capital investment ($KF$), and labour ($L$), respectively. Each of the coefficients, $\alpha_1$, $\alpha_2$, and $\beta$ measures the percentage change in output for a given percentage change in $KD$, $KF$, and $L$, respectively. Because the level of TFP is expected to vary across the sample countries, country specific dummies, $d_i$, have been incorporated into the estimated model. The subscript $i = 1, 2, \ldots, N$ represents each of the countries (in our case $N = 7$), and the subscript $t = 1, 2, \ldots, T$ represents each of the time periods (in our case $T = 16$ – covering years 1975 to 1990).

Owing to statistical problems of multicollinearity between labour and capital input, the ratio form of the Cobb-Douglas production function can be used (Gujarati, 1988), which assumes a constant returns to scale (CRS) framework. The results confirm the presence of CRS and allow the estimation of the ratio form of the Cobb–Douglas production.[2] After incorporating the assumption of CRS ($\alpha_1 + \alpha_2 + \beta = 1$) into Equation 1, Equation 2 can be obtained, where $Y/L$ represents the output–labour ratio or average productivity of labour, $KD/L$ represents the domestic capital investment–labour ratio, and $KF/L$ represents the foreign capital investment–labour ratio.

$$\ln\left(\frac{Y}{L}\right)_{it} = \sum_{i=1}^{7} \gamma_i d_i + \alpha_1 \ln\left(\frac{KD}{L}\right)_{it} + \alpha_2 \ln\left(\frac{KF}{L}\right)_{it} + \varepsilon_{it} \tag{2}$$

The data set is longitudinal in nature, indicating a combination of both time-series and cross-sectional data. Therefore, the presence of both autocorrelation and heteroscedasticity could falsely inflate the statistical significance of the estimated regression coefficients. Using *Shazam*, the models are estimated under the POOL command, which corrects for both heteroscedasticity and autocorrelation, and is also referred to as a *cross-sectionally*

[1] The 27 industries included in the manufacturing sector are: Food products, Beverages, Tobacco, Textiles, Wearing apparel (except footwear), Leather and fur products, Footwear (except rubber or plastic), Wood products (except furniture), Furniture and fixtures (excluding metal), Paper and paper products, Printing and publishing, Industrial chemicals, Other chemicals, Petroleum refineries, Rubber products, Plastic products, Pottery (including china and earthenware), Glass and glass products, Other non-metallic mineral products, Iron and Steel, Non-ferrous metals, Fabricated metal products, Non-electrical machinery, Electrical machinery, Transport equipment, Professional and scientific equipment, and Other manufacturing industries.

[2] To determine whether the assumption of CRS does in fact hold, the following null and alternate hypotheses are tested using a pooled $t$-test.

$H_O$: $\alpha_1 + \alpha_2 + \beta = 1$

$H_A$: $\alpha_1 + \alpha_2 + \beta \neq 1$

At the 1% level of significance and with 102 degrees of freedom, the critical $t$-value is $t_c = 2.617$.
The observed $t$-value is calculated as

$$t_o = \frac{(\hat{\alpha}_1 + \hat{\alpha}_2 + \hat{\beta}) - 1}{SE(\hat{\alpha}_1 + \hat{\alpha}_2 + \hat{\beta})}$$

where $SE(\cdot) =$ square root of [Var ($\alpha_1$) + Var ($\alpha_2$) + Var ($\beta$) + 2 Cov ($\alpha_1, \alpha_2$) + 2 Cov ($\alpha_1, \beta$) + 2 Cov ($\alpha_2, \beta$)], and results in an observed $t$-value of $t_o = 0.5807$

Since $0.5807 < 2.617$, $t_0 < t_c$, and the null hypothesis of CRS is accepted. Estimated results of Equations 1 and 2 are not reported in the paper but can be obtained upon request.

