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Abstract

A robust empirical determinant of long-term economic growth in many developing countries has been the expansion and diversification of the export sector. The latter, in turn, has been influenced by capital accumulation and economic growth. The growth model developed here explores this interdependence in the context of the "new growth theory". The analytical results are consistent with empirical regularities observed in the exports-economic growth linkages. The paper also derives a formula for the optimal rate of return to capital in the presence of learning effects and improvement of human resources brought about by export expansion and its interaction with saving and investment.

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	<u>Page</u>
Summary	iii
I. Introduction	1
II. The Growth Model	3
1. The standard versus modified models: an overview	4
2. A two-sector modified model	9
3. Some extensions	14
III. Optimal Saving	15
IV. Conclusions	16
References	18
 <u>Text Tables</u>	
Table 1. The Standard and Modified Growth Models	5
Table 2. The Modified Two-Sector Model	11
 <u>List of Figures</u>	
Figure 1. Long-Run Growth Equilibrium	8a
Figure 2. The Two-Sector Model	12a

Summary

Exports affect, and are affected by, long-term economic growth through various mechanisms, including production and demand linkages, learning effects and improvement of human resources, adoption of superior technology embodied in foreign produced capital goods, and the general easing of the foreign exchange constraint associated with the expansion of the export sector. After surveying these mechanisms, this paper formally incorporates one--the learning effect that leads to the improvement of human capital--into a modified neoclassical growth model via the dependence on exports of labor-augmenting technological progress and vice versa.

A key analytical result is that, both in the short run and in the long run, an increase in export activity will raise the growth rate of output. Although the short-run transitional dynamics in the standard neoclassical analysis of the relationship between exports and economic growth remain valid, the modified model's long-run result is at variance with the standard proposition that the growth rate of output is independent of export activity. Another important result is that, for the level of long-run real consumption per unit of effective labor to be maximized, the rate of return to capital should be higher than the population growth rate adjusted for any exogenous labor-augmenting technical change. Capital is thereby partially compensated for its additional effect on the long-run growth rate of output through learning effects and improvement of human resources brought about by the positive externalities of export activities and their interaction with investment and capital accumulation.

Because of the central role of exports in the absorption of the latest technology and the interdependence of investment, technical change, and the size of the export sector, several important policy implications can be drawn for the external area. First, a key policy objective should be to adopt an outward-looking strategy to export manufactures early in the process of industrial development. High protective tariffs tend to create an inefficient industrial sector, prevent the introduction of modern techniques, and stunt factor productivity. Second, a crucial policy instrument is a competitive, market-determined or market-related exchange rate, complemented by low, nondiscriminatory tariffs and the elimination of nontariff import barriers. Third, strong anti-inflationary financial policies are essential to keep domestic input prices and wages lower than those in competitor countries, so as to maintain external competitiveness. These policies would necessitate strict limits on fiscal subsidies, tax exemptions, and credit expansion.

"An outward-looking strategy emphasizes the quality and direction rather than the absolute magnitude of industrial development. Human resources and other investments generated early in the process will exert a lasting influence over the character of subsequent growth. New high-quality human resources will be created through industrial experience that could not be obtained under heavy protection. Outside competition will spur adoption of new technology and efficient methods." Keesing (1967, p. 320).

I. Introduction

One of the robust empirical determinants of long-term output growth in many countries, particularly the developing ones, has been the whole gamut of outward-looking exchange and trade policies designed to promote the expansion and diversification of the export sector. 1/ The explanation why such strategies improve growth performance has, however, proven elusive, despite several formal theoretical models, notably that of Feder (1983). 2/ While the conclusion that strong export performance promotes long-run growth seems intuitively reasonable, it is a clear implication of the standard neoclassical model that exports cannot exert a sustained long-run effect on the economy's growth rate. As Lucas (1988, pp. 12-13) puts it, "The empirical connections between trade policies and economic growth that Krueger (1983) and Harberger (1984) document are of evident importance, but they seem to me to pose a real paradox to the neoclassical theory we have, not a confirmation of it." There is thus a gap between empirical work on the nexus of export expansion and economic growth on the one hand, and standard neoclassical growth theory (Solow, 1956 and Swan, 1956) on the other.

