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Productivity Spillovers and Economic Growth
-- Was East Asia Unique? --

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Abstract

Recent empirical studies on international R&D spillovers have shown that technology diffusion across countries raises productivity and, hence, boosts economic growth. However, these studies do not explain how technological knowledge accumulated in the tradable sector can be transferred to the rest of the economy. This paper answers this question by focusing on the aspect of externalities between the tradable and non-tradable sectors. The second purpose of this paper is to test for the statistical similarity of East Asian countries. In so doing, we modify the multi-sector framework and estimate the reduced forms using pooled data comprised of 51 countries over 24 years. Empirical results clearly show that some Asian countries can be regarded as one group in terms of the magnitude of the productivity spillover effect. We find statistical differences in the estimated parameters between East Asian countries, developed countries, and developing countries, with the East Asian countries showing the highest spillover effects.

Keywords: Multi-sector model; Spillover; Growth; East Asia; Externality

JEL Classification: F43, O41, O53, O57

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1 Introduction

International transactions across borders affect economic growth mainly through three channels of technology transfer: productivity increase by capital or intermediate goods imports, learning by exporting, and foreign direct investment activities. These three channels are important especially for technology diffusion. This technology diffusion increases productivity and boosts economic growth.

Coe and Helpman (1995) initiated the argument on international R&D spillovers. They confirmed that there exist international R&D spillovers between developed countries. Although their estimation framework was based on the theories by Grossman and Helpman (1991), their estimated equation assumed that total imports play a crucial role of transmitting R&D spillovers. Coe, Helpman and Hoffmeister (1997), Xu and Wang (1999) and Eaton and Kotum (2001), instead, considered capital imports as carriers of knowledge capital. Coe, Helpman and Hoffmeister (1997) estimated North-South knowledge spillovers controlling for the effects of capital imports. Xu and Wang (1999) discussed the effects of capital imports on North-North international knowledge spillovers more directly.

On the other hand, Keller (2000, 2002a, 2002b) focused on the role of intermediate goods imports as carriers of knowledge capital. Keller's estimations were based on the theory of "love of variety" of intermediate goods and he used industry level data. He captures more precisely the mechanism of knowledge spillovers than previous "nation-wide" estimations.

However, these papers focused on the spillover mechanism between countries but not between industries. Only Keller (2002) implicitly controlled for the effects of knowledge spillovers between industries. In every economy, there are tradable and non-tradable sectors. Especially for developing countries, the share of non-tradable sectors is relatively high. In the process of economic growth, positive effects from growing sectors to the rest are important. These effects have been called "positive externalities" or "learning spillovers".

In the last two decades, the trade and growth literatures have identified several channels of externalities through international trade. Among these, the multi-sector models of trade and growth via external effects first developed by Feder (1982) has been most widely used to identify factors of economic growth. However, except for Esfahani (1991), all empirical studies of multi-sector models formulated only the growth-export relationship, although important theoretical contributions, such as Grossman and Helpman (1991) and Young (1991), have addressed the importance of international trade, i.e., both imports and exports.

In this paper, the role of imports is explicitly included in the multi-sector model so that we can discuss the spilloers between industries and the relationship between trade and growth. The second purpose of this paper is to reconsider the meaning of "East Asia". Since the publication of the World Bank report "Asian Miracle" (1992), many authors have discussed the uniqueness or conformity of Asian countries. However, no studies have been attempted thus far to answer the following question: Are Asian countries similar or different for one another? If they are similar or different, how?

To analyze the conformity of these economies, we modify the test of poolability for panel data, e.g., Maddala(1971, 1977) and Baltagi (1995). We use the poolability test in a stepwise fashion in order to identify groups within which each country has a statistically identical structure (coefficient estimate).

The structure of this paper is as follows: Section 2 presents two multi-sector frameworks, a capital import model and an intermediate import model. Section 3 provides data description. Section 4 presents the parametarization and estimation methods. Section 5 discusses the results. Section 6 tests the poolability of Asian countries and reports the estimation results based on the results of poolability tests. Section 7 concludes the paper.

2 Multi-sector Frameworks

Feder's (1982) pioneering work first introduced the paradigm of a two sector framework with productivity spillovers between tradable and non-tradable sectors. Feder's framework makes it possible to estimate parameters of sectoral productivity differentials as well as productivity spillovers.[1]

However, Feder's model does not include imports as a factor of production. According to the recent empirical literature on international R&D spillovers, capital goods imports and/or intermediate goods imports play important roles for the diffusion of knowledge. In the present paper, we identify two international trade channels of knowledge spillovers: learning by exporting and capital and/or intermediate goods imports.[2] Thus, we develop the modified multi-sector framework that includes these two channels. For convenience, we show these two frameworks separately.

2.1 Capital Goods Import

The economy is assumed to have two sectors, tradable (X) and non-tradable (N) sectors. The tradable sector can earn foreign currencies by exporting, thus it can also import from the world market. The tradable sector has a Marshallian external effect on the non-tradable sector. Both sectors need capital (K_n, K_x) and labor (L_N, L_X) as primary inputs, and the tradable sector use imported capital goods (K_m).

$$N(t) = F(K_n(t), L_n(t), X(t)) \quad (1)$$

$$X(t) = G((K_x(t), K_m(t), L_x(t)) \quad (2)$$

Assume that there exist productivity differentials between sectors. The marginal

[1]See Alexander et al. (1996) for the survey of the applications.