*heteroscedastic and time-wise autoregressive model* (Kmenta, 1986).[3]

## III. THE EMPIRICAL MODEL AND RESULTS

To incorporate differences in the stage of development among the seven countries, the sample countries are divided indeed into two groups. Group 1 consists of Hong Kong, Singapore and South Korea, three of the 'Four Asian Tigers', which represent the higher-income developing countries. Indonesia and Malaysia, two of the newly industrializing Asian economies (NIAEs), are grouped with India and the Philippines to represent the lower-income developing countries, in Group 2. So Equation 2 is modified by including only Group 1 and Group 2 dummies (i.e. $d_1$ and $d_2$) resulting in the final empirical specification used in this paper (see Table 1 for the regression results):

$$\ln\left(\frac{Y}{L}\right)_{it} = \gamma_1 d_1 + \gamma_2 d_2 + \alpha_1\left[d_1 * \ln\left(\frac{KD}{L}\right)_{it}\right] + \alpha_2\left[d_1 * \ln\left(\frac{KF}{L}\right)_{it}\right] + \beta_1\left[d_2 * \ln\left(\frac{KD}{L}\right)_{it}\right] + \beta_2\left[d_2 * \ln\left(\frac{KF}{L}\right)_{it}\right] + \varepsilon_{it} \quad (3)$$

The three countries in Group 1 – Hong Kong, Singapore and South Korea – have a higher level of development than the countries in Group 2 – Indonesia, Malaysia, the Philippines and India. Although a country's stage of development is determined by several economic, social, and political factors, this classification has been made on the basis of the level of per capita income and human development in the sample countries. The relative abundance of attributes such as labour skills and technical knowledge is highly correlated with the level of per capita income (Dodaro, 1991). Also, the human development index (HDI) of a country is an indicator of the level and quality of education, skills, and technological efficiency of a country's labour force.[4] It is for these reasons that the per capita income level and HDI of a country reflect the relative abundance of productive attributes in a country and consequently the extent to which a country's labour force can efficiently utilize both foreign and domestic capital.[5]

Table 1. *Pooled regression results for Equation 3 (dependent variable:* $\ln(Y/L)$*)*

| Variable | Coefficient | Estimate | $t$-ratio | $p$-value |
|---|---|---|---|---|
| $d_1$ | $\gamma_1$ | −0.6653* | −3.649 | 0.000 |
| $d_2$ | $\gamma_2$ | −1.1461* | −2.890 | 0.005 |
| $d_1 * \ln\left(\frac{KD}{L}\right)$ | $\alpha_1$ | 0.1939* | 3.426 | 0.001 |
| $d_1 * \ln\left(\frac{KF}{L}\right)$ | $\alpha_2$ | 0.4196* | 14.15 | 0.000 |
| $d_2 * \ln\left(\frac{KD}{L}\right)$ | $\beta_1$ | 0.3850* | 5.215 | 0.000 |
| $d_2 * \ln\left(\frac{KF}{L}\right)$ | $\beta_2$ | 0.1867* | 3.487 | 0.001 |
| Buse $R^2$ | | 0.9245 | DF = 106 | |

* Significant at the 1% level

[3]This technique subjects the observations to two transformations, one to remove heteroscedasticity, and the other to remove autocorrelation. The technique comes up with a disturbance term ($\varepsilon_{it}$), that is both asymptotically non-autoregressive and homoscedastic. First, OLS is used to obtain the regression residuals, which are then used to perform transformations to obtain an asymptotically nonautoregressive and homoscedastic error term (for details see Kmenta, 1986, pp. 618–22). The characteristics of this model are as follows:

$E(\varepsilon_{it}^2) = \sigma_i^2$(heteroscedasticity)

$E(\varepsilon_{it}, \varepsilon_{jt}) = 0$ (where $i \neq j$ denotes cross-sectional independence – no autocorrelation across countries in a given time period)

where

$\varepsilon_{it} = \rho\varepsilon_{i,t-1} + u_{it}$ (where autocorrelation is concerned, $\rho$ is assumed to be constant across the cross-sectional units, and $u_{it}$ is the classical error term)

$u_{it} \sim N(0, \sigma_{ui}^2)$

$\varepsilon_{it} \sim N(0, [\sigma_{ui}^2/1 - \rho^2])$

and

$E(\varepsilon_{i,t-1}, u_{jt}) = 0$ for all $i, j$

[4]The human development index (HDI) is calculated on the basis of various socio-economic factors. A country's HDI reflects the overall well-being of a country's population, and the opportunities and choices they enjoy.

[5]Hong Kong ($9896), Singapore ($9877), and South Korea ($4132) have high levels of per capita income. Malaysia ($2335), the Philippines ($636), Indonesia ($517), and India ($377) have lower levels of per capita income. On the basis of the level of human development, Hong Kong (0.914), Singapore (0.9), and South Korea (0.89) have high HDIs. On the other hand, the Philippines (0.672), Indonesia (0.668), and India (0.446) have lower HDIs. Malaysia's HDI (0.832), is closer to those of the three Asian Tigers represented in the sample. For details please refer to *Human Development Report* (1997). Nevertheless, Malaysia has been grouped with the lower-income countries of the samples since it shares regional and other socio-economic characteristics with these countries.

