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TRADE AS A CARRIER OF KNOWLEDGE IN ECONOMIC GROWTH

by

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ABSTRACT

This paper presents empirical evidence of the effects of trade on economic growth. The main contribution of this study is that the "cumulated past volume of exports and imports" is taken as the carrier of knowledge or the source of externality, while the previous studies assume that only the export sector generates positive externalities. We also investigate the contribution of exports as a source of foreign exchange. The empirical test on 119 countries indicates that trade, being the carrier of knowledge, plays an important role in contributing to economic growth. However, the empirical test does not show any correlation between exports and the reduction of import shortage, which is presumed to be a binding constraint on output growth.
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I. Introduction

There is a widespread view that outward-looking trade policies contribute to
economic growth. An analysis of the relationship between trade orientation and
economic growth is done in two stages. First, it is assumed that more “liberal trade
policies” result in faster growth of exports. Then it is shown that faster growth of exports
contributes to a more rapid rate of growth of domestic products (GDP). Recent studies
take a production function approach in which exports enter into the production function
in addition to such conventional inputs as labor and capital.1 Within this framework
exports growth contributes to GDP growth in two fundamental ways. First, it is
hypothesized that the export sector generates positive externalities on the rest of the
economy through more efficient management and improved production techniques.
Second, it is argued that, because the export sector is more efficient, a factor productivity
differential exists in favor of the export sector. So a larger allocation of resources in the
exports sector contributes to a higher GDP growth. In empirical testing most of these
studies have used cross-country data, and, with some qualification, the statistical results
support the hypothesis that growth of exports contributes to the growth of output.
Typically, these empirical studies are conducted by using a multiple-regression equation

1See, for example, Michalopoulos and Jay (1973), Michaely (1977), Balassa (1978; 1985), Tyler
in which a measure of export performance is included in addition to capital stock and some measure of employment to explain the variation in the observed growth of output.

However, there may be other channels through which export performance may affect economic growth. One problem facing developing countries is the shortage of foreign exchange that is needed to import capital goods for economic development. Most of the previous analyses conducted within the production function framework ignore the role of exports as the main sources of foreign exchange for purchasing the intermediate goods. Export expansion affects economic growth by relaxing the foreign exchange constraint. So the linkage between trade liberalization and GDP growth should also take into account the role of imports in economic growth. Exports generate more foreign exchange. If there is shortage of foreign exchange, export expansion makes it possible to get much needed intermediate and capital goods. By allowing an increase in imports of intermediate inputs, export expansion relaxes this crucial bottleneck and hence positively affects output growth. Esfahani (1991) takes this approach to highlight the role of exports in acquiring more capital inputs. He emphasizes the role of exports as the main source of foreign exchange for imports of intermediate and capital goods. In his empirical work on the semi-industrialized countries, Esfahani shows that the positive contribution of exports to GDP growth is attributed more to the reduction of import shortages than to externalities generated by the export sector. The analysis of Esfahani is extended in this study to include growth of intermediate imports as a relevant variable in the study of the relationship between trade orientation and economic growth.

Earlier studies on exports-growth relationship regard exports as the provider of externalities for the rest of the economy. However, there are other studies that emphasize
the importance of trade as a source of externalities transmitted through interactions with the rest of the world. In their study of the growth performance of a small country, Grossman and Helpman (1991) found that the scientific and technological knowledge flowing from abroad are related to the extent of foreign trade. Their analysis shows that the level of scientific and technological know-how is related to the number of contacts that local firms make with their counterparts in other countries. The number of contacts most probably increases with the extent of commercial exchange. Models by Riviera-Batiz and Romer (1991) and Romer (1990) show that expanded international trade increases the availability of specialized inputs and, thus, raises growth rates as economies become increasingly open to international trade. In his study of the economic development strategy of poor countries, Romer (1993) introduces two concepts known as idea gaps and object gaps. These two concepts highlight the importance of a country's exposure to international trade. If a developing country suffers from lack of physical objects, like material inputs, then it is said that there exists an object gap and the country has no easy solution to acquiring them for economic development since filling object gaps involves resource costs. It may take a long time for a poor country to attain the higher standard of living of a rich country because of costs associated with filling object gaps. This view on underdevelopment offers a gloomy prospect for poor countries that want to grow fast. If a country does not have relevant ideas for economic development, then there exists what is termed as idea gaps. Idea gaps are relatively less costly to fill in than object gaps, because acquiring ideas involves lower opportunity costs. In the context of economic development, examples of ideas are related to information regarding packaging, marketing, distribution, inventory control, payments systems, information
systems, transactions processing, quality control, and worker motivation. These are all used in the creation of economic value in a modern economy.

