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Endogenous Growth and the Openness of Economy to Trade

BASSIM SHEBEB
Assistant Professor of Applied Economics
Department of Economics and Finance
College of Business Administration, University of Bahrain,
Sakhir, Kingdom of Bahrain

YOUSEF Al-EBRAHEEM
Associate Professor of Economics
College of Administrative Sciences, Kuwait University, Kuwait

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ABSTRACT. In this paper, the impact of the imported intermediate inputs on the economic growth of an open economy to trade is examined. It has been argued that the production function of an open economy to trade in foreign supplies should include the intermediate inputs in addition to the domestic primary factors of production. For an open economy, the optimal growth rate has been derived based on gross output production function with endogenous technological progress to identify the effect of the imported intermediate inputs on economic growth. The model suggests that a decision to open the economy to trade is beneficial for economy with low stock of human capital devoted to technological improvements.

1. Introduction

In the recent years, most economists argued that the openness of the economy to trade in intermediate supplies contributes significantly to the country's economic growth(1). A recent study by Ben-David and Loewy (2000) shows that the accumulation of human capital can be determined by the amount of knowledge spillovers as a result of opening the economy to trade. Moreover, the endogenous growth models reveal the fact that human capital is an essential factor in achieving higher-level growth via R&D, (Audretsch, 2000).

(1) However, it does not necessarily imply that an open economy will grow faster than a closed one.

It is also shown, on the other hand, that the aggregate production function of an open economy to trade should include the intermediate inputs in addition to the domestic primary inputs (Gollop, 1981, 1983). This implies that growth modeling in an open economy to trade in intermediate inputs should be different from that in a close economy. The purpose of this paper is to identify the impact of the imported intermediate inputs on the economic growth of an open economy to trade. That is, based on a gross output production function, a growth model with endogenous technological progress is exploited to examine this effect.

The concern of the next section is to investigate how the openness of an economy should be presented in growth modeling. It emphasizes the specification of the aggregate production function in an open economy to trade. In Section 3, the optimal growth rate for an open economy to trade is derived and the effect of the imported intermediate inputs on the steady-state growth rate is identified. The conclusions are presented in Section 4.

2. The Production Function in an Open Economy

Intermediate inputs (M) are excluded from growth models that are based on the value added production function (which includes the primary inputs only: labor and capital). This exclusion is due to viewing intermediate inputs as self-canceling transactions. For example, Kendrick (1973: p. l6), mentioned that *inclusion of intermediate inputs obviously involves double counting, since such inputs have already been included in the final products and the factor services required to produce them are likewise included in total factor input.* On the other hand, Gollop (1981) argued that the self-canceling property of the intermediate inputs is neither an economic truism nor the result of any particular characterization of society's economic objective. It follows, instead, from the assumption that the economy is closed to trade in foreign produced inputs.

Two important results were demonstrated in Gollop (1983, 1987). First, for a closed economy, the value-added or the gross output (deliveries to final demand) growth models produce equivalent measures for aggregate productivity growth[(2)]. Second, for an open economy trading in foreign supplies of intermediate inputs, the value added growth model results in a higher measure of aggregate productivity growth than a model defined in terms of deliveries to final demand (gross output)[(3)].

It follows that growth modeling in an open economy is parallel to the development of its closed economy counterpart. However, the imported intermediate inputs should be taken into account in both the aggregate and sectoral models of production and growth. These arguments are clearly presented by Gollop (1987). Having said this, specifying the form of the aggregate production function in terms of

(2) That is, given the absence of any imported intermediate inputs, all domestic sales and purchases of intermediate inputs are self-canceling transactions, **Domar** (1961).

(3) Domestic deliveries to intermediate demand are produced by the primary labor and capital inputs, which are supplied in the domestic economy. That is, domestic deliveries to intermediate demand are purely internal, canceling transfers in intermediate inputs, while foreign deliveries are totally external transactions in primary inputs.

value added or gross output will depend on whether the economy is open or closed to trade in intermediate inputs.