[2]See Barba Navaretti and Tarr (2000) and Keller (2001) for the survey on the channels of spillover.

productivity of both capital and labor in the tradable sector exceeds those in the non-tradable sector by δ^a. Superscript "a" stands for the capital goods import framework. Further we assume that in the tradable sector the productivity of imported capital exceeds that of domestic capital by η^a.

$$\begin{aligned} \frac{G_{K_x}}{F_K} &= \frac{G_L}{F_L} = 1 + \delta^a, \qquad \delta^a \in [0, +\infty) \\ \frac{G_{K_m}}{G_{K_x}} &= 1 + \eta^a, \qquad \eta^a \in [0, +\infty) \end{aligned}$$

Under the perfect competitive equilibrium, both δ^a and η^a are zero which mean the optimal resource allocation. On the other hand, non-zero δ^a or non-zero η^a represents a potentially important source of growth through reallocation of resources. In other words, a large distorted economy can get more benefits from reallocating factors toward optimal condition ($\delta = \eta = 0$).[3]

Using an identity $Y = N + X$, defining $\dot{Z} = dZ/dt$, and making use of assumptions, the following equation is obtained (see Appendix A for the derivation),

$$\begin{aligned} \dot{Y} &= F_K \dot{K}_n + F_L \dot{L}_n + F_X \dot{X} \\ &\quad + \delta^a (F_K \dot{K}_x + F_K \dot{K}_m + F_L \dot{L}_x) + (1 + \eta^a + \eta^a \delta^a) F_K \dot{K}_m. \end{aligned} \tag{3}$$

Using equation (2) and the assumption of productivity differentials between tradable and non-tradable sectors, we can rewrite the first parenthesis in the right hand side of equation (3) as

$$F_K \dot{K}_x + F_K \dot{K}_m + F_L \dot{L}_x = \frac{\dot{X}}{1 + \delta_a} - \eta^a F_K \dot{K}_m.$$

Ignoring depreciation for simplicity ($\dot{K}_n + \dot{K}_x = I$ and $\dot{K}_m = M_k$, where I is domestic investment and M_k represents imported capital.), the following equation is

[3]S. Robinson (1971) first showed that the reallocation, or structural change in his term, is an important source of growth in developing countries.

obtained,

$$\dot{Y} = F_K I + F_L \dot{L} + \left(\frac{\delta_a}{1+\delta^a} + F_x \right) \dot{X} + (1+\eta^a) F_K M_k. \tag{4}$$

The following is the last assumption about the production function,

$$N = F(K_n, L_n, X) = X^{\theta^a} \phi(K_n, L_n), \qquad \theta^a \in [0,1].$$

ϕ represents a linear homogenous function. θ^a represents the degree of externality effect of productivity spillover from tradable to non-tradable sectors which is a main concern in this paper. The marginal productivity of tradable sector's outputs X in the non-tradable sector is then,

$$F_X = \theta^a \left(\frac{N}{X} \right) = \theta^a \frac{(N/Y)}{(X/Y)} = \theta^a \frac{1-(X/Y)}{(X/Y)} = \frac{\theta^a}{X/Y} - \theta^a.$$

Following Feder (1983), in the second term in the right hand side of equation (4) we assume a linear relationship between the marginal productivity of labor and the average productivity of labor, that is $F_L = \lambda^a (Y/L)$. Putting these together with equation (4) and transforming it into the growth rate term, the following equation of GDP growth rate is obtain,

$$\frac{\dot{Y}}{Y} = F_K \left(\frac{I}{Y} + \frac{M_k}{Y} \right) + \lambda^a \frac{\dot{L}}{L} + \frac{\delta^a}{1+\delta^a} \frac{X}{Y} \frac{\dot{X}}{X} + \theta^a \frac{N}{Y} \frac{\dot{X}}{X} + \eta^a F_K \frac{M_k}{Y}. \tag{5}$$

Equation (5) will be used for estimating the parameters in the later sections.[4] The interpretation of the equation (5) is as follows: the rate of GDP growth is composed of the contribution of factor accumulation (capital and labor), and the efficiency gains from shifting factors from the non-tradable sector to the tradable sector. The efficiency gains have two different sources: one comes from the resource reallocation between low (non-tradable) productivity and the high productivity (tradable) sectors, and the other

[4] Alternative specification for equation (5) is; $\frac{\dot{Y}}{Y} = F_K \frac{I}{Y} + \lambda^a \frac{\dot{L}}{L} + \frac{\delta^a}{1+\delta^a} \frac{X}{Y} \frac{\dot{X}}{X} + \theta^a \frac{N}{Y} \frac{\dot{X}}{X} + (1+\eta^a) F_K \frac{M_k}{Y}$. Estimation results of this specification do not affect the other coefficients estimated much, but worsen the overall results. So we don't report the results of this alternative specification.

comes from the productivity spillover effect of tradable sector to non-tradable sector. The former effect is captured by δ^a and η^a and the latter is by θ^a. Unlike the existing literature, our main purpose is to observe θ, not δ.

However, equation (5) has a problem for estimation. As Alexander et al. (1996) point out, equation (5) is non-linear in δ. Hence, even if the estimated coefficient, $\delta/(1+\delta)-\theta$, is an unbiased estimate, the derived δ is biased although consistent since the expected value of a non-linear function is not the non-linear function of the expected value. The problem of non-linearity is discussed and solved in the next section.

2.2 Intermediate Goods Import

The other carrier of technology across borders through international trade is intermediate goods imports. Since it is difficult to combine capital import framework together with intermediate framework, we instead argue each framework separately. In this subsection we analyze technology spillover effects between sectors formulating intermediate goods import framework.