In this study in measuring trade, exports and imports are lumped together and the volume of trade is taken as the source of externalities transmitted through interactions with the rest of the world. An increase in trade implies that a country has more interaction with other countries. This interaction means that the developing country has access to a higher level of production technology. It is assumed that the flow of relevant knowledge through interaction with foreign countries is a function of the volume of exports and imports. At any point in time, the stock of knowledge acquired by the developing countries can be proxied by the cumulative amount of trade. The amount of trade during a time period like a year is a flow variable and can be regarded as an addition to the stock of trade. The addition of new ideas brought about by an increase in trade should be included in the knowledge variable. The other important assumption is the spill-over aspect of accumulated knowledge generated by accumulated trade. This becomes public knowledge that can be used by other firms at no costs. The stock of trade accumulated over past years represents the externality effects on production and is included as a relevant variable representing externalities.

Section II is devoted to developing an analytical framework based on the neoclassical production function to show the relationship between exports growth and income growth. The new feature of this model is the addition of accumulated trade as

\[2\] However, some portion of old ideas depreciates. To make the model simple, this is ignored, and it is assumed that externalities or new ideas are the positive function of accumulation of trade. Here, new ideas, externalities, and knowledge are used interchangeably in a sense that those are by-products of trade.
carrier of knowledge. The advantages of this model are threefold. First, in an econometric analysis using this framework it is possible to measure and test the marginal factor productivity differentials between sectors directly from the model. In previous export-growth studies, disentangling the marginal factor productivity differentials from other effects was somewhat arbitrary. Second, the role of trade as a source of beneficial externalities in an economy can be measured and tested directly from the model. Third, in this framework it becomes possible to show whether the observable positive export-GDP association, which is attributed in previous studies to possible externalities of competition in world markets, is mainly due to reduction of import shortages made possible by expansion of exports. The implication is that one should reexamine the role of export promotion in a country that cannot obtain sufficient foreign aid or capital.

The rest of the paper is organized as follows. Section III presents the empirical part based on the baseline model. Section IV reports the empirical findings. Section VI concludes and makes suggestions for future research.

II. Baseline Model

The model developed in this essay is in some basic respects similar to those of Feder (1982) and Esfahani (1991). The economy is divided into two sectors, one of which is called the domestic goods sector and the other is the export sector. The domestic goods sector produces goods for domestic use whereas the export sector produces only for exports.

The total output, Y, consists of production of the domestic-goods sector, D, and that of the exports sector, X.
Here, the total output is the sum of all outputs produced in the different processes. The value added in the process is produced by the total capital, K, and the total labor, L, available in the economy. To capture the potential externality effect that trade may bring into the economy, productivity of factors used in production in the D sector is assumed to depend on the accumulated trade, which is the sum of total exports and imports up to the current time. Both exports and imports are viewed as carriers of knowledge from the outside world. So at time \( t_0 \), the total trade made from past years indicates the total accumulated knowledge that positively affects other activities. These externality effects of accumulated trade are assumed to take the form of improved technology, training of productive labor, and development of more efficient management.

To allow for the effects of binding foreign exchange shortage in the supply of imported intermediate goods, an intermediate good, N, is included in production of each product. N is defined as a composite good produced by imported intermediate good, M, and domestic products, R.

\[
N = J(M, R).
\]  

The intermediate good production function is assumed to be a well-behaved, constant-returns-to-scale production function.

We define the production function of a representative firm \( i \) in the domestic goods sector as

\[
D_i = G(T/b_S) F(K_{di}, L_{di}, N_{di})
\]

where \( K_{di}, L_{di}, \) and \( N_{di} \) are, respectively, capital, labor, and intermediate goods used by firm \( i \) in that sector to produce its output, \( D_i \). \( F \) is a smooth, constant-returns-to-scale
production function, and G is a productivity factor that depends on the size of the accumulated stock of trade, T, per firm in the domestic-goods sector relative to a measure of the scale of operation of firm \( i \), \( S_i \). As \( b_d \) stands for the number of firms in that sector, it is reasonable to use \( T/b_d S_i \) rather than the absolute amount of the accumulated stock of trade. This is so because the overall productivity increase in the domestic sector is likely to be proportional to the relative rather than to the absolute size of the accumulated stock of trade. Equation (3) basically implies that the domestic goods sector enjoys the benefits of accumulated knowledge, i.e., positive externality, acquired through trade with foreign countries. How much benefit does the representative firm producing domestic goods get from accumulated trade? This depends on the ratio of the accumulated stock of trade relative to its total activity, \( S_i \). Thus, G, the productivity index, is assumed to depend on \( (T/b_d)(1/S_i) \).