Table 2. *TFP in the two country groups*

| Country group | Dummy coefficient $\gamma_i$ | Anti-log of (dummy coefficient) |
|---|---|---|
| Group 1 | $-0.66535$ | 0.514 |
| Group 2 | $-1.1461$ | 0.318 |

The Table 1 results indicate that the level of TFP (captured by the anti-log of the coefficients of dummy variables) in the countries that constitute Group 1 is higher than that in the countries included in Group 2. Table 2 reports the differential levels of TFP in the two country groups.

As expected, the TFP value in the higher-income country group is greater than the TFP value in the lower-income country group. These results indicate that a higher stage of development is associated with a higher TFP value. In other words, the contribution of management, organization, and technological progress to average manufacturing productivity is higher in those countries characterized by a higher stage of development.

The result reported in Table 1 indicate that the output elasticity with respect to foreign capital investment is higher than the output elasticity with respect to domestic capital investment of the countries in Group 1 (Hong Kong, Singapore and South Korea). The value of $\alpha_2$ is higher than the value of $\alpha_1$. In contrast, the output elasticity with respect to foreign capital investment is less than the output elasticity with respect to domestic capital investment for the countries in Group 2 (India, Indonesia, Malaysia and the Philippines). The value of $\beta_1$ is greater than the value of $\beta_2$.

To determine whether there is a statistically significant difference between the coefficients of the domestic capital investment–labour ratio and foreign capital investment–labour ratio, the following null and alternate hypotheses are tested:[6]

$$H_O{:}\alpha_1 - \alpha_2 = 0 \quad \text{and} \quad H_O{:}\beta_1 - \beta_2 = 0$$

$$H_A{:}\alpha_1 - \alpha_2 \neq 0 \qquad\qquad H_A{:}\beta_1 - \beta_2 \neq 0$$

The results also show that the difference between the elasticities of average manufacturing productivity with respect to foreign and domestic capital investment is statistically significant at the 1% level for Group 1 and at the 10% level for Group 2. Thus, the values of $\alpha_1$ and $\alpha_2$ are statistically different at the 1% level and the values of $\beta_1$ and $\beta_2$ are statistically different at the 10% level.

The Table 1 results also indicate that the stage of development of a country significantly impacts its output elasticities with respect to foreign and domestic capital investment. It appears that attributes such as skills and technical knowledge are abundant in Hong Kong, Singapore and South Korea. Consequently, these attributes allow the labour force in these countries to utilize technologically superior foreign machinery and equipment more efficiently and productively. On the other hand, the level and quality of skills and technical knowledge appear to be low in the countries that constitute Group 2 (Malaysia, Indonesia, the Philippines, and India). This results in a relatively more efficient utilization of domestic machinery and equipment rather than of foreign machinery and equipment by the labour force in these countries.

The stage of development classification incorporated in the model suggests that a certain degree of development and domestic productive efficiency needs to be achieved before the potential advantages and benefits of foreign capital can be fully realized. The importance of a qualitatively superior labour force indicates that the focus of economic policy-making in developing countries should be a high investment in its people. Without such investment in human capital, the benefits of liberalization policies that promote foreign direct investment and bring in superior foreign capital to developing countries cannot be fully maximized. The results of the model suggest that the pace of investment in human capital in developing countries needs to keep up with their inflows of foreign capital. This conclusion supports the contention that a certain degree of economic development and internal productive efficiency is necessary before developing countries can fully and effectively absorb the potential benefits of the utilization of technologically superior foreign machinery and equipment.

The above results also suggest that the technology embodied in foreign machinery and equipment might be inappropriate for the production techniques that characterize the Group 2 countries. Foreign capital might be more effective in capital-intensive production techniques (Marsden,

[6] A pooled $t$-test similar to footnote 2 can be employed. With 106 degrees of freedom and at the 1% and 10% levels of significance, respectively, the critical $t$-values are

$t_c = 2.617$ and $t_c = 1.658$

The observed $t$ values are calculated as

$$t_o = \frac{(\hat{\alpha}_1 - \hat{\alpha}_2)}{SE(\hat{\alpha}_1 - \hat{\alpha}_2)} \text{ and } t_o = \frac{(\hat{\beta}_1 - \hat{\beta}_2)}{SE(\hat{\beta}_1 - \hat{\beta}_2)}$$

which results in observed $t$-values as

$t_o = 2.731$ and $t_o = -1.834$

Since $2.731 > 2.617$, $t_o > t_c$, and the first null hypothesis ($H_O{:}\alpha_1 - \alpha_2 = 0$) is rejected at the 1% level. Since $1.834 > 1.658$, $t_o > t_c$, and the second null hypothesis ($H_O{:}\beta_1 - \beta_2$) is rejected at the 10% level.