In the intermediate goods framework, the exportable sector can import intermediate goods instead of capital goods.

$$N(t) = F(K_n(t), L_n(t), V_n(t), X(t)) \tag{6}$$

$$X(t) = G(K_x(t), L_x(t), V_x(t), V_m(t)), \tag{7}$$

where V_n, V_x are intermediate goods produced domestically and used for non-tradable and tradable sectors respectively. V_m is imported intermediate goods used for tradable sector. It should be noted that $N(t)$ and $X(t)$ represent *outputs*, not *value added*, of non-tradable and tradable sectors, respectively. Other variables are the same as in the capital import case. The superscript "b" indicates the parameters of intermediate goods import framework. The productivity differential assumptions are the same as the capital goods import case. We therefore assume productivity differences between non-tradable and tradable sectors same as capital import case.

$$\begin{aligned} \frac{G_K}{F_K} &= \frac{G_L}{F_L} = \frac{G_{V_x}}{F_V} = 1+\delta^b, \qquad && \delta^b \in [0,+\infty) \\ \frac{G_{V_m}}{G_{V_x}} &= 1+\eta^b, && \eta^b \in [0,+\infty) \end{aligned}$$

Since the total output (Q) is the sum of two sectors' outputs (N and X).[5]

$$\dot{Q} = F_K\dot{K} + F_L\dot{L} + F_V\dot{V}_d + F_X\dot{X} + \delta^b[F_K\dot{K}_x + F_L\dot{L}_x + F_v\dot{V}_x] + G_{V_x}\dot{V}_m \tag{8}$$

where $V_d = V_n + V_x$ is the intermediate goods domestically produced. From the production function of tradable sector, the following relationship is derived,

$$F_K\dot{K}_x + F_L\dot{L}_x + F_V\dot{V}_x = \frac{\dot{X}}{1+\delta^b} - \frac{G_{V_m}}{1+\delta^b}.$$

By using this relationship, equation (8) is rewritten,

$$\dot{Q} = F_K I + F_L\dot{L} + F_V\dot{V}_d + \left(\frac{\delta^b}{1+\delta^b} + F_X\right)\dot{X} + \frac{1}{1+\delta^b}G_{V_x}\dot{V}_m, \tag{9}$$

where $I = \dot{K}_n + \dot{K}_x$.

We assume that non-tradable sector benefits from technology spillover effects from tradable sector. Since technology spillover is assumed to occur in the form of externality between sectors as same as capital import case, the production function of non-tradable sector is as follows,

$$N = F(K_n, L_n, V_n, X) = X^{\theta^b}\phi(K_n, L_n, V_n), \qquad \theta^b \in [0,1],$$

where θ^b represents the degree of technology spillover to non-tradable from tradable sector in intermediate goods case. ϕ is a linear homogenous function.

The marginal productivity of non-tradable sector (F_x) is, then, expressed as,

$$F_X = \theta^b\left(\frac{N}{X}\right) = \theta^b\frac{(N/Q)}{(X/Q)} = \theta^b\frac{1-(X/Q)}{(X/Q)} = \frac{\theta^b}{(X/Q)} - \theta^b.$$

[5]See Appendix B for the derivation.

Taking derivative with respect to time, t, of the relationship between total output and total value-added which is $p_y Y = pQ - p_v V_d - p_m V_m$, where p, p_y, p_v, and p_m are price indexes of total output, total value-added, domestic intermediates and imported intermediates, the following relationship is obtain,

$$\dot{Y} = \left(\frac{p}{p_y}\dot{Q} - \frac{p_v}{p_y}\dot{V}_d - \frac{p_m}{p_y}\dot{V}_m \right) + \left(\frac{p}{p_y}\frac{\dot{p}}{p}Q - \frac{p_v}{p_y}\frac{\dot{p}_v}{p_v}V_d - \frac{p_m}{p_y}\frac{\dot{p}_m}{p_m}V_m - \frac{\dot{p}_y}{p_y}Y \right) \tag{10}$$

Plugging the previous relevant equations into this equation, we have:

$$\begin{aligned} \dot{Y} &= \frac{p}{p_y}\left[F_K I + F_L \dot{L} + \left(F_V - \frac{p_v}{p} \right) \dot{V}_d + \left(\frac{\delta^b}{1+\delta^b} \right) \dot{X} + \theta^b Q \frac{\dot{X}}{X} \right] \\ &\quad + \left[\frac{p}{p_y} \frac{1}{1+\delta^b} G_{V_m} - \frac{p_m}{p_y} \right] \dot{V}_m + P \end{aligned} \tag{11}$$

where P represents the price change effect which are in the second parenthesis of equation (10).[6] Under the assumption that the firms maximize their profits, the marginal productivity of domestic intermediates in the non-tradable sector (F_V) equals p_v/p. We further assume $F_L = \lambda^b (Y/L)$, the growth rate of GDP is,

$$\begin{aligned} \frac{\dot{Y}}{Y} &= F_K \frac{pI}{p_y Y} + \lambda^b \frac{p}{p_y}\frac{\dot{L}}{L} + \frac{\delta^b}{1+\delta^b}\frac{pX}{p_y Y}\frac{\dot{X}}{X} \\ &\quad + \theta^b \frac{pN}{p_y N}\frac{\dot{X}}{X} + \left[\frac{p_v}{p_y}(1+\eta^b) - \frac{p_m}{p_y} \right] \frac{V_m}{Y}\frac{\dot{V}_m}{V_m} + \frac{P}{Y}. \end{aligned} \tag{12}$$

The interpretation of each parameter is the same as one in the capital import framework. The fifth term needs some comments, however. Inside the bracket of fifth term in right hand side would be affected by not only η^b but also the prices, p_v and p_m. If an economy that has relatively small distortions may have $p_v \doteq p_m$, and $\eta^b \doteq 0$, the effects of intermediate inputs on economic growth would be small. This is the case for developed countries. On the other hand, if an economy has a large productivity

[6] Syrquin (1987) and Esfahani (1991) assume that the price change effcts are zero.

difference between domestic and imported intermediate goods, i.e., $\eta^b > 0$, the size of coefficient depends on the relative size of p_v and p_m. However, if domestic marginal productivity is less than foreign marginal productivity, that is, $\eta^b > 0$, and if both markets are perfectly competitive and there are no trade barriers, the price of imported intermediate p_m must be less than the price of domestic intermediate p_v. In this case, the size of coefficient of the last term becomes large. However, whether the coefficient is also small or large crucially depends on policy induced distortion that affect both domestic and import prices of intermediate goods. Even if the productivity differential (η^b) is large, for example, industrial policy that subsidizes domestic intermediate sectors reduces the price of domestic intermediate goods, p_v. In this case, the estimated coefficient may be small. Hence if estimated coefficient is large, we interpret this term as the effect of intermediate goods import on the growth rate. On the other hand, if coefficient is small, we have two different interpretations; One is that the effect of intermediate imports on the economic growth is small. The other one is that a strong industrial policy may distort the price system.