To make the model operational, we make the following assumption: 

\[
G(T/b_d S_i) = 1 + \theta(T/b_d S_i)
\]

The scale of activity in the domestic goods sector is designated as \( S_i \) and depends on \( K_{di}, L_{di}, \) and \( N_{di} \). Hence, we write \( S_i = F(K_{di}, L_{di}, N_{di}) \), which indicates the amount produced by the \( i^{th} \) firm if there is no externality effect generated by the total accumulated trade, \( T \). However, the efficiency of the domestic goods sector depends on the total trade. So we write

\[
D_i = F(K_{di}, L_{di}, N_{di}) + \theta(T/b_d S_i) F(K_{di}, L_{di}, N_{di})
\]  

To simplify the model, it is hypothesized that \( \theta(T/b_d S_i) \) takes the form, \( \theta T/b_d S_i \). Then equation (4) becomes

\[
D_i = F(K_{di}, L_{di}, N_{di}) + \theta T/b_d S_i
\]
Assuming that all firms use the same amount of inputs and denoting the total inputs used in the domestic goods sector by $K_d = b_d K_{d^*}$, $L_d = b_d L_{d^*}$, and $N_d = b_d N_{d^*}$, the aggregate production function of the domestic-goods sector takes the following form:

$$D = \theta T + F(K_d, L_d, N_d).$$  \hspace{1cm} (6)

$\theta T$ represents the productivity factor, which depends on the accumulated knowledge transmitted through trade. Although old knowledge becomes obsolete with the passage of time, to keep the model simple and predictions tractable it is assumed that knowledge once obtained persists for a long time.

If $K_x$, $L_x$, and $N_x$ are, respectively, the capital, labor, and intermediate goods used in the export sector, the production function for the export sector can be written as

$$X = H(K_x, L_x, N_x),$$  \hspace{1cm} (7)

where $H$ is a smooth and constant-returns-to-scale production function.

In addition to the externality effects captured in the domestic-goods sector, it is assumed that marginal factor productivities are higher in the export sector than in the domestic-goods sector. This is in line with Feder (1982), who postulates that, due to a more competitive environment, a higher perceived uncertainty, or more stringent regulations and constraints in the export sector, there exists a productivity differential in favor of the export sector. This concept of productivity differential is formalized in the following manner:

$$\frac{H_K}{F_K} = \frac{H_L}{F_L} = \frac{H_N}{F_N} = 1 + \delta,$$  \hspace{1cm} (8)
where the subscripts denote partial derivatives and $\delta$ is a factor that measures the difference in the marginal factor productivities of inputs in two sectors. If the factors are perfectly mobile in the two sectors, $\delta$ will be equal to zero.

Equation (8) provides a basis to derive the relationship between the rate of growth of total output and the rates of growth of $K$, $L$, $N$, and $T$. To estimate empirically the effects of factor productivity differential and externalities within the present framework, further mathematical manipulation is needed. Total differential of equation (1), (6), and (7) and mathematical manipulation using (8) yields

$$dY = F_KdK + F_LdL + F_NdM + F_TdR + 0dT + \left[ \frac{\delta}{1+\delta} \right] dX.$$  

If the growth rate of each variable is denoted by its corresponding lower case letter, (9) can be written as

$$\frac{y}{y} = \frac{K}{Y} F_Kk + \frac{L}{Y} F_Ll + \frac{M}{Y} F_NJ_M M + \frac{R}{Y} F_TJ_T R + \theta \frac{dT}{Y} + \frac{X}{Y} \left[ \frac{\delta}{1+\delta} \right] x.$$  

Equation (10) reduces to the familiar neoclassical growth equation when $\theta = \delta = 0$ and when introduction of intermediate goods into the production function is not considered, i.e., when the third and fourth terms are ignored. $\delta = 0$ implies that factor markets are competitive and so there are no productivity differentials between sectors. $\theta = 0$ excludes the possibility of externality, which is one of the assumptions of the neoclassical model. The first and second terms of equation (10) indicate the contribution of capital and the contribution of labor respectively to the observed growth rate. The economic interpretation of the third and the forth term is discussed later. The fifth term, $\theta \frac{dT}{Y}$,
captures the externality effect of trade on the rate of growth of the total output. The last term, \( \frac{X}{Y} \left[ \frac{\delta}{1+\delta} \right] x \), represents the effects of export growth on the rate of growth of total output. \( \delta/(1 + \delta) \) can be rewritten as \( \delta/(1 + \delta) = (H_k - F_k)/H_k = (H_L - F_L)/H_L \). This captures the intersectoral productivity differential as a percentage of the productivity in the export sector. This can be interpreted as the source of gains brought about by shifting factors from a low productivity sector to a high productivity sector.

