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Jong-Wha Lee

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ABSTRACT

This paper presents an endogenous growth model of an open economy in which the growth rate of income is higher if foreign capital goods are used relatively more than domestic capital goods for the production of capital stock. Empirical results, using cross country data for the period 1960-85, confirm that the ratio of imported to domestically produced capital goods in the composition of investment has a significant positive effect on per capita income growth rates across countries, in particular, in developing countries. Hence, the composition of investment in addition to the volume of total capital accumulation is highlighted as an important determinant of economic growth.

Jong-Wha Lee
Department of Economics
Korea University
Anam-Dong, Sungbuk-Ku
Seoul 136-701
KOREA
and NBER

I. Introduction

The links between international trade and economic growth have interested economists for a long time. Can international trade increase the growth rate of income? Should less developed countries follow their comparative advantage in order to become as rich as developed countries or should they protect certain key industries to grow faster? Free trade orthodoxy since Adam Smith typically predicts that international trade, by following the law of comparative advantage, produces static gains in income in all trading partner countries. It has, however, been equivocal in answering the question of whether international trade and a free trade regime can bring about any gains in the growth rate of income. This paper presents a new theoretical model and empirical evidence which show that international trade, by providing relatively cheaper foreign capital goods, increases efficiency of capital accumulation and thus the growth rates of income in less developed countries.

Recently there is a growing literature suggesting that international trade and trade policy may increase growth rates of income. Many researchers have provided a variety of frameworks for an open economy that are rooted in the closed economy endogenous growth models of Romer(1986) and Lucas(1988) (see the survey in Roubini and Sala-i-Martin(1991)). One of the key lessons from this branch of literature is that imports of foreign inputs are an important determinant of the link between trade and growth. Grossman and Helpman(1991), Rivera-Batiz and Romer(1991), and Quah and Rauch(1990) show that international trade can increase the growth rate by providing a wider range of intermediate inputs, which in turn facilitates more research and development or learning-by-doing activities. Thus, this literature seems to provide a theoretical foundation for the long-held conviction among development economists that international trade, by providing essential and efficient foreign inputs for industrializing

sector, is an important factor of economic growth. Anne Kruger(1983, p.9), for example, points out: "a reduction in capital goods imports would reduce the GDP growth rate and a reduction of intermediate goods and raw material imports would adversely affect output and employment."

The model presented here shares a common feature with these recent endogenous growth models in that it focuses on the importance of foreign inputs to economic growth. But, in contrast to the previous literature, which stresses the effects of trade on technological progress, this paper emphasizes another link between foreign inputs and growth--that is, the efficiency of capital accumulation. The price of capital goods has been relatively cheaper in higher income countries. (Section II shows detailed data from the United Nations Comparison Project and the Penn World Table.) Thus, lower income countries, by importing the relatively cheaper capital goods from high income countries, increase the efficiency of capital accumulation and thereby the growth rates of income. A simple model of an open economy that incorporates this characteristic is presented by extending a recent endogenous growth model of Rebelo(1991) in which two final goods--one consumption and one capital good--are produced and the "core" capital good sector determines the long-run growth rate of per capita income. The model of Rebelo implies that the relative price of the capital good decreases over time along the balanced growth path and thus the price of the capital good relative to the consumption good is cheaper in a higher income country, which has a larger capital stock. This closed economy model is extended to a framework of a global economy in which a less developed country imports capital goods from a developed country and combines them with domestic capital goods for the production of its core capital goods sector. The cheaper foreign capital goods then make the less developed country grow faster. Hence, the growth rate is higher in the country that uses imported inputs relatively more than domestically-produced inputs for investment.

This paper tests the empirical implications of the model. Using cross-country data for the period 1960~85, regression results show that the ratio of imports in investment(i.e., the ratio of imported to domestically-produced capital goods) has a

significant positive effects on per capita income growth rates across countries. On the other hand, the share of total imports in GDP has no significant effect on growth. The results, thus, highlight that the composition of investment in addition to its size should be considered important in determining economic growth.

This paper consists of six sections. Section II presents information on the relative price of capital goods. Section III presents an open economy growth model in which an imported capital good is a key input to the production of the domestic capital stock. The impact of the imported capital good on the growth rate of per capita income is discussed. Section IV discusses the impact of distortionary trade policies on capital goods imports and thus on growth rates. The results of the empirical investigations are presented in Section V, and finally, Section VI summarizes the principal finding of the paper.

II. The Relative Price of Capital Goods and Per Capita Income

There are some studies that discuss characteristics of cross-country data on the relative price of capital goods. For example, by using data on price of investment components drawn from the 1980 United Nations International Comparison Project(UN ICP), De Long and Summers (1991) have found that there is a negative correlation between GDP per worker and the real price of equipment (which is defined by the price of equipment relative to the GDP deflator in 1980). They note that "the fast growing countries are also those that have experienced the steepest declines in relative real machinery prices," inferring that as investment drives economic growth, the relative price of capital goods declines with capital accumulation. Unfortunately, their price measure is the real price of equipment investment goods relative to the GDP deflator, not to the price of consumption goods.