3. Growth Model

Economic growth can be formulated as an optimal control problem. This formulation has been known as neo-classical theory of optimal growth, due to its analytical framework that is based on the neo-classical production function. The assumptions underlying the use of this production function are: (1) constant returns to scale; (2) positive marginal product; and (3) diminishing returns to each production input. As indicated above, measuring and analyzing the economic growth in an open economy has to be based on a gross output production function in which the imported intermediate inputs are included in addition to the primary inputs.

In general, a dynamic production function can be written as $Q = f(X_i, A)$, where X_i is the vector of inputs, i=1, 2, 3, ..., n, $\partial Q / \partial A > 0, \text{and } dA/dt > 0.$ This formulation allows for either endogenizing or exogenizing the technological change (A). However, one critical issue related to the exogenous technological change is that it could not offer an explanation to the causes of such technical change. To overcome such a shortcoming, it is critical to endogenize the technological change (4).

We present an endogenous technological progress growth model following Romer (1990). However, the growth model in this paper is based on a gross output production
function rather than a value added production function (5). In this model, the technologi cl progress (knowledge) is decomposed into two components; human capital (H) and technological change (A). As in Romer (1990), H can be used in both production and technological improvement. It follows that $H = H_Q + H_A$, where H_Q represents the portion of human capital which is involved in production sector and H_A is that portion of H which is devoted to technological improvement (6). Assuming that the dynamic aggregate production function in an open economy follows a Cobb-Douglas technology, it can be simply written as:

$$Q = H_Q^a L^b M^q \sum_{i=1}^{A} X_i^{1-a-b-q} \qquad (1)$$

This gross output production function includes imported intermediate inputs (M) and labor (L) in addition to the human capital (H_Q). Labor input (L) is assumed to be

(4) Originally, the endogenizing of technological progress was explored by **Arrow's** "learning-by-doing model", 1962.

(5) The model was originally presented based on a value-added production function by **Romer** (1990). However, the distinction made in this paper provides a procedure that can be used in examining the effect of the imported intermediate inputs on the economic growth rate in an open economy with endogenous technical change.

(6) The human capital is defined as to have no externalities, where the technology is assumed to be generally available to all economic agents (non-rival good).

in a fixed amount. In this function capital input is disaggregated into a finite number (A) of distinct types of producer durable goods (X_i). Assuming that $\overline{X} = X_i$ for all i =1, 2, ..., n, it follows that equation (1) can be written as:

$$Q = A H_Q^a L^b M^q \overline{X}^{1-a-b-q} \qquad (2)$$

Let capital goods (K) be defined by the amount of accumulative foregone consumption goods: $\dot{K} = Q - C$, where C is the total consumption. Then, assuming that Z units of capital goods are needed to produce one unit of knowledge ($K = Z\overline{X}A \Rightarrow \overline{X} = K / ZA$), it follows that equation (2) can be written as:

$$Q = H_Q^a L^b M^q K^{1-a-b-q} A^{a+b+q} Z^{a+b+q-1} \qquad (3)$$

Equation (3) expresses the gross output as a function of the imported intermediate inputs in addition to the primary inputs of the model.

The rate of technological change is defined as $\dot{A} = mAH_A$, where $\dot{A} = dA / dt$ and m is a constant that represents the successful research. It follows that the growth rate of technological change can be written as $\dot{A} / A = mH_A$. Focusing on the steady-state[7] solution, a common growth rate (g) for all variables of the model may be obtained as

$$g = \dot{K} / K = \dot{C} / C = \dot{A} / A = mH_A = m(H - H_Q) \ .$$

However, the allocation of human capital (H) is determined by the value of its marginal product in each of the two sectors production and technology improvements. The value of the marginal product of the human capital (H_A) in the technology improvement sector is equal to mAP_A, where P_A is an approximate price of knowledge. Thus, it follows from equalizing the returns to human capital in both sectors, the optimal amount of human capital (H_Q) that may be employed by the production sector can be given as follows:

$$H_Q = \frac{r.a}{mg(a + b + q)} \qquad (4)$$

where (r) represents the rate of return to the spot price for capital.