The derivation of equation (10) is based on the Esfahani (1991) model with the difference that cumulated trade, \( T \), enters the growth equation in this model. To derive the GDP growth equation from equation (10), some further mathematical manipulation is required. Let \( G \) be the real GDP of the economy and the price indices of \( Y, G, \) and \( M \) be denoted by \( P, P_g, \) and \( P_m \), respectively. Then by definition, \( P_g G = P_Y Y - P_m M - P_R \). This indicates that GDP is the difference between total output and imported and domestically produced intermediate goods. In terms of growth rate, this becomes

\[
g = \frac{1}{s_g Y} \left[ \frac{P_m M}{s_g P_Y} m - \frac{R}{s_g Y} \right] \]

(11)

where \( g \) is the rate of growth of GCP, and \( s_g = P_g G / P_Y \) is the share of GDP in total output. Substitution of (10) into (11) results in

\[
g = \frac{KF_k}{s_g Y} k + \frac{LF_L}{s_g Y} l + \frac{X}{s_g Y} \left[ \frac{\delta}{1+\delta} \right] x + \left[ F_n J_m - \frac{P_m P}{P} \right] \frac{M}{s_g Y} m \\
+ \left[ F_n J_r - l \right] \frac{R}{s_g Y} r + \frac{\theta}{s_g Y} dT
\]

(12)

The third term in equation (12) describes the effect of sectoral productivity differences on GDP growth. It is now possible to measure and test the marginal factor
productivity differentials between sectors directly from equation (12). The last term represents the effect of externality generated by accumulated trade on GDP growth. This term shows how the role of trade, as a source of beneficial externalities in an economy, can be measured and tested directly from the model.

The economic implication of the term related to imported intermediate goods in equation (12) is explained below. It is assumed that there are n identical profit-maximizing firms in the domestic goods sector and that all firms in the domestic goods sector face foreign exchange shortage in procuring imported intermediate goods, M, but they do not face any constraint in purchasing domestically produced intermediate goods, R. Each firm would maximize its own profit by equating the value of marginal products of capital, labor, and home-produced intermediate goods to the price of each input. The price of imported intermediate goods, however, would not be equated to the value of its marginal product, if there is foreign exchange shortage in the economy. To make the analysis simple, it is assumed that the economy is managed by a benevolent social planner, who dictates the amount of production and seeks to maximize the profit of each firm. Since each firm has an identical production function and faces the same input prices, the solution will be the same as that for the decentralized economy. The maximization problem of a benevolent social planner takes the form

$$\text{Max } \Pi = PF(K_d, L_d, N_d) - \gamma K_d - \omega L_d - PR - P_m M \quad \text{subject to } P_m M \leq R^*,$$

where $\gamma$ is the rental price of capital, $\omega$ is the wage rate, and $R^*$ denotes the foreign exchange constraint. In the constrained optimization problem in equation (13), let $\lambda$ be the Lagrangian multiplier associated with the foreign exchange constraint. One of the
first-order necessary conditions in the constrained maximization problem is $F_N J_R = 1$, which ensures that the fifth term, $(F_N J_R - 1)$, of (12) will vanish. The Lagrange multiplier, $\lambda$, represents the extra profit that this economy can get when the foreign exchange constraint is relaxed by one unit. $\lambda$ is therefore interpreted as the shadow price or shadow value of foreign exchange. The complementary-slackness condition, $\lambda (R^* - P_m M) = 0$, implies that if $\lambda$ is strictly positive, then the constraint of foreign-exchange shortage must be binding.

This condition has an important implication for the role of imports in the model. Imports may not play any role in the analysis of GDP performance if the constraint is not binding. In that case, $\lambda$ is equal to zero and the first-order condition will be $F_N J_M = (P_m / P)$. Then the coefficient on the import growth rate must be equal to zero. If it is binding, the first-order necessary condition, $F_N J_M = (1 + \lambda) P_m / P$, implies that the level of intermediate imports deviates from its unconstrained level. Then one should include the import growth rate as one of explanatory variables in the model. The coefficient of $(M/s_\text{Y})m$ in equation (12) is $[F_N J_m - P_m / P]$. The analysis presented above indicates that this terms can be reduced to $\lambda (P_m / P)$. The empirical significance of $\lambda$ will be explained in later sections. Note that a nonnegative value of $\lambda$ implies that the level of intermediate imports may be less than the optimum, and exclusion of this variable from the model may bias the coefficient of trade variable.