Summers and Heston(1991) report the 1980 UN ICP data on national prices and international dollar prices of aggregate commodities groups. They divide all 60

countries into six groups according to per capita income. Using their data, Table 1 presents the ratio of the national to the international price, which indicates the difference between the domestic price and the international price in each aggregate commodity and country group. For example, national prices of domestic investment goods are relatively expensive in the poorest group 1 countries, by a factor of 1.55, compared with the international price, which is defined by the U.S. price. The data of the first row show that the price of food declines only slightly with income. In contrast, as shown in the next three rows, the price of investment goods decreases dramatically with per capita income. Therefore, the relative prices of investment goods to consumption goods are more expensive in lower income countries, as depicted in the bottom three rows.[1)]

Data from the UN ICP are limited in showing trends of the relative price of investment goods over time because they do not cover a wide range of countries, in particular, for the earlier years. To examine whether the negative relationship between the relative price of capital goods and per capita income holds over time, the relative price of investment goods has been constructed as the ratio of the investment deflator to the consumption deflator in the four groups of countries, which are classified according to 1960 per capita income.[2)] Figure 1 demonstrates that the negative relationship between the relative price of investment goods and per capita GDP is stable over time among income groups: the lower the income, the higher is the relative price of the capital goods.

All findings show that capital goods have been relatively cheaper in richer countries. Thus, in the international trade between LDCs and DCs, the lower income countries have a comparative advantage in consumption goods, while the higher income countries have a comparative advantage in investment goods.

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1) Food is used to represent total consumption goods excluding nontradable services.

2) The data come from Summers and Heston(1991). The sample covers 99 countries excluding small countries, which had total population smaller than one million in 1960.

Ⅲ. An Endogenous Growth Model

This section first discusses the model of a closed economy in which the capital good sector determines the long-run growth rate of per capita income and the relative price of the capital good in terms of the consumption good decreases over time along the balanced growth path. And then the model is extended to an open economy where an imported foreign capital good is a key input to the production of domestic capital goods.

1. The closed economy

Consider a country that is assumed to have the same features of the two sector endogenous growth model as that of Rebelo(1991). The economy produces a consumption good and a capital good. The consumption good is produced by a Cobb-Douglas combination of capital and labor. The capital share is fixed by α:

$$C = (\phi K)^{\alpha} L^{1-\alpha}, \quad 0 < \alpha < 1 \qquad (1)$$

where K is capital stock, L is labor, and ϕ is a fraction of the capital stock employed in the consumption good sector. Time subscripts are omitted. To simplify the exposition, the total size of labor L will be normalized to one.

The capital good is produced using only capital stock:

$$I = A(1-\phi)K \qquad (2)$$

where A is a parameter of productivity that may reflect the level of technology. All capital goods are used for capital accumulation:

$$\dot{K} = I \qquad (3)$$

where the dot over K indicates the time derivative of the capital stock K. No depreciation of capital and no reversibility of investment($I \geq 0$) are assumed to simplify discussions.

The profit maximization condition specifies that the marginal productivity of capital will be the same in both sectors:

$$pA = \alpha(\phi K)^{\alpha-1} \qquad (4)$$

where p is the relative price of the capital good in terms of the consumption good. Since in the steady-state the fraction of capital stock employed in the consumption goods sector is fixed, equation (4) implies that the relative price of the capital good decreases with capital accumulation in the steady-state. Thus, the relative price of the capital good is cheaper in a country with a higher per capita capital stock.

National income measured in terms of the consumption good is derived by combining all the above equations:

$$Y = C + pI = [1+\alpha(1-\phi)/\phi]\ C \qquad (5)$$

Thus, GDP grows at the same rate as consumption in the steady-state, implying that economic growth always leads to a higher level of consumption and of utility.

The consumption side of this model assumes that the representative, infinitely-lived household maximizes a lifetime utility given by

$$U = \int_0^{\infty} e^{-\rho t}\log(C)\ dt \qquad (6)$$

where $\rho > 0$ is the constant rate of time preference. In the steady-state, the household chooses the optimal consumption growth path at the rate $g_c = r_c - \rho$, where r_c is the interest rate denominated in terms of the consumption

good. The standard arbitrage condition in the capital market requires that $r_c = A + g_p$ (see Rebelo (1991)). From equations (1) and (4), in the steady-state the growth rate of the relative price of the capital good $g_p = (\alpha - 1)g_k$ and $g_c = g_k + g_p = \alpha g_k$. Then, combining all these results with equation (5) gives the steady-state growth rate of income as follows:

$$g_y = \alpha (A - \rho) \qquad (7)$$

The expression implies that the more patient (lower ρ) and the more productive(higher A) an economy is, the faster it grows. In this endogenous growth model, therefore, the divergence of growth rates across countries is explained by the difference in preference or productivity among countries.[3] The model thus predicts that poor countries remain always poor.

The optimal saving rate $s^* = p\dot{K} / Y$ is solved by combining equations (2), (4) and (5) :[4]

$$s^* = [\, 1 + \alpha^{-1}\phi(1-\phi)^{-1}]^{-1} = [1+\alpha^{-1}\ \rho(A-\rho)^{-1}]^{-1} \qquad (8)$$

Thus, the optimal saving rate is higher in an economy that is more patient and more productive.