3 Data

The data used for estimation were collected for 51 countries over 24 years (1968 to 1992). 51 countries include 19 OECD member countries and 32 developing countries. The classifications of high and low income countries by region follow the World Bank, *World Tables*. Country classification is shown in Appendix Table 1.

The data on GDP, investment, population, price indices of capital good were obtained from the Penn World Table 5.6 compiled by Summers and Heston (Summers and Heston, 1991). We also used World Bank, *World Tables*, various issues to fill the missing data in the Penn World Table.

The data on exports, capital imports, and intermediate imports were obtained AID-

XT International Trade Data Search System provided by the Institute of Developing Economies, Tokyo. Capital imports goods consist of SITC 7 (machinery and transportation equipment), and intermediate imports consist of SITC 5 (chemical products and SITC 6 (products classified by materials).

To transform international trade data from nominal term into real term, we used export and import price indices which were obtained from the International Monetary Fund (IMF), *International Financial Statistics*, various issues.

Since international trade data fluctuate greatly every year especially in developing countries, we took three-year moving average on all variables for getting meaningful results.

4 Parametarization and Estimation

By adding constant term, c, and well-behaved error term, ϵ, on the equation (5), we get following equation:

$$y = c + \alpha_1 (s_I + s_{Mk}) + \alpha_2 l + \alpha_3 s_X x + \alpha_4 s_N x + \alpha_5 s_{Mk} + \epsilon \tag{13}$$

where $y = \dot{Y}/Y$, $s_I = I/Y$, $s_{Mk} = M_k/Y$, $l = \dot{L}/L$, $s_X = X/Y$, $s_N = N/Y$, $x = \dot{X}/X$, and the parameters to be estimated are $\alpha_1 = F_K$, $\alpha_2 = \lambda^a$, $\alpha_3 = \delta^a/(1+\delta^a)$, $\alpha_4 = \theta^a$, and $\alpha_5 = \eta^a F_K$.

Since δ is a non-linear function of estimated parameter, α_3, i.e.,

$$\hat{\delta} = \frac{\hat{\alpha_3}}{1-\hat{\alpha_3}} = f(\hat{\alpha_3}),$$

δ_a can be tested from the following Wald statistics,

$$z = \frac{\hat{\delta}}{\sqrt{est.Var(\hat{\delta})}} = \frac{f(\hat{\alpha_3})}{\sqrt{[f'(\hat{\alpha_3})]^2 Var(\hat{\alpha_3})}} \sim N(0,1)$$

and $H_0 : \delta = o$, $H_1 : \delta \neq 0$.

The effect of capital import η^a can be estimated from dividing α_5 by α_1. η^a is also tested from the above Wald statistics. Productivity spillover effects (θ^a) is directly obtained from the estimate of α_4.

In the same manner we obtain the following estimated equation from equation (12),

$$y = c + \beta_1 s_I^n + \beta_2 l + \beta_3 s_X^n x + \beta_4 s_N^n x + \beta_5 s_{Vm} v_m + \epsilon, \tag{14}$$

where $s_I^n = pI/p_y Y$, $s_X^n = pX/p_y Y$, $s_N^n = pN/p_y Y$, $s_{Vm} = V_m/Y$, $v_m = \dot{V}_m/V_m$, $\beta_1 = F_K$, $\beta_2 = \lambda^b p/p_y$, $\beta_3 = \delta^b/(1+\delta^b)$, $\beta_4 = \theta^b$, and $\beta_5 = \eta_p^b$. The term P/Y in equation (12) is now included in the constant term in equation (14).[7]

The productivity differences between tradable and non-tradable sectors δ^b and η^b are estimated and tested in the same way in equation (13). Productivity spillover parameter θ^b is directly estimated from β_4.

5 Results

Table 1 reports the results of the regressions using Equations (13) and (14). All regressions use groupwise heteroscedastic model with fixed effect (Greene, 2000, p598).

Foe all 51 country sample, developing 31 country sample, and Latin American 15 country sample, all estimated coefficients except for α_5 are positive and highly statistically significant. This is consistent with the hypotheses that each factor of input affects the economic growth positively. On the other hand, OECD 19 and Asian 7 group do not have positive α_1 either α_5.

Productivity differentials (δ) between trade and non-trade sectors have positive effects on the economic growth in capital import framework for all samples with highly statistically significant level. On the other hand in intermediate import model, only the OECD sample has statistically significant positive effect of productivity differentials.

[7] As we will see in the estimation results section, P/Y term is interpreted as a difference in fixed effects.

If we focus on the size of productivity spillover θ^a, which is equal to α_4, we find that all sample have positive and statistically significant effects and that OECD19 sample has very high θ^a but developing samples do not.

Results of intermediate import model in Table 1 show that for all 51, developing 32 and OECD19 samples have all positive estimated coefficients which are consistent with the hypotheses. Furthermore, almost all estimates are statistically highly significant. Calculated δ^b says that OECD19 sample has higher δ than Developing 32 sample but the latter is not significant. θ^b is higher in the OECD sample than in developing sample but again estimated θ^b in developing 32 sample is not statistically significant. That intermediate good import effect η^b is higher in developing sample than in OECD19 sample and both are statistically highly significant is consistent with the hypothesis that the developed country has lower η^b than developing country has.

However, Latin American 15 countries sample has negative η^b and East Asia7 countries sample has negative β_1 which are inconsistent with the predictions of the model.