Equation (12) is not in an empirically testable form. This baseline model must be parameterized for estimation. The empirical version of the model is derived in the next section.
III. Empirical Model

The model in equation (12) needs to be developed in an empirically testable form. For this purpose we assume that first, the function $F$—the production function of domestic goods sector—takes the Cobb-Douglas functional form for actual estimation. Second, coefficients of equation (12) are classified as cross-country-invariants or as cross-country-variants. The coefficients of capital, labor, and export growth rates are assumed to be constant across countries, and those associated with trade and import are assumed to vary across countries.

Let $F$ be defined as

$$ F(K_d, L_d, N_d) = BK_d^a L_d^b N_d^γ, \tag{14} $$

where $B$, $α$, $β$, and $γ$ are constant parameters. The capital growth term in equation (12) can be written as

$$ \frac{KF_K}{s_g Y} k = \frac{KF_K}{s_g Y} \left( \frac{I_n}{K} \right) = α \left( \frac{F}{K_d} \right) \left( \frac{I_n}{I} \right) \left( \frac{PI}{Pg G} \right) = α' k^*, \tag{15} $$

where $I$ and $I_n$ are the gross and net investments in the economy, respectively, $k^* = PI/P_g G$, and $α' = α(F/K_d)(I_n/I)$. If it is assumed that a linear relationship exists between the marginal productivity of capital and the average product of capital in the domestic sector and that the price of capital relative to the price of output is more or less the same across sample countries, $F/K_d$ will be approximately constant and $α'$ may be taken as an easily estimable constant parameter. This form takes the share of investment in GDP, $k^*$, as the explanatory variable for which data are available.

Substituting $F_L$ in the labor growth term yields
where $\beta = (\beta{s_g})[(F/L_d)/(Y/L)]$. If it is assumed that the share of GDP in total output and the average output per worker in the domestic-sector net of the trade externality effect relative to the economy-wide output-labor ratio are approximately proportional across observations, $\beta'$ can be easily estimated as another constant parameter. Though this specification is not an ideal form from a theoretical point of view, fortunately, the estimates of the coefficients of $x$, $m$, and $dT$, which interest us most, are not very sensitive to the specification of the capital and labor growth terms.

The export growth term in equation (12) is written as $\gamma s^*_x x$, where $s^*_x = PX / P_g G$ is the share of exports in GDP and $\gamma = \delta(1+\delta)$ is a parameter that can be estimated by treating $s^*_x x$ as an explanatory variable. In Feder (1982) and Esfahani (1991), $\gamma$ is a combination of externality and productivity differential effect. In this study, the coefficient of the export growth term shows just the productivity differential effect in the two sectors since the externality effect is extracted from the trade term. If it is assumed that the productivity differentials between sectors are more or less the same across sample countries, $\gamma$ can also be taken as a constant parameter across countries.

To specify the parameters of the import-growth term in equation (12), remember that $\lambda$ is the shadow price of the foreign-exchange constraint as defined in our earlier discussion. Another interpretation of $\lambda$ is that it is a measure of import shortage as shown in the relationship, $F_{N,M} = (1+\lambda)P_m/P$. Using this relationship, we can write the import-
growth term in equation (12) as \( s_m \) under the assumption of \( \lambda \neq 0 \), where \( s_m = (P_m M)/(P_g G) \) is the import-GDP ratio.

It is reasonable to assume that \( \lambda \) is not a constant parameter since the intensity of import shortage varies across countries. The marginal product of imports, \( F_N J_M \), and \( \lambda \) are expected to rise to the extent that the import-GDP ratio in a country falls short of its expected level given the country’s size and level of development. As we emphasize the first-order effects only, \( \lambda \) can be written as \( \lambda = \lambda_0 + \lambda_1 r_m \), where \( r_m \) is the measure of openness or the deviation of a country’s import-GDP ratio from its “expected” value. The “expected value” of a country’s import-GDP ratio could be thought of as some function of size of economy and geographical characteristics of a country.

The deviation of the actual from the expected import-GDP, \( r_m \), may represent import shortage of a country, though other economic and trade policies may affect the deviation. Several authors suggest ways to measure the deviation of actual from the expected level of imports. Chenery and Syrquin (1975) suggest the residuals from the regression of the import-GDP ratio on GDP per capita, square of GDP per capita, and labor force (or population) as proxies of deviation of actual from expected level of imports.