2. The open economy

The closed economy in the above subsection does not consider any possibility of trade between countries. Now consider a global economy in which two countries--a less developed country (LDC) and a developed country (DC)--are engaged in trade.

3) As well noted, in this "AK"-type of endogenous growth model, differences in government policy influence growth rate in the long-run. See Rebelo(1991), Barro(1991), Easterly(1990) and Jones and Manuelli(1990).

4) To get the second equality it is used that the equilibrium ϕ is ρ/A, which is derived by combining equations (2), (3) and (7).

Suppose that the DC has already achieved industrialization and grows at the steady-state rate as given by equation (7). In contrast, the LDC is just starting to produce its own capital goods sector. Equation (4) implies that domestic price of the capital good is relatively lower in the DC, which has a larger capital stock. Thus, the DC has a comparative advantage in the capital good, while the LDC has a comparative advantage in the consumption good. By trading with each other, the DC gets a relatively cheaper consumption good and the LDC gets a relatively cheaper capital good. The importation of the cheaper capital good from the DC raises the LDC's growth rate, while the DC gets higher utility by importing the cheaper consumption good.

Let's suppose that the LDC requires both a domestic capital and an imported capital good to build its own capital goods sector under the assumption that the capital good of the DC is an imperfect substitute for the capital good of the LDC. The assumption of imperfect substitutability between domestic and imported capital goods is considered to be more realistic than the usual assumption of the perfect substitutability between the DC and LDC capital goods.[5] Some components of investment, such as public capital goods (for example, railways) are nontradable and little substitutable for the imported capital goods (for example, locomotives). If the capital stock of the LDC includes human capital as well as physical capital, the imported capital goods will have little substitutability for the human capital.

Let's assume that the LDC's capital good is produced by a Cobb-Douglas combination of a domestic capital good, I_D, and an imported capital good, I_M:

$$I = I_D^{1-\gamma} I_M^{\gamma}, \quad 0<\gamma<1 \qquad (9)$$

5) The assumption of imperfect substitutability between domestic and imported capital goods is crucial in this model as it prevents the small LDC from becoming immediately specialized in the consumption good. Oniki and Uzawa(1965) investigate the links between trade and growth in the standard two-sector, two-country Heckscher-Ohlin-Samuelson model, where consumption and investment goods are all perfectly substitutable and freely traded. Also, see a survey of the related literature in Smith(1984).

where γ denotes a parameter given by production technology.

The domestic capital good is produced using only capital stock as in the developed country:

$$I_D = A(1-\phi)K \tag{10}$$

Equation (9) can be rewritten as:

$$I = [A(1-\phi)K]\ Z^{\gamma} \tag{11}$$

where Z denotes the ratio of imported to domestic capital good in the production of the capital good, that is :

$$Z = I_M / I_D = I_M / [A(1-\phi)K] \tag{12}$$

The variable Z will be called henceforth by *ratio of imports in investment*.

Assuming that the consumption goods sector has the same production function as given by equation (1), the profit maximization condition gives

$$p\ A(1-\gamma)\ Z^{\gamma} = \alpha\ \phi^{\alpha-1}\ K^{\alpha-1} \tag{13}$$

$$p_M = p\ \gamma\ Z^{\gamma-1} \tag{14}$$

where p_M denotes the price of the imported capital good, which is assumed to be given to the LDC exogenously. Equation (14) implies that equilibrium Z is determined by the difference between the domestic price p and the foreign price p_M. Using equations (13) and (14), the equilibrium Z is solved by:

$$Z = \gamma/(1-\gamma)\ (\phi K)^{\alpha-1}\ \alpha^{-1}\ p_M^{-1}\ A^{-1} \tag{15}$$

Equation (15) shows that, given the capital stock (K) and other parameters, a cheaper imported capital good leads to a higher value of Z.

The competitive equilibrium gives the steady-state growth rate by the same procedure as in the closed economy. Assume that the representative household in the LDC maximizes the intertemporal utility function given in equation.[6] Combining the optimal consumption path such that $g_c = r_c - \rho$ and the arbitrage condition such that $r_c = A(1-\gamma)Z^{\gamma} + g_p$, we get:

$$g_c = A(1-\gamma)Z^{\gamma} + g_p - \rho \qquad (16)$$

Capital accumulation occurs by the production of capital goods. From equation(11), the growth rate of capital stock is given by:

$$g_k = A(1-\phi)Z^{\gamma} \qquad (17)$$

National income measured in terms of the consumption good is given by:

$$Y = C + (1-\gamma)pI = [1+\alpha(1-\phi)/\phi]\, C \qquad (18)$$

Thus, GDP grows at the same rate as consumption in the steady-state.

The saving rate, $s = p\dot{K} / Y$, is solved by:

$$S = (1-\gamma)^{-1}\,[1+\alpha^{-1}\phi(1-\phi)^{-1}]^{-1} \qquad (19)$$

Steady-state equilibrium

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6) It is assumed that the DC and the LDC have the same parameters for productivity (A) and preference (ρ). Any complication of this assumption does not change the qualitative results in the paper.