Table 2 reports the results of test whether East Asia 7 countries sample has statistically different coefficients from other countries focussing on productivity spillover effect, θ. Using dummy variable which equals 1 if a variable is in the group of East Asia 7 and equal 0 if not. D in column of "Variable" in Table 2 indicates East Asian dummy variable. If the estimated coefficients of dummy variables are significant we can say that East Asia has statistically different parameter from other samples. Productivity spillover effect θ is directly observed from the estimated parameter α_4 which variable is $S_N x$ in capital import model and β_4 and $S_N^n x$ in intermediate import model respectively. Only the variable $D \cdot S_N x$ in all 51 countries sample has significant estimated coefficient but shows negative sign. In the next section, we consider which East Asian countries actually constitute a group using the idea of poolability.

6 Test of Poolability - Was East Asia different from others?

In the previous section, we estimated both capital and intermediate goods imports equations using pooled data and found that the intermediate goods imports model fit the data very well while the capital import model does not. In this section we describe the methodology to analyze the structural similarities of East Asia countries and discuss the results. We have two questions. First, when we say "East Asia countries," can those countries actually be regarded as one group? Second, if some Asian countries may form a group, which countries belong and does that group have a distinct economic structure?. The poolability test is applied for these purposes. This test is essentially a Chow test, extended to the case of N linear regressions. To test the poolability of the data, we estimate unrestricted and restricted regression equations and test the corresponding F value. For our purposes, we use these F test procedures for every combination among East Asia 7 countries, ie, 120 regressions for each model. Appendix C explain the detailed procedures.

The results of the stepwise poolability test, classified by the parameter θ, show the following (See Appendix Table 2 for details): In capital import framework, the test concludes that Hong Kong, South Korea, Taiwan, Singapore and Thailand have statistically (25% of F test) same estimated parameter θ while in the intermediate import framework, Hong Kong, South Korea, Taiwan and Thailand form one group in terms of the statistical similarity of parameter θ.

Table 3 shows the results of regressions conducted on East Asian groups. While the results of the capital import model have estimated coefficients which have opposite expected signs (α_1, α_2, and α_5), the intermediate import model has all expected signs of parameters and 4 parameters out of 5 are highly significant. Calculated δ^b for East Asia is 0.574, which is much higher than the developing country sample estimate of 0.094

and the OECD sample estimate of 0.144. This means that East Asia 4 countries have a large productivity difference between tradable tradable and non-tradable sectors. Calculated θ^b, 0.065 which is also higher than developing sample 0.013 and OECD sample 0.057 means that East Asia 4 has higher spillover effects from tradable to non-tradable sectors.

Table 4 shows the test of differences between East Asian group classified by θ and other countries using dummy variables. The results in Table 4 contrast with those in Table 2. In the capital import model, many dummy variables have statistically significant coefficients, but some are negative. The difference in the parameter θ (coefficient of $D \cdot S_N x$) is positive and significant at the 5% level both in the sample containing all 51 countries, and in the sample containing the 32 developing countries. This result strongly suggests that East Asia 5 has a stronger spillover effect than the other countries. In the intermediate import model, many parameters of dummy variables are positive and significant. The difference in parameter θ^b (the coefficient of variable $D \cdot S_N^n x$) is positive and highly significant. This finding also indicates that East Asia 4 has statistically different (stronger) spillover effect than other countries.

7 Summary and Conclusions

We can summarize the empirical findings of our analyses as follows;

(1) Regression results of pooled data show that the productivity differentials (δ) between the tradable and non-tradable sectors have positive effects on economic growth in the capital import framework. In the intermediate import model, only the sample of developed countries has positive and statistically significant parameter estimates.

(2) While the impact of capital imports (η) on economic growth is unclear, imports

of intermediate goods increase economic growth in all samples.

(3) The parameter estimate for the productivity spillover effect (θ) between the tradable and non-tradable sectors is positive and highly significant for all samples in the capital import model. The all-countries sample and the developed sample have positive and highly significant effects on economic growth in the intermediate imports framework.

(4) The productivity spillover effect in developed countries is much greater than that in developing countries in both the capital and intermediate imports frameworks.

(5) The effect of intermediate goods imports (η) in developing countries is greater than that in developed countries. This implies that there may be a large quality gap between imported and domestic intermediate goods in developing countries.

(6) According to the poolability test for East Asia 7 countries, only Hong Kong, Korea, Taiwan, and Thailand can be regarded as one group with respect to the productivity spillover effect θ in the intermediate goods framework, i.e., they have statistically identical estimates of the structural parameter θ.

(7) In the intermediate goods framework, the group of East Asia 4 has greater productivity differentials and spillover effects, and a lower intermediate goods effect compared to the developing and developed groups. A high productivity differential (δ) implies the existence of the allocative distortions in the market.

(8) East Asia 4 has statistically different parameter estimates of θ than the parameter estimates of θ for the group of all other countries, and the group of developing countries. This suggests that East Asia 4 experienced larger productivity spillovers in the 1970s and 1980s.

Although, as we have seen, productivity differentials of tradable and non-tradable sectors (δ) and between imported and domestic capital or intermediate goods (η) are sources of economic growth, these differentials come from the misallocations of the factors. In other words, as a source of economic growth, productivity differentials are unsustainable engines of growth. Thus, in the long run, the effects of productivity differentials may diminish as an economy grows. On the other hand, the benefits of productivity spillover effects can continue after the misallocations are resolved. In this sense, policies that enhance this spillover are crucially important for economic growth in any country. Spillover effects occur though both forward and backward linkages of industries. However, theoretical and empirical investigations of this linkage mechanism would serve as a valuable extension to the present study.