Another approach, introduced by Leamer (1988), uses a theoretical model to predict the pattern and volume of trade in the absence of protection. Leamer then measures “openness” as a function of the extent to which actual trade deviates from the pattern of trade predicted by the model. Esfahani (1991) uses, as a measure of openness,
the residuals in the following regression of total import-GDP ratio, $s_m^*$, on variables that are considered as its main determinants:

$$s_m^* = \mu_0 + \mu_1(\log G_{pc}) + \mu_2(\log G_{pc})^2 + \mu_3(\log L) + \mu_4(\log L)^2 + \mu_5(\log A) + \mu_6(\log A)^2 + r_m$$  \hspace{1cm} (17)

where $G_{pc}$ is the GDP per capita and $A$ is the area of the country. The size of the labor force is expected to have a negative effect on the import-GDP ratio because of wider markets and greater possibilities of division of labor in countries with larger labor forces. The rationale for including area as an explanatory variable is that geography is a powerful determinant of the import-GDP ratio. Countries with large area are expected to have a greater variety of complementary natural resources, and so the need for imports is reduced. Also, larger countries may engage in less trade with other countries because they may engage in more within-country movement of goods or the transaction costs involved in importing from other countries are prohibitively high.

Regression results, with and without area variables, are reported in columns 2 and 3 of Table 1. This regression result is compared with that of previous studies, which use only GDP per capita and labor force (or population) as explanatory variables [e.g., Chenery and Syrquin (1975)]. The model in its deterministic form is as follows:

$$s_m^* = \mu_0 + \mu_1(G_{pc}) + \mu_2(G_{pc})^2 + \mu_3(L)$$  \hspace{1cm} (18)

Estimates of three different versions of measure of openness are presented in Table 1. Unlike results of Esfahani (1991), which use only data for 31 semi-industrial countries,

3\footnote{Data for each variables for 119 countries are gathered from the Levine and Renelt (1992) (from hereon, L&R) data set, where $G_{pc}$ and population data come from Summers and Heston’s (1988) Penn-World Table, and area data from World Bank (Social Indicators). $G_{pc}$ data are those of 1970 obtained from Summers and Heston (1988). Population data, which are used as a proxy for labor variables, are those of 1970 from the same source.}
Table 1 reports that area does not play a major role in explaining variation in import-GDP ratios. The coefficient of the log of area is statistically significant, but the square of the log of area is not. Also, $R^2$ is improved only by 5% by adding area variables.\(^4\)

To parameterize the trade term, it is assumed that $dT$ is the addition to the accumulation of trade during estimation periods. $dT$ denotes the average of trade (exports + imports) of each year during estimation periods. The last term in (12) can be rewritten

\(^4\)For the measure of $\lambda$, we should find the one that does not reflect government exchange policy, tariff, and nontariff barriers, since $\lambda$ reflects only the shadow price of foreign exchange constraints. $r_n$ in equations (24) and (25) captures the deviation of a country’s import-GDP ratio from its “expected” value. However, note that $r_n$ may be affected by other policy or nonpolicy influences in addition to import shortage due to foreign exchange constraints. Since the higher the $\lambda$ is, the lower the rate of growth of output, we expect $\lambda$ to be negative.
as \( \frac{\theta}{s_i^*Y} \) \( dT = \theta \frac{PdT}{P_G} = \theta s_i^* \), where \( s_i^* \), which is considered an explanatory variable, is the ratio of trade to GDP. The ratio of trade to GDP, \( s_i^* \), is used here as a measure of externality due to interaction with the rest of the world. The advantage of using it as a measure of externality is that data for \( s_i^* \) are available for a large number of countries.

Romer (1993) argues that “a country benefits from interaction with the rest of the world in proportion to the level of human capital it possesses. Consistent with the technology gap interpretation of development, rapid growth is a function of both access to foreign technology and a domestic capability for using it” (p. 568). In other words, the ability to take advantage of the ideas available in the rest of the world is higher for countries that have a higher level of human capital. Following this view, \( \theta \) is expected to increase with the level of human capital in a country. If it is assumed that secondary-school enrollment ratio can be used as a proxy of the level of human capital, this relationship can be modeled as the following linear approximation, \( \theta = \theta_0 + \theta_1 \text{Sec} \), where Sec is the secondary-school enrollment ratio. The above hypothesis implies that \( \theta_1 \) must be positive.

Equation (12) is now fully parameterized. The resulting equation is summarized as

\[
g = \alpha^*k^* + \beta^*l + \gamma s_i^*x + \lambda s_m^*m + \theta s_i^*
\]

\[
= \alpha^*k^* + \beta^*l + \gamma s_i^*x + \lambda s_m^*m + \lambda_i s_m^*r_m m + \theta_0 s_i^* + \theta_1 \text{Sec} \cdot s_i^*
\]

(19)

Greek letter coefficients in (19) represent the parameters to be estimated.
IV. Empirical Results