In the steady-state, the fraction of capital stock employed in each sector is fixed. By combining equations (16), (17) and $g_k = g_c - g_p$, the equilibrium share is solved by:

$$\bar{\phi} = pA^{-1}\bar{Z}^{-\gamma} + \gamma, \; 0<\phi<1 \qquad (20)$$

where $\bar{Z}$ denotes the steady-state value of Z. Using $g_y = g_c = \alpha g_k$, the balanced growth rate in the steady-state is given by:

$$\bar{g}_y = \alpha[A(1-\gamma)\bar{Z}^{\gamma} - \rho] \qquad (21)$$

Equation (14) implies that in the steady-state the growth rate of price should be the same in the LDC and DC. Thus the steady-state equilibrium requires that the growth rate of income in the LDC be equal to the growth rate is determined by the given preference and technology parameters.[7]

Transitional dynamics

During the transitional period in which a LDC economy approaches the steady-state from a low initial level of capital stock, the capital stock and per capita income rise monotonically toward their steady-state values.

. Throughout the transitional period, the growth rate of income is higher in an economy with a higher ratio of imports in investment (Z). As shown in equation (17), given parameters, the growth rate of capital stock (and thereby income) is higher with Z. Thus, if an economy uses imported capital goods relatively more than its own domestic capital goods for capital accumulation, it grows faster. If two LDCs have the same per capita income and trade with the same DC, the country that devotes relatively more of a given portion of its income to the importation of cheap foreign

7) Comparing the growth rate in equation (21) with equation (7), the steady-state equilibrium requires that the productivity of capital be the same in both countries. Since $\bar{Z}^{\gamma}$ is a monotonic increasing function of Z, there exists a unique equilibrium $\bar{Z}$.

capital goods than to the purchase of domestic capital goods, grows faster than the other country.

Another prediction of the model is that the capital stock and income rise at decreasing rate in the transitional period. Equation (15) shows that Z decreases as the capital stock increases. By replacing P_M with equation (4), equation (15) can be rewritten as:

$$Z = \gamma / (1-\gamma) [(\phi K) / (\phi^* K^*)]^{(\sigma-1)/\sigma} = \gamma/(1-\gamma) (y/y^*)^{(\sigma-1)/\sigma} J \qquad (22)$$

where $J = \{[(1-\sigma)+\phi^{-1}] / [(1-\sigma)+\phi^{*-1}]\}^{(1-\sigma)/\sigma}$. The national income per capita is denoted by y and the superscript * denote the DC. Equation (22) shows that, given other parameters, Z decreases as income gap between the LDC and the DC decreases.[8] Thus, When the LDC starts with a smaller capital stock, it has a higher Z and thereby exhibits a higher growth rate than in the steady-state.[9] As the LDC economy, which starts with a huge income gap, approaches the steady-state, the ratio of imported capital goods (Z) and thereby the growth rate of income decreases. This prediction implies a convergence of income--since the growth rate of income is higher in lower income countries, the gap of per capita income between countries declines over time.

8) The model thus predicts that the *volume* of trade is smaller as the factor proportions become similar between trade partners. This prediction is the common feature in the Heckscher-Ohlin model (see Krugman and Helpman (1986)).

9) Equation (17) shows that the growth rate of capital stock decreases unambiguously as Z decreases if $(1-\phi)$ were unchanged in the transitional period. Equation (19) indicates that $(1-\phi)$ would be constant if saving rate were fixed over time. Although optimal saving rate can be either constant, increasing or decreasing monotonically in the transitional period of the neoclassical model as shown in Barro and Sala-i-Matin (1991, Chapter 1), the saving rate decreases over time for reasonable values of the parameters in the economy considered here. The decline of saving rate in the transitional period can be explained intuitively as follows: As the economy starts with a small capital stock, it has a relatively higher ratio of (M/AK) than the steady-state ratio. Thus, in this economy the present export of consumption goods (which is needed for the importation of capital goods) is larger relative to the present capital stock, implying that the present level of consumption relative to the capital stock is lower than the steady-state level. Hence, the representative consumer who wishes to maximize his intertemporal utilities will decrease saving and reallocate his capital stock relatively more to the consumption goods sector in order to smooth out his consumption over time.

Thus, although the model considered here is built on the endogenous growth model, it implies the convergence of income through trade among countries: international trade makes trade partners' income gap smaller and the LDCs catch up to the DC in terms of per capita income.[10]

IV. Trade Distortions, Capital Goods Imports and Growth

In the transitional period over which an economy approaches the steady-state, the ratio of imports in investment(i.e., the ratio of imported to domestically-produced capital goods in the investment sector) turns out to be important for the growth rate. This section discusses what may influence the ratio of imports in investment.

Equation (22) shows that trade policies adopted by the government could be a crucial determinant of the ratio of imports in investment. Any kind of trade distortions imposed on capital goods imports, such as tariffs and quantitative restrictions, increases the price of imported capital goods and thereby decrease Z. Thus the distortionary trade policies decrease the growth rate by forcing the economy to use domestic capital goods more than their efficient level. With other parameters equal, therefore, a high distorted country exhibits a lower growth rate of per capita income than a low distorted country.