Appendix

A Derivation of Equation (3)

Using the identity $Y = N + X$, and of course the time derivative of both sides, $\dot{Y} = \dot{N} + \dot{X}$,

$$\begin{aligned}
\dot{Y} &= \dot{N} + \dot{X} \\
&= F_K\dot{K}_n + F_L\dot{L}_n + F_X\dot{X} + G_{K_x}\dot{K}_x + G_{K_m}\dot{K}_m + G_L\dot{L}_x \\
&= F_K\dot{K}_n + F_L\dot{L}_n + F_X\dot{X} \\
&\quad + \delta^a(F_K\dot{K}_x + F_K\dot{K}_m + F_L\dot{L}_x) + (1 + \eta^a + \eta^a\delta^a)F_K\dot{K}_m
\end{aligned}$$

B Derivation of Equation (8)

From $Q = N + X$,

$$\begin{aligned}
\dot{Q} &= \dot{N} + \dot{X} \\
&= F_K\dot{K}n + F_L\dot{L}_n + F_V\dot{V}_n + F_X\dot{X} + G_K\dot{K}_x + G_L\dot{L}_x + G_{V_x}\dot{V}_x + G_{V_x}\dot{V}_m \\
&= F_K\dot{K} + F_L\dot{L} + F_V\dot{V}_d + F_X\dot{X} + \delta^b[F_K\dot{K}_x + F_L\dot{L}_x + F_v\dot{V}_x] + G_{V_x}\dot{V}_m
\end{aligned}$$

C Stepwise Poolability Test

To test the poolability of pooled data, we estimate both unrestricted and restricted regression equations.
(Unrestricted)

$$\text{For each region } i, \quad y_i = Z_i\gamma_i + u_i, \text{ for } i = 1, 2, ..., N.$$

where $y_i' = (y_{i1}, y_{2i}, ..., y_{iT})$, $Z_i = [\iota_T, X_i]$, ι_T a vector of ones of dimension T. X_i is $T \times K$ matrix, γ_i' is $1 \times (K+1)$ and u_i is $T \times 1$.
(Restricted)

$$\text{For a group of } N \quad y = Z\gamma + u,$$

where $Z' = (Z'_1, Z'_2, ..., Z'_N)$ and $u'_i = (u'_1, u'_2, ..., u'_N)$.

Under the null hypothesis $H_0 : \gamma_i = \gamma$ for all i, we can test using the following F ratio;

$$F = \frac{(S_2 - S_1)/(2N - 1)}{S_1/(\sum T_i - 2N)}$$

where S_1 is unrestricted sum of squares and S_2 is restricted sum of squares. If this F ratio is significant, it means that there are significant differences in the coefficients. Otherwise we estimate the pooled data. We apply this test to our pooled data focusing on the parameter θ. Tests have been done for all possible combinations among East Asia 7 countries, so that 120 $(= C_{7,2} + C_{7,3} + C_{7,4} + C_{7,5} + C_{7,6} + C_{7,7})$ regressions for each framework have been calculated.

Setting the critical value at 25% significant level, we find that Hong Kong, Taiwan, Singapore, and Thailand form a group for capital import model and that Hong Kong, Korea, Taiwan, and Thailand form a group for intermediate import model.

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Table 1
Estimation Results with Pooled Data

Capital Import Model

	All 51 Sample51	Developing 32	OECD19	LA 15	E-Asia 7
Parameter(Variable)					
$\hat{\alpha}_1\,(S_I + S_{Mk})$	0.023	0.051	−0.031	0.071	−0.055
	(2.784) ***	(4.771) ***	(−2.050) **	(4.357) ***	(−2.720) ***
$\hat{\alpha}_2\,(l)$	0.682	0.611	0.811	2.327	−0.413
	(4.616) ***	(3.096) ***	(3.335) ***	(4.390) ***	(−1.932) *
$\hat{\alpha}_3\,(S_X x)$	0.263	0.396	0.232	0.433	0.317
	(5.845) ***	(5.649) ***	(3.690) ***	(3.064) ***	(4.492) ***
$\hat{\alpha}_4\,(S_N x)$	0.037	0.027	0.072	0.025	0.042
	(5.089) ***	(2.872) ***	(5.926) ***	(1.840) *	(2.090) **
$\hat{\alpha}_5\,(S_{Mk})$	−0.057	−0.095	−0.003	−0.245	0.019
	(−6.270) ***	(−7.001) ***	(−0.227)	(−4.271) ***	(0.891)
R^2	0.550	0.594	0.473	0.433	0.573
$\overline{R}^2$	0.528	0.573	0.443	0.400	0.542
F-value	341.34***	255.62***	92.57***	61.99***	50.01***
Sample Size	1173	736	437	345	161
$\hat{\delta}^a$	0.356	0.656	0.302	0.765	0.463
	{4.311}***	{3.411}***	{2.834}***	{1.736}*	{3.070}***
$\hat{\theta}^a$	0.037	0.027	0.072	0.025	0.042
	(5.089) ***	(2.872) ***	(5.926) ***	(1.840) *	(2.090) **
$\hat{\eta}^a$	−2.426	−1.855	0.101	−3.456	−0.355
	{−3.995}***	{−7.981}***	{0.208}	{−3.980}***	{−1.281}

Table 1 (Cont')
Intermediate Import Model

	All Countries 51	Developing 32	OECD19	LA 15	E-Asia 7
Parameter (Variable)					
$\hat{\beta}_1 (S_I^n)$	0.044	0.071	0.003	0.09	−0.05
	(5.659) ***	(6.864) ***	(0.216)	(7.194) ***	(−2.404) **
$\hat{\beta}_2 (l)$	1.026	1.757	0.451	2.06	0.44
	(6.530) ***	(7.368) ***	(1.989) **	(5.038) ***	(1.438)
$\hat{\beta}_3 (S_X^n x)$	0.072	0.086	0.126	0.11	−0.03
	(1.644)	(1.107)	(2.322) **	(1.129)	(−0.334)
$\hat{\beta}_4 (S_N^n x)$	0.019	0.013	0.057	−0.01	0.03
	(2.826) ***	(1.470)	(4.920) ***	(−0.970)	(1.677) *
$\hat{\beta}_5 (S_{Vm} v_m)$	1.925	2.600	1.568	5.72	0.85
	(14.180) ***	(11.736) ***	(9.421) ***	(13.536) ***	(3.855) ***
R^2	0.595	0.647	0.515	0.566	0.563
$\overline{R}^2$	0.575	0.629	0.488	0.540	0.531
F-value	385.93***	290.41***	109.57***	105.76***	47.96***
Sample size	1104	667	437	345	161
$\hat{\delta}^b$	0.078	0.094	0.144	0.12	−0.03
	{1.525}	{1.012}	{2.029}**	{1.010}	{−0.344}
$\hat{\theta}^b$	0.019	0.013	0.057	−0.01	0.03
	(2.826) ***	(1.470)	(4.920) ***	(−0.970)	(1.677) *
$\hat{\eta}_p^b$	1.925	2.600	1.568	5.72	0.85
	(14.180) ***	(11.736) ***	(9.421) ***	(13.536) ***	(3.855) ***