The data set for estimation includes 119 countries over 1974-1989. To raise the efficiency of estimation with one less parameter and to go around the data problem, the per capita version of (19) is devised. Since the function, F, in equation (5) is assumed to be constant-returns-to-scale, it is easy to express the function, F, in terms of capital-labor ratio and intermediate goods-labor ratio. Then (19) can be easily rewritten in the per capita form

\[ g_{pc} = \alpha k^* + \gamma s^*_x x_{pc} + \lambda_0 s^*_m m_{pc} + \lambda_1 s^*_m r_m m_{pc} + \theta_0 s^*_i + \theta_1 sec \cdot s^*_i \]  

(20)

where \( g_{pc} = g-l \), \( x_{pc} = x-l \), and \( m_{pc} = m-l \) is the rate of growth per capita of each arguments, respectively. Ideally, the measure of imports used in our estimations should not include any imports of final goods. Unfortunately, only the data for the ratio of imports to GDP are available. However, if the share of final goods in the imports is fairly constant during the sample period, using the data for the imports-share instead of the intermediate-goods imports-share should not greatly affect the results. Therefore, the total imports data are used under the assumption that the growth rates of total and intermediate imports during sample period have been approximately the same.

Table 2 reports the OLS estimation of (20), using Esfahani version of measure of of \( r_m \). Column (1) of Table 2 presents the regression results of per capita GDP growth rate on measures of capital, export growth rates, and trade-GDP ratio as the explanatory

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5The data set of 119 countries includes OPEC countries. We estimated the model without OPEC countries and the model only with SICs (semi-industrialized countries), but the results were basically invariant. Appendix describes the country list and source of these data.

6Estimations with various measures of \( r_m \) show basically the similar results. Reports of the estimation results are omitted to save space.
Table 2. OLS Regression Results for 119 Countries
Dependent variable: GDP growth rate

<table>
<thead>
<tr>
<th>Right-Hand-Side Variables</th>
<th>Exports &amp; Trade Included</th>
<th>Exports &amp; Imports Included</th>
<th>Trade &amp; Imports Included</th>
<th>Imports Only Included</th>
<th>Complete Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-1.435</td>
<td>-2.133</td>
<td>-2.254</td>
<td>-2.894</td>
<td>-1.693</td>
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<tr>
<td></td>
<td>(-2.829)*</td>
<td>(-3.838)*</td>
<td>(-3.493)*</td>
<td>(-4.249)*</td>
<td>(-3.129)*</td>
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<tr>
<td></td>
<td>(5.440)*</td>
<td>(4.765)*</td>
<td>(5.558)*</td>
<td>(5.042)*</td>
<td>(5.617)*</td>
</tr>
<tr>
<td>s_{x}* x</td>
<td>0.831</td>
<td>0.871</td>
<td></td>
<td>0.792</td>
<td>(6.888)*</td>
</tr>
<tr>
<td></td>
<td>(10.049)*</td>
<td>(7.648)*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>s_{t}*</td>
<td>-2.243</td>
<td>-2.596</td>
<td></td>
<td>-2.055</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(-4.586)*</td>
<td>(-3.920)*</td>
<td></td>
<td>(-3.706)*</td>
<td></td>
</tr>
<tr>
<td>Sec·s_{t}*</td>
<td>1.995</td>
<td>3.694</td>
<td></td>
<td>1.899</td>
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</tr>
<tr>
<td></td>
<td>(2.748)*</td>
<td>(4.310)*</td>
<td></td>
<td>(2.510)*</td>
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</tr>
<tr>
<td>s_{m}* m</td>
<td>0.030</td>
<td>0.688</td>
<td>0.689</td>
<td>0.115</td>
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</tr>
<tr>
<td></td>
<td>(0.156)</td>
<td>(6.003)*</td>
<td>(5.655)*</td>
<td>(0.912)</td>
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<tr>
<td>r_{m}·s_{m}* m</td>
<td>-0.745</td>
<td>-0.648</td>
<td>-1.087</td>
<td>-0.430</td>
<td></td>
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<tr>
<td></td>
<td>(-2.523)*</td>
<td>(-1.842)*</td>
<td>(-2.987)*</td>
<td>(-1.466)</td>
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<tr>
<td>R^2</td>
<td>0.665</td>
<td>0.626</td>
<td>0.518</td>
<td>0.414</td>
<td>0.672</td>
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<tr>
<td>R^2</td>
<td>0.652</td>
<td>0.612</td>
<td>0.494</td>
<td>0.397</td>
<td>0.652</td>
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</table>

Notes: 
- Numbers in parentheses are t-statistics.
- * indicates the significance of estimate at the 5% level.
- c. r_m is the residuals of model (3) of Table 1.

variables, excluding the imports-related terms. The model is similar to those estimated in previous studies except for inclusion of trade terms. This model reports relatively high R^2 and t-ratios. The coefficient of export variable is statistically significant and relatively large. This indicates that in a country with an export-GDP ratio of 0.257, which is the median in our sample, a 1% increase in the rate of growth of exports could raise the growth rate of GDP per capita by 0.22%.