In addition to trade policies, structural features of an economy can influence how much the economy depends on foreign capital good relative to domestic capital good in building its own capital stock. If the economy has plentiful endowment of diversified

10) The model, as it predicts the convergence of income among countries, contrasts with the other previous endogenous growth literature, which predicts "uneven development": "gains from trade" in growth rates can be negative to one trading partner, which is usually the LDC in north-south trade. For example, in Krugman(1981) trade with developed nations, by preventing industrialization in less developed countries, makes poor countries remain poor. Young(1991) shows that the less developed countries are likely to specialize in goods that have exhausted their potential to exhibit learning-by-doing, so that the impact of trade on the growth rate can be negative in poor countries. Also see the survey by Findlay(1984).

natural resources, it can be more easily to be self-sufficient in the production of capital goods. Also if a country has a natural trade barrier, such as high transportation costs, it is likely to import less. Thus the ratio of the foreign to the domestic component of investment may be determined by structural characteristics such as factor endowments and natural trade barriers, that are present in each economy.

V. Empirical Implementation

1. Specification of the empirical equation

The previous sections have illustrated how international trade could lead to a higher rate of growth in a less developed country, which imports cheaper capital goods from developed countries in accordance with the comparative advantage in trade. This section investigates empirically the main theoretical prediction on the positive link between the growth rate and the ratio of imports in investment.

In order to test the importance of imported capital goods in economic growth, a regression model using cross-country data is specified as follows:

$$GY_i = \text{constant} + aZ + b_iI_i + \varepsilon_i \qquad (23)$$

where GY is the growth rate of per capital income, and I is a set of variables that are included in the regression as important explanatory variables. Thus, the regression tests whether any independent effects exist with respect to the ratio of imported to domestic capital good (Z) on the growth rate of per capita income, controlling other "relevant" explanatory variables. The "relevant" variables in I include the initial real GDP, the initial secondary school enrollment rate, the investment share of GDP and the average annual rate of population growth as suggested by Levine and Renelt (1992), who control the same variables in their regressions in order to investigate the effects of various policy variables on growth rates.[11]

Equation (23) can be estimated, in principle, by the ordinary least squares (OLS) method, by assuming that the ratio of imports in investment is independent of the unmeasured country-specific error terms ϵ_i. However, a certain degree of correlation may exist: correlation between the imports of capital goods and the error term may arise, for instance, if any unobserved macroeconomic policy affects both imports of capital goods and growth rate of income. If the correlation were present, unbiased estimates of the coefficients should be obtained by using instrument variables, which are correlated with the independent variable but not with the error terms. Thus, equation (23) is estimated by the two-stage least squares(2SLS) method in addition to the OLS method. As discussed in Section Ⅳ, the ratio of imports in investment can be determined by each economy's structural characteristics, such as natural resources, natural trade barrier, and the trade restrictions imposed by government. Thus, in the 2SLS estimation of equation (23), we use the following variables as instruments: land size (as a measure of total resources), distance from trade partners (as a measure of the natural barriers) and tariff rate (as a measure of trade distortion) in addition to the included I variables. Lee(1993), for instance, shows that in a sample of 79 countries the share of imports in GDP are significantly relates to a log value of land size, a log value of distance from trading partners, and measures of trade distortions such as tariff rate and black market exchange rate premium.

2. Data

For the empirical investigation, most of the national account data are from the Summers and Heston(1991) data set. The growth rate is the annual rate of per capita real GDP growth during the period of 1960~85. The per capita real GDP in 1960 is used for the initial income. The investment rate is measured by the average share of

11) One controversy is to include the investment rate as one of the independent variables in the estimation. Investment may be endogenously determined. For example, in Barro(1991) and Romer(1990), both the investment rate and the growth rate are driven by the initial human capital stock. When the regression uses a subset of I excluding the investment rate in considering this endogeneity problem, there is no significant change in the estimation results.

real investment in real GDP during 1960~85. The initial secondary school enrollment ratio comes from Barro(1991). Data for the other instrument variables, such as land size, distance from trading partners, and tariff rate, come from Lee(1993). The distance is an import-weighted average distance of each country to major world exporting countries. The tariff rate is an import-weighted tariff rate on imported capital and intermediate goods.

Data on imports of capital goods are collected from the data tape of the OECD Trade Series C. This data reports total value of machinery exports from OECD countries to their individual trading partner.[12] This measure is a good approximation of the total value of capital goods imported by each country from its higher-income trade partners at world prices. Then, the value of domestic capital goods is calculated by subtracting the value of total imported capital goods from total investment, which is the total value of investment in terms of the PPP-adjusted current international price in Summers and Heston(1991). The ratio of imports in investment is measured by the value of the imported capital goods divided by the value of the domestic capital goods.