1970). Lower-income developing countries (such as those included in Group 2) are mostly labour-abundant and capital-scarce. For this reason, labour-intensive production technique are better suited to and characterize production activities in these countries. Foreign capital might require fewer rather than more labourers to utilize it most efficiently and productively. An excess number of labourers using foreign machinery might lower its beneficial impact on average productivity.

Foreign machinery and equipment might also be inappropriate for domestic production conditions in the Group 2 countries. Superior foreign equipment might be better suited for large-scale production. Conditions in lower-income developing countries – inefficient management and organization, lack of factory discipline, inadequate infrastructure, small and scattered markets, inefficient distribution channels – might not be suited for large-scale production (Marsden, 1970). Therefore, foreign capital might be under-utilized and not achieve its maximum potential. Also, service engineers and highly skilled technicians, who are familiar with foreign capital, are needed to repair and maintain sophisticated and complicated foreign machinery. The scarcity of service engineers in several developing countries results in a waste of foreign machinery.

The level and quality of human capital, investment in education and technical training programmes, and the level of workers' skills and technical knowledge are higher in countries characterized by a higher stage of development. For this reason, foreign capital appears to embody more appropriate technology in the Group 1 countries and technology that is inappropriate in the Group 2 countries. This conclusion raises interesting policy questions. Should governments of lower-income developing countries (such as those in Group 2) restrict inflows of foreign capital? Should these governments increase the pace of liberalization of foreign capital investment and FDI in these countries? Should investment in human capital or foreign capital be emphasized? The answers to these questions are not easy. The results of the model show that, while domestic capital investment appears to contribute more to average productivity than does foreign capital investment in Group 2 countries, foreign capital investment does contribute to average productivity. Also the scarcity of financial and other resources in lower-income developing countries makes it difficult for the governments of lower-income countries to invest heavily in human capital.

## IV. CONCLUSIONS

Two conclusions might be drawn from the empirical evidence presented in this paper. The first is that investment in human capital is crucial for economic growth in developing countries. A higher level of development is associated with a more educated and technically-trained labour force. This observation suggests that investment in human capital does play a significant role in determining manufacturing productivity.

The second conclusion deals with a more complex issue: how appropriate the technology embodied in foreign capital is for domestic manufacturing conditions and techniques in lower-income developing countries. More important, however, is whether liberalization policies encouraging foreign capital imports should be continued or restricted, given that inappropriate technology could be embodied in foreign capital. The pace of the implementation of external liberalization policies is an important issue for lower-income developing countries. The empirical results of this paper indicate that perhaps investment in human capital needs to precede liberalization policies that encourage foreign direct investment and foreign capital imports.

In drawing policy conclusions from this empirical analysis, it must be kept in mind that the benefits associated with foreign capital imports in developing countries go far beyond the impact of foreign capital investment on productivity growth. The role of superior foreign machinery and equipment on indigenous inputs in developing countries is worth considering. The duplication and imitation of equipment and techniques imported from developed countries account for much of the technological progress evident in developing economies (Brada and Hoffman, 1985). Such imitative activities raise manufacturing productivity in the long run. Through imports of foreign machinery and equipment, more advanced and superior technology is transferred from developed to developing economies. This transfer of technology breaks technological bottlenecks in developing economies and raises the productivity of domestic inputs.

The benefits of foreign direct investment include a transfer of knowledge, skills, and technical abilities from managers to domestic workers. Through their interaction with technically knowledgeable and well-organized management, domestic labourers learn new and modern skills. In a competitive environment, these skills and technical knowledge gradually spill over to the rest of the domestic economy. Such interaction facilitates improved conditions and techniques of production. Domestic workers gain technical knowledge and greater efficiency that improves their ability to utilize better not only foreign equipment but indigenous inputs as well. Better management and organization also increase TFP, which is considered to be the most sustainable source of economic growth in the long run.

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## APPENDIX: DATA SOURCES

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