The coefficient of Sec·s_{t}* is statistically significant and supports the hypothesis that a country with higher human capital has higher ability to absorb new ideas obtained
from interactions with the rest of the world. It is remarkable that the model explains 65.5% of variation in output growth rates. Romer (1993), with the same data set and more explanatory variables, shows that $R^2$ ranges from 0.34 to 0.46.

Column (2) shows the OLS regression results, including imports-related variables instead of trade-related variables. $\lambda_0$ is statistically insignificant, and $\lambda_1$ has an expected sign and is statistically significant. This model loses 2-3% of explanatory power, compared with the previous model. Column (3) reports the estimation results of regression of $g_{pe}$ on trade and imports-related terms, excluding export term. The trade and imports-related variables are statistically significant, but much explanatory power is lost. Column (4) reports the estimation results of the model only with imports-related terms. The coefficients are all statistically significant and have the expected signs. But the explanatory power of the model diminishes by about 10%. This may imply that foreign-exchange shortages do not play a role in explaining output growth, unlike the one that Esfahani (1991) reports.\footnote{Each model is regressed on the data set of 31 countries of SICs as Esfahani did and on the data set excluding OPEC countries. However, the role of exports as relieving the foreign exchange constraints is not significant.}

The complete model is reported in column (5). All coefficients, except those related to import variables, are statistically significant, but the explanatory power of the model is only improved by less than 2%, compared with the model (1). In contrast, the coefficient of Sec·$s_t^*$ reinforce our hypothesis. These might result from the fact that the variable selected as a proxy of openness is not correct, which might be affected by other exchange policy variables, tariff, and nontariff barriers. What may be seen in these
simple OLS regression models is that there is no evidence that import-shortage caused by lack of exports deters economic growth.

V. Conclusion

This research sheds light on the role of trade in economic growth. It examines the proposed role of exports in relaxing import shortages in the process of economic growth. It is hypothesized that the total volume of trade as a carrier of knowledge creates positive externalities for the nonexport sector. This happens because with trade there is interaction with foreign countries. So the domestic country gains by way of learning by doing. The empirical results support the role of trade as a carrier of knowledge, especially the hypothesis that a country with higher human capital has a higher ability to absorb new ideas obtained from interactions with the rest of the world is not rejected. Another finding is the existence of sectoral productivity differentials. The policy implication of this finding is that a reallocation of resources in favor of the export sector will have a positive effect on economic growth. The empirical test of the import supply effect of exports is at variance with the findings of Esfahani (1991). There is an externality effect of trade, though the import supply effect of exports has been taken into account. No evidence is found to suggest that the major contribution of exports to the GDP growth rate is to relieve the import shortage. This might be due to the fact that the variable selected as a proxy of openness is not correct, which might be affected by other exchange policy variables, tariff, and nontariff barriers.

In this study the importance of trade is reemphasized in the process of development. The volume of trade generates positive externalities to an economy by
filling in the idea gap that most developing countries suffer. So the public attempts need to be made to promote trade by way of making the economy open. A greater volume of trade implies more exports and more imports. Increases in exports and imports contribute to accumulation of stock of capital, both human and nonhuman. This factor accumulation generates externalities and contributes to growth.
References


## Appendix

### Country List:

<table>
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<tr>
<th></th>
<th>Country</th>
<th>Code</th>
<th>Country</th>
<th>Code</th>
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<td>HND Honduras</td>
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<td>IRL Ireland</td>
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<td>LBR Liberia</td>
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<td>MDG Madagascar</td>
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<td>MLI Mali</td>
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<td>MAR Morocco</td>
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<td>NLD Netherlands</td>
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<td>FJI Fiji</td>
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<td>NZL New Zealand</td>
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<td>PAN Panama</td>
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<td>37</td>
<td>GRC Greece</td>
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<td>PNG Papua New G</td>
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### Variables and Sources:

**Area**  
Land area (in thousands of square kilometers).  
Source: World Bank (Social Indicators).

**L**  
\( G_{pc} \) Average of real GDP per capita for 1974-1989.
\( k^* \) Investment share of GDP.
\( m \) Growth of imports.
\( s_{m}^* \) Import share of GDP.
\( s_i^* \) Ratio of total trade to GDP.
\( s_x^* \) Export share of GDP.
\( x \) Growth of exports.

**Data Sources:**

WBNA: World Bank (National Accounts).
WBSI: World Bank (Social Indicators).