3. Estimation results

Table 2 presents the estimation results of equations (23) using the compiled cross-section data of the 89 sample countries.[13] The results confirm that there is a positive relationship between the ratio of imports in investment and the growth rates of per capita income, when the other important variables are controlled. The first regression shows that for a given value of initial income, school enrollment, population growth, and investment rate countries grow faster if they use more imported capital goods than domestic capital goods in building their capital stock. The estimated

12) When the sum of machinery and transport equipment is used for a measure of capital goods, the regression results change only slightly.

13) The data set includes all countries for which data can be assembled except Sudan, which is an extreme outlier. Sudan is the only country in which the value of imported capital goods is larger than the value of domestic capital goods over the sample period. The credibility of the Summers and Heston data on Sudan is unclear. (Sudan's total investment rate on average is 0.018 in Summers and Heston(1991), which it was 0.132 in Summers and Heston(1988)).

coefficient on the ratio of imports in investment is positive and significant (the coefficient = 0.029 and t-value = 3.1). It implies that an increase of 0.1 in the ratio of imports in investment leads to an increase in the growth of per capita income of 0.3 percent per year. The importance of foreign capital goods in economic growth is much stronger in the second regression, in which the 2SLS estimation method is used: the estimation coefficient jumps to 0.071 (t-value = 2.8).[14]

Since the ratio of imports in investment has a significant, independent effect on growth rates when the investment rates are controlled, imported capital goods increase growth rates directly by enhancing the productivity of capital. Thus, the regression results imply that imported capital goods have a much higher productivity than domestically-produced capital goods. Therefore, by switching a portion of GDP devoted to the purchase of domestic capital goods for investment to the importation of cheap foreign capital goods, countries can grow faster.

Regression (3) shown in Table 2 includes the share of imports in GDP in the regression. If foreign trade affects growth mainly by providing access to cheaper improted capital goods, the usual trade indicators, such as share of exports or that of imports in GDP, may not be accurate measures for the purpose of investigating the link between trade and growth. This conjecture can be tested by estimating the equation (23) with the additional independent variable: the share of total imports in GDP.[15] Regression result shows that, when the ratio of imports in investment is included, the share of total imports in GDP turns out insignificant. [16] Thus, the result indicates that

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14) The orthogonality between the instruments and the error term in the growth rate equation(23) is tested by using a standard error-orthogonality test, which involves regressing residuals from the second-stage regression on the set of instrument variables: the R^2 from this regression times N, which is the sample size, asymptotically follows a chi-squared distribution. The chi-squared test of the null hypothesis of orthogonality fails to reject at the 0.10 level.

15) Data come from Summer and Heston(1991). Due to the availability of the data, the sample size shrinks to 84 countries as it excludes Angola, Guinea, Iran, Iraq, and Taiwan from the 89 country sample.

16) Many economists claim that there is a positive, though weak, correlation between the share of total imports in GDP and the growth rate (see Harrison(1991), and Quah and Rauch(1990)). In contrast, Levine and Renelt(1992) find that once investment is controlled, measures of trade--the import share in GDP and its growth--are insignificantly related to growth.

the importation of capital goods, not total imports, is the key factor that links trade to economic growth.

Levine and Renelt(1992) note that cross-country relationship between long-run growth rates and macroeconomic policy indicators can change a lot, depending on which variables are included in the regressions. In considering this skepticism regarding the cross-country regressions, regression (4) of Table 3 includes a more comprehensive set of right-hand side variables by adding government consumption, political instability (number of revolutions and coups, and number of assassination), and deviation of investment deflator, such as in Barro(1991). With these additional explanatory variables held constant, the estimated coefficient of the import ratio of investment is still significant (the coefficient = 0.058 and t-value = 2.7). The significant positive association between the ratio of imports in investment and the growth rate appears in Figure 2 where the vertical axis is the per capita growth rate net of the value predicted by the regressors other than the ratio of imports in investment.

One would wonder whether the ratio of imports in investment is proxying for some other unknown determinant of growth that is specific to a group of countries. Regression (5) of Table 3 adds three continent dummies for countries in Sub-Saharan Africa, Latin America and East Asia, and a dummy for OPEC countries to the regression. Again, the positive effect of capital goods import on growth appears significantly even when the continent dummies held constant (the coefficient = 0.056 and t-value = 2.4).

The regressions of Table 2 includes all countries-both less developed countries (LDCs) and developed countries (DCs) - in the sample. Although the benefits from cheap foreign capital goods can be applied to any country that imports capital goods from the higher income countries, the LDCs would get more benefits from the importation of cheap capital goods. Regressions (1) to (4) of Table 3 presents the estimation results of equation (23) when the sample is restricted to only 68 non-OECD countries. The results show that the estimated coefficient of the ratio of imports in

investment are still significantly positive in the sample of 68 non-OECD countries. In contrast, however, the ratio of capital goods imports shows a negative sign in the sample of OECD countries alone (regression (5) of Table 3). Thus, the significant positive association between the capital goods imports and the growth rate are mainly from the LDCs, as predicted from the model.

VI. Conclusions

This paper examines the role of capital goods imports on economic growth. Using an endogenous growth framework of a two-sector open economy where a "core" capital goods sector, which is produced by combining foreign and domestic capital goods, is an "engine of growth", the model points out that lower income countries with relatively smaller capital stocks have a comparative advantage in the consumption goods sector and that they can grow faster by importing relatively cheaper capital goods from higher income countries.