Romer (1990: p.599) concluded, based on a closed-economy growth model, that the most interesting positive implication of the model is that an economy with a larger total stock of human capital will experience faster growth. This finding suggests that free international trade can act to speed up the growth. It also suggests a way to understand what it is about developed economies in the twentieth century that permitted rates of growth of income per capita that are unprecedented in human

(7) For more detailed discussion on the steady endogenous growth, see **Howitt** (1999).

history. The model also suggests that low levels of human capital may help explain why growth is not observed in underdeveloped economies that are closed and why a less developed economy with a very large population can still benefit from economic integration with the rest of the world.

Using equation (4), it can be shown that the common growth rate (g) depends on the amount of H_A and the level of successful research m as follows:

$$g = mH - \frac{r \cdot a}{g\,(a + b + q)}. \qquad (5)$$

Then, in what follows, the impact of the imported intermediate input in the growth rate (g) is examined. That is, by taking the partial derivative of (g) with respect to$q$ (the "share" of the imported intermediate input in total cost), the effect of imported intermediate inputs on the growth rate can be captured. This can be simply written as follows:

$$\frac{\partial g}{\partial q} = \frac{r \cdot a}{[g\,(a + b + q)]^2} > 0 \qquad (6)$$

The intuition behind this formula suggests that there is a positive effect of the imported intermediate inputs on the growth rate. It is not surprising to have $\partial g / \partial q$ depends only on the shares (technological parameters) of the production factors ordinary labor, capital, and intermediate inputs in addition to the level of human capital devoted to the production sector. It implies that the larger the imports from nations with higher stock of human capital the higher is the growth rate despite of the amount of the local human capital that is devoted to the technological improvements sector(8).

This finding is exclusively consistent with the concluding remark made by Romer (l990). His model also suggests that the low levels of human capital may help explain why growth is not observed in underdeveloped economies that are closed to trade. This conclusion, however, was based on a value-added growth model that was not able to give an explicit measure to the magnitude of the effect of the imported intermediate inputs on the economic growth. On the other hand, a gross output growth model was qualified to identify and measure the magnitude of that effect on the rate of economic growth.

4. Conclusions

The deliveries to final demand (gross output) and the value added models of aggregate production growth, offer fundamentally different descriptions of macroeconomic and microeconomic activity. For an open economy to trade in

(8) As mentioned earlier, the foreign deliveries are totally external transactions in the foreign primary inputs (foreign human capital, ordinary labor, capital and technology).

intermediate inputs, these differences are important in modeling and measuring economic growth.

The main finding of the gross output-based growth model is its explanation of how trade in intermediate inputs could be beneficial to the economies with low levels of human capital. It also shows how those economies could benefit from the accumulated human capital in the foreign economies through imports. It has been shown that the imported intermediate inputs (the openness to trade) have a positive effect on a country's economic growth.

It follows that a decision to open the economy to trade may be beneficial for economies with low stock of human capital devoted to the technological improvement sector. The model also encourages these countries to integrate with economies that have a large stock of human capital to be able to speed up their economic growth.

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النمو الاقتصادي وانفتاحية الاقتصاد للتجارة الدولية

باسم شبيب
أستاذ مساعد – قسم المال والاقتصاد
كلية إدارة الأعمال – جامعة البحرين – مملكة البحرين

يوسف الإبراهيم
أستاذ الاقتصاد المشارك
كلية العلوم الإدارية – جامعة الكويت – الكويت

المستخلص: يهدف هذا البحث إلى دراسة العلاقة بين النمو الاقتصادي وانفتاح الاقتصاد للتجارة الدولية في المدخلات الوسيطة. وقد تم الاعتماد على نموذج رياضي لدراسة تلك العلاقة من خلال دالة إنتاج الإجمالي والتي تأخذ في اعتبارها المدخلات الوسيطة المستوردة بالإضافة إلى عناصر الإنتاج المحلية الأولية من عمل ورأس مال. وبناءاً على ذلك وجد أن معدل النمو الاقتصادي المشتق من دالة الإنتاج الإجمالي تلك يعتمد على مدى تطور المدخلات الوسيطة المستوردة. ولذلك فقد خلصت الدراسة إلى أن قرار انفتاح اقتصاد ما على التجارة الدولية يكون ذا فائدة أكبر في حال افتقاد الاقتصاد للموارد البشرية القادرة والموجهة إلى قطاع البحث والتطوير التكنولوجي.