Notes: Groupwise heteroscedastic model with fixed effect is used for estimation. *t*-value in (･), z-value in {･}, ***,**,* indicate significance at 1%, 5%, and 10% level respectively.

Table 2
Uniqueness of East Asian Countries

Capital Import Model			Intermediate Import model		
Variable	All Countries 51	Developing 32	Variable	All Countries 51	Developing 32
$S_I + S_{Mk}$	0.032	0.066	S_I^n	0.054	0.091
	(3.258)***	(5.219)***		(6.451)***	(8.481)***
$D(S_I + S_{Mk})$	−0.087	−0.120	$D \cdot S_I^n$	−0.104	−0.140
	(−3.913)***	(−5.116)***		(−4.751)***	(−6.113)***
l	1.092	1.477	l	0.802	1.442
	(5.824)***	(4.745)***		(4.464)***	(4.590)***
$D \cdot l$	−1.504	−1.890	$D \cdot l$	−0.350	−0.990
	(−5.327)***	(−5.023)***		(−0.998)	(−2.268)**
$S_X x$	0.181	0.380	$S_X^n x$	0.072	0.106
	(3.437)***	(2.910)***		(1.411)	(1.179)
$D \cdot S_X x$	0.136	−0.064	$D \cdot S_X^n x$	−0.101	−0.135
	(1.554)	(−0.429)		(−0.987)	(−1.067)
$S_N x$	0.032	0.024	$S_N^n x$	0.009	−0.004
	(4.124)***	(2.174)**		(1.184)	(−0.382)
$D \cdot S_N x$	0.009	0.018	$D \cdot S_N^n x$	0.022	0.034
	(0.437)	(0.786)		(1.091)	(1.621)
S_{Mk}	−0.067	−0.182	$S_{Vm} v_m$	2.451	4.392
	(−6.588)***	(−6.147)***		(14.609)***	(14.037)***
$D \cdot S_{Mk}$	0.086	0.202	$D \cdot S_{Vm} v_m$	−1.593	−3.534
	(3.621)***	(5.505)***		(−5.796)***	(−9.255)***
R^2	0.587	0.649	R^2	0.592	0.652
$\overline{R}^2$	0.565	0.629	$\overline{R}^2$	0.570	0.631
F-value	175.77***	142.86***	*F-value*	179.06***	144.48***
Sample size	1173	736	Sample size	1173	736

Notes: See footnotes in Table 1. The variables with D are Asian Dummies. East Asia 7 countries are Hong Kong, Indonesia, Korea, Malaysia, Taiwan, Singapore, and Thailand.

Table 3

Estimation Results of East Asian Group classified by θ

Parameter (Variable)	Capital Import HKG,KOR,OAN, SGP,THA	Parameter (Variable)	Intermediate Import HKG,KOR,OAN, THA
$\hat{\alpha}_1 (S_I + S_{Mk})$	−0.007	$\hat{\beta}_1 (S_I^n)$	0.019
	(−0.249)		(0.681)
$\hat{\alpha}_2 (l)$	−0.371	$\hat{\beta}_2 (l)$	1.302
	(−1.708)***		(4.566)***
$\hat{\alpha}_3 (S_X x)$	0.356	$\hat{\beta}_3 (S_X^n x)$	0.365
	(4.809)***		(3.208)***
$\hat{\alpha}_4 (S_N x)$	0.077	$\hat{\beta}_4 (S_N^n x)$	0.065
	(3.557)***		(3.189)***
$\hat{\alpha}_5 (S_{Mk})$	−0.028	$\hat{\beta}_5 (S_{Vm} v_m)$	0.503
	(−1.000)		(2.497)**
R^2	0.450	R^2	0.629
$\overline{R}^2$	0.403	$\overline{R}^2$	0.594
F-value	21.50***	*F-value*	35.25***
Sample size	115	Sample size	92
$\hat{\delta}^a$	0.554	$\hat{\delta}^b$	0.574
	{3.096}***		{2.038}**
$\hat{\theta}^a$	0.077	$\hat{\theta}^b$	0.065
	(3.557)***		(3.189)***
$\hat{\eta}^a$	4.149	$\hat{\eta}_p^b$	0.503
	{0.200}		(2.497)**

Note: See footnotes in Table 1.