The theoretical predictions accord with the regression results using cross-country data for the period of 1960~85. The ratio of imported to domestic capital goods in the investment sector has a significant positive effect on the per capita income growth rates across countries, in particular, in developing countries. Thus, it is implied that imported capital goods have a higher productivity than domestically-produced capital goods. The growth rate is higher in a country that uses relatively more imported capital goods for the production of capital stock than other countries at the same stage of economic development.

This paper highlights the importance of the composition of investment in addition to the size of total investment in determining economic growth. While the importance of investment in economic growth has always been emphasized in literature, the issue of how to build the investment sector has been somewhat neglected. This paper shows that the ratio of foreign to domestic components of investment is an important

factor in economic growth. More use of imported inputs, which are relatively cheaper and more efficient than domestic capital goods, increases efficiency of capital accumulation and thereby growth rates of income. Therefore, any trade distortions that restrict the importation of capital goods reduce real incomes in the long run.

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Table 1. Price of Consumption Goods and Capital Goods, 1980

Country group		(1)	(2)	(3)	(4)	(5)	(6)	All
Number of countries		12	14	10	10	8	6	60
Per capita GDP (% of the U.S. GDP)		<10%	10-20	20-35	35-60	60-75	>75%	
Consumption goods								
Food	(A)	106	105	106	102	96	91	104
Capital goods								
Domestic investment	(B)	155	146	112	95	93	94	115
Producers durables	(C)	149	172	131	115	84	84	124
Construction	(D)	170	135	98	87	99	100	110
Relative prices of Capital goods to consumption goods								
B/A		1.46	1.39	1.06	0.93	0.97	1.03	1.11
C/A		1.41	1.64	1.24	1.13	0.88	0.92	1.19
D/A		1.60	1.29	0.92	0.85	1.03	1.09	1.06

Note: The price of each aggregate commodity is an unweighted average for the countries in each income group when the price of that commodity for the United States is normalized to 100. The countries are grouped by per capita GDP, which is shown as a percent of the U.S. per capita GDP.

Source: Calculated from Summers and Heston(1991), Table 1, p.338.

Table 2. Imported Capital Goods and Economic Growth in a Sample of 89 Countries, 1960~85.

	(1)	(2)	(3)	(4)	(5)
Estimation method	OLS	2SLS	OLS	2SLS	2SLS
No. of obs.	89	89	84	89	89
Constant	-0.0143 (0.0086)	-0.0279 (0.0121)	-0.0118 (0.0093)	-0.0036 (0.0115)	0.0064 (0.0125)
Initial income	-0.0019 (0.0004)	-0.0020 (0.0004)	-0.0018 (0.0004)	-0.0023 (0.0004)	-0.0022 (0.0003)
Secondary enroll. rate	0.0368 (0.0143)	0.0360 (0.0158)	0.0314 (0.0144)	0.0323 (0.0139)	0.0192 (0.0132)
Population growth	0.3789 (0.2490)	0.4337 (0.2774)	0.3187 (0.2579)	0.4959 (0.2460)	0.5131 (0.2628)
Investment rate	0.0962 (0.0259)	0.1226 (0.0322)	0.0963 (0.0330)	0.0909 (0.0286)	0.0644 (0.0312)
Ratio of imports in investment	0.0294 (0.0095)	0.0706 (0.0252)	0.0278 (0.0145)	0.0584 (0.0215)	0.0559 (0.0230)
Import/GDP			0.0012 (0.0210)		
Gov.-cons./GDP				-0.0945 (0.0273)	-0.0629 (0.0278)
Revolution				-0.0070 (0.0073)	-0.0044 (0.0070)
Assassination				-0.0172 (0.0176)	-0.0212 (0.0189)
Deviation of invest. deflator				-0.0149 (0.0072)	-0.0133 (0.0070)
Sub-Saharan Africa					-0.0178 (0.0070)
Latin America					-0.0072 (0.0044)
OPEC					-0.0115 (0.0071)
East Asia					0.0038 (0.0064)
R^2	0.45	0.33	0.46	0.52	0.62

Table 2 Continued.

Notes: Standard errors are in parentheses. The sample includes all countries-both OECD and non-OECD countries. The dependent variable is the annual growth rate of real GDP per capita over the period 1960~85. The two-stage least squares (2SLS) technique uses a log value of land size and a log value of distance from trading partners, a tariff rate in addition to the other independent variables in the table as instruments for the ratio of imported to domestic capital goods.

The ratio of imports in investment is measured as the value of imported capital goods(which is the value of machinery exports from OECD countries to each individual country) divided by the value of the domestic capital goods (which is defined by subtracting the value of the imported capital goods from the total value of investment in terms of PPP-adjusted current international prices from Summers and Heston(1991)).

Initial income is real per capital GDP in 1960 in terms of the thousand current international price. Population growth is the annual growth rate of total population over the period of 1960~85. Investment rate is the annual average over the same period of the ratio of real investment to real GDP. Import/GDP is the annual average over the sample period of the ratio of total imports to GDP in terms of current international prices. These variables are from Summers and Heston(1991).

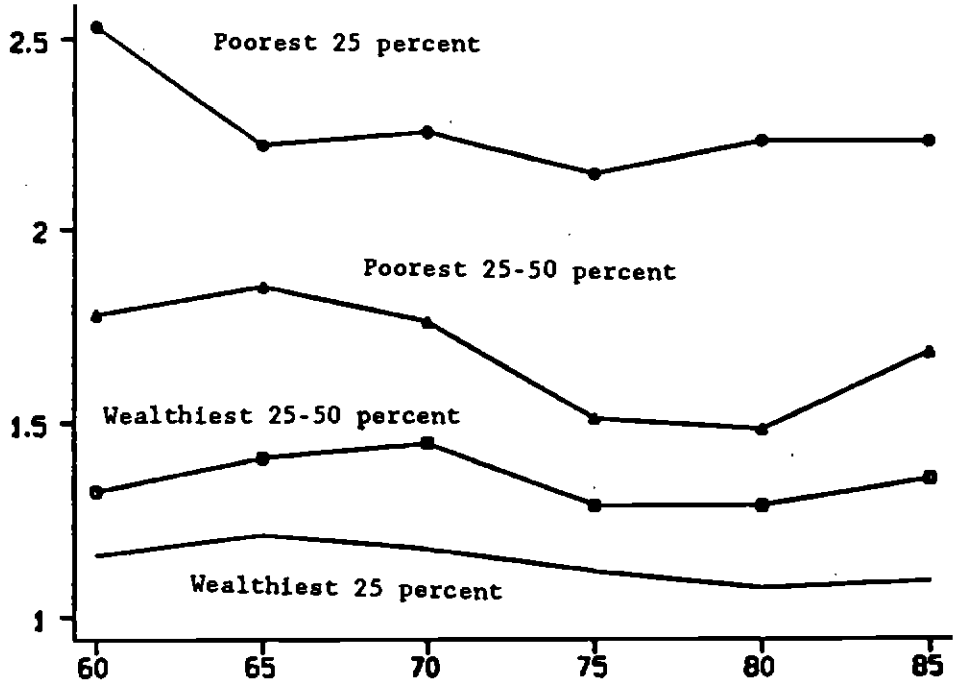
Secondary school enrollment rate is the value in 1960. Gov. -cons/GDP is the annual average over the sample period of the ratio of real government consumption (exclusive of defense and education) to real GDP. Revolution is number of revolutions and coups per year. Assassination is number of assassination per million population per year. Deviation of investment deflator is measured as the magnitude of the deviation of 1960 PPP value of investment deflator from the mean value. These variables are taken from Barro(1991).

Table 3. Imported Capital Goods and Economic Growth in a Sub-sample of Countries, 1960~85.

	(1)	(2)	(3)	(4)	(5)
Estimation method	OLS	2SLS	2SLS	2SLS	2SLS
No. of obs.	68 (LDCs)	68 (LDCs)	68 (LDCs)	68 (LDCs)	21 (DCs)
Constant	-0.0267 (0.0108)	-0.0361 (0.0139)	-0.0127 (0.0137)	-0.0001 (0.0147)	0.0323 (0.0127)
Initial income	-0.0025 (0.0005)	-0.0025 (0.0005)	-0.0028 (0.0005)	-0.0024 (0.0005)	-0.0028 (0.0007)
Secondary enroll. rate	0.0798 (0.0269)	0.0723 (0.0296)	0.0680 (0.275)	0.0367 (0.0287)	0.0111 (0.0082)
Population growth	0.8858 (0.3728)	0.8461 (0.4027)	0.8640 (0.3646)	0.7603 (0.3606)	-0.3657 (0.3369)
Investment rate	0.0572 (0.0350)	0.0860 (0.0442)	0.0608 (0.0395)	0.0449 (0.0453)	0.0568 (0.0336)
Ratio of imports in investment	0.0326 (0.0108)	0.0666 (0.0297)	0.0583 (0.0259)	0.0549 (0.0291)	-0.0365 (0.0177)
Gov.-cons./GDP			-0.0862 (0.0322)	-0.0605 (0.0331)	
Revolution			-0.0084 (0.0080)	-0.0062 (0.0079)	
Assassination			-0.0227 (0.0199)	-0.0218 (0.0212)	
Deviation of invest. deflator			-0.0149 (0.0080)	-0.0132 (0.0081)	
Sub-Saharan Africa				-0.0156 (0.0063)	
Latin America				-0.0053 (0.0053)	
OPEC				-0.0108 (0.0071)	
East Asia				0.0060 (0.0081)	
R^2	0.46	0.38	0.55	0.64	0.67

Notes: The sample includes 68 non-OECD countries(LDCs) for regression 1-4 and 21 OECD countries(DCs) for regression 5. See notes to Table 2.

Figure 1. Relative Price of Capital Goods By Income Group, 1960-85
(Ratio of investment deflator to consumption deflator
in the four groups of 99 countries)



Source: Summers and Heston (1991)

Figure 2. Partial Association between Growth Rate and Ratio of Imports in Investment (Regression 4, Table 2)