Table 4
Uniqueness of East Asian Group classified by θ

Capital Import Model			Intermediate Import Model		
Variable	All Countries 51	Developing 32	Variable	All Countries 51	Developing 32
$S_I + S_{Mk}$	0.032	0.066	S_I^n	0.054	0.091
	(3.258)***	(5.219)***		(6.451)***	(8.481)***
$D(S_I + S_{Mk})$	−0.039	−0.072	$D \cdot S_I^n$	−0.035	−0.071
	(−1.379)	(−2.474)**		(−1.223)	(−2.409)**
l	1.092	1.477	l	0.802	1.442
	(5.824)***	(4.745)***		(4.464)***	(4.590)***
$D \cdot l$	−1.463	−1.849	$D \cdot l$	0.500	−0.139
	(−5.156)***	(−4.897)***		(1.508)	(−0.331)
$S_X x$	0.181	0.380	$S_X^n x$	0.072	0.106
	(3.437)***	(2.910)***		(1.411)	(1.179)
$D \cdot S_X x$	0.175	0.053	$D \cdot S_X^n x$	0.293	0.259
	(1.956)*	(2.230)**		(2.402)**	(1.807)*
$S_N x$	0.032	0.024	$S_N^n x$	0.009	−0.004
	(4.124)***	(2.174)**		(1.184)	(−0.382)
$D \cdot S_N x$	0.045	0.053	$D \cdot S_N^n x$	0.058	0.070
	(1.982)**	(2.230)**		(2.697)***	(3.131)***
S_{Mk}	−0.067	−0.182	$S_{Vm} v_m$	2.451	4.392
	(−6.588)***	(−6.147)***		(14.609)***	(14.037)***
$D \cdot S_{Mk}$	0.039	0.155	$D \cdot S_{Vm} v_m$	−1.947	−3.887
	(1.338)	(3.835)***		(−7.525)***	(−10.495)***
R^2	0.592	0.659	R^2	0.638	0.705
$\overline{R}^2$	0.570	0.638	$\overline{R}^2$	0.614	0.687
F-value	172.15***	139.47***	*F-value*	201.68***	166.92***
Sample size	1127	690	Sample size	1104	667

Note: See footnotes in Table 2. East Asian groups in capital and intermediate import models are same as the group of Table 3.

Appendix Table 1
Classification of Countries

Region	Africa	Asia	Oceania	Europe	South America	North/ Central America
Developing Countries 32	Egypt Morocco Tunisia	India Indonesia (*) Sri Lanka Malaysia(*) Philippines Thailand(*) Korea(*) Hong Kong(*) Singapore(*) Taiwan(*) Israel	Fiji	Turkey Greek	Bolivia Chile Colombia Ecuador Paraguay Peru Argentine Brazil Venezuela	Honduras Costa Rica El Salvador Guatemala Panama Mexico
OECD19		Japan	Australia Newzieland	Austria Belgium Denmark Finland France West Germany Iceland Ireland Italy Netherlands Norway Spain Sweden U.K.		Canada U.S.A.
Total 51	3	12	3	16	9	8

Notes: East Asia 7 are indicated with (*). Latin American 15 are developing countries in South-America and North- and Central-America.

Appendix Table 2

Categorization of East Asian Countries

Capital Import Model

Categorization by Productivity Differentials delta

$y = c + \alpha_3 s_X x + \varepsilon_1$

H_0: $\alpha_3^{HKG} = \alpha_3^{IDN} = \alpha_3^{KOR} = \alpha_3^{MYS} = \alpha_3^{OAN} = \alpha_3^{SGP} = \alpha_3^{THA}$,

IDN,KOR,MYS,OAN,SGP (F=0.7880) Threshold: $F_{0.25}(4,110)=1.37$

Categorization by Trade Externality theta

$y = c + \alpha_4 s_N x + \varepsilon_2$

H_0: $\alpha_4^{HKG} = \alpha_4^{IDN} = \alpha_4^{KOR} = \alpha_4^{MYS} = \alpha_4^{OAN} = \alpha_4^{SGP} = \alpha_4^{THA}$,

HKG,KOR,OAN,SGP,THA (F=0.9794) Threshold: $F_{0.25}(4,110)=1.37$

Categorization by Capital Import Differentials etha

$y = c + \alpha_1 (S_I + S_{Mk}) + \alpha_5 S_{Mk} + \varepsilon_3$

H_0: $\alpha_1^{HKG} = \alpha_1^{IDN} = \alpha_1^{KOR} = \alpha_1^{MYS} = \alpha_1^{OAN} = \alpha_1^{SGP} = \alpha_1^{THA}$

$\alpha_5^{HKG} = \alpha_5^{IDN} = \alpha_5^{KOR} = \alpha_5^{MYS} = \alpha_5^{OAN} = \alpha_5^{SGP} = \alpha_5^{THA}$,

HGK,IDN,OAN (F=1.1899) Threshold: $F_{0.25}(4,60)=1.38$

HGK,IDN,SGP (F=1.0073) Threshold: $F_{0.25}(4,60)=1.38$

Intermediate Import Model

Categorization by Productivity Differentials delta

$y = c + \beta_3 s_X^n x + \varepsilon_4$

H_0: $\beta_3^{HKG} = \beta_3^{IDN} = \beta_3^{KOR} = \beta_3^{MYS} = \beta_3^{OAN} = \beta_3^{SGP} = \beta_3^{THA}$,

IDN,KOR,MYS,OANSGP (F=0.9766) Threshold: $F_{0.25}(4,110)=1.37$

Categorization by Trade Externality theta

$y = c + \beta_4 s_N^n x + \varepsilon_5$

H_0: $\beta_4^{HKG} = \beta_4^{IDN} = \beta_4^{KOR} = \beta_4^{MYS} = \beta_4^{OAN} = \beta_4^{SGP} = \beta_4^{THA}$.

HGK,KOR,OAN,THA (F=1.3977) Threshold: $F_{0.25}(3,88)=1.40$

Categorization by Capital Import Differentials etha

$y = c + \beta_5 s_{Vm} v_m + \varepsilon_5$

H_0: $\beta_5^{HKG} = \beta_5^{IDN} = \beta_5^{KOR} = \beta_5^{MYS} = \beta_5^{OAN} = \beta_5^{SGP} = \beta_5^{THA}$.

IDN,KOR,MYS,THA (F=0.4338) Threshold: $F_{0.25}(3,88)=1.40$

Notes: HKG=Hong Kong, IDN=Indonesia, KOR=Korea,
MYS=Malaysia, OAN=Taiwan、SGP=Singapore,
THA=Thailand