The importance of the export sector to the development process has long been recognized by many economists. The literature on this subject identifies two channels through which sustained growth effects of export activity are expected to be transmitted. First, Keesing (1967) emphasized *learning* effects, the improvement of *human capital*, and the value of competition and close communication with advanced countries. This important channel is reiterated recently by Feder (1983, p. 61) with the observation that exports enhance labor productivity via the training of skilled workers, "who find themselves subjected to greater pressures to perform and to train others." Second, Goldstein and Khan (1982) cite production and demand linkages, including the opening up of *investment* opportunities in areas far removed from the actual export activity as the need to supply inputs rises,

1/ For a partial survey of the literature, see Khan and Villanueva (1991), and the references cited therein.

2/ Feder's two-sector (exports and non-exports) model has the standard long-run (steady-state) property that the growth rate of aggregate output is equal to the exogenously determined growth rate of the labor force, adjusted for an exogenous rate of labor-augmenting technical change. See Section II.

and as productive facilities are created utilizing inputs and outputs that were nonexistent prior to the expansion of exports. The increase in income that comes directly from exports leads in time to a rise in demand for a wide range of products, including nontradables. These demand pressures are reflected in a higher rate of capacity utilization and ultimately involve investment in facilities providing such products. 1/

First, aggregate savings may rise because of the general increase in incomes associated with the initial rise in exports. As argued by Maizels (1968), the marginal propensity to save in the export sector could be higher than in other sectors, in which case the rise in aggregate savings would be magnified. The rise in savings translates into a rise in investment in physical and human capital, and thus in the rate of economic growth. Second, foreign direct investment and foreign loans may be encouraged by the expansion of the export sector, since investment and lending decisions take into account a country's ability to repay out of export earnings. By enhancing profitability and the capacity to service the external debt (thereby improving creditworthiness), the expansion of the export sector induces higher flows of direct foreign investment and foreign loans that permit an even higher rate of investment (and thus a higher rate of growth). Third, exports provide the necessary foreign exchange to import advanced capital goods and raw materials for which there are no convenient domestic substitutes (Khang, 1968, and Bardhan and Lewis, 1970). The transfer of efficient technologies and the availability of foreign exchange have featured prominently in recent experiences of rapid economic growth (Khang, 1987 and Thirlwall, 1979). Of course, the superior technology embodied in foreign-produced capital goods is widely recognized as a powerful factor in transmitting technological innovations directly to developing economies. Export earnings and export-induced foreign direct investment and loans serve to facilitate the importation of these advanced capital goods. To the extent that these capital imports are stimulated by brisk export activity, the production and demand linkages identified by Goldstein and Khan (1982) are reinforced.

This paper formally analyzes one important channel in the linkage between exports and growth; namely the learning effect that leads to the improvement of human capital first identified by Keesing (1967) and Feder (1983). It does so by incorporating this effect into a modified

1/ There are several other growth effects, which are just as important. Balassa (1978) cites the improvement in overall factor productivity arising from the transfer of factors from the rest of the economy to the export sector, which is typically the most productive. This, however, represents a one-time shift in the aggregate production function.

neoclassical model with endogenous growth. 1/ A key result is that the long-run equilibrium growth rate of output is a positive function of, among other variables, the domestic saving rate and the rates of utilization of capital and labor in the export sector. The empirical growth literature (see Khan and Villanueva, 1991) confirms these hypotheses. Following a critical review of the literature on the exports-economic growth relationship, Section II presents and contrasts the standard growth-cum-exports model and the modified model proposed in this paper, discusses more fully a two-sector version of the modified model, and extends it in several directions. Section III derives new Golden Rule results relating to the optimal saving rate, taking into account the positive externalities of export activities operating through an endogenous rate of labor-augmenting technological progress. Section IV concludes with several policy implications.

II. The Growth Model

In the theoretical literature on the relationship between exports and economic growth a typical approach has been to adopt the standard neoclassical assumption of an exogenously determined rate of labor-augmenting technical change, and to include the export variable as a third factor (in addition to capital and labor) in the aggregate production function, on the premise that exports engender scale effects and externalities. 2/ A model developed by Feder (1983) typifies this approach, and has been invoked in empirical studies of the exports-growth nexus (see, among others, Ram (1985), and references cited therein).

Feder (1983) presents a two-sector model consisting of exports and non-exports. The two sectoral production functions employ capital and labor, with the marginal factor productivities in the export sector assumed to be higher than those in the non-export sector. Inter-sectoral externalities are incorporated by introducing the output of the export sector as a third input in the production function of the non-export sector. Feder shows that the *off-steady-state* growth rate of total output (exports plus non-exports) is a function of the aggregate investment-output ratio, the growth rate of the total labor force, and the ratio of the change in exports to the level of output. Feder then estimates the parameters of such a growth rate

1/ See, among others, Conlisk (1967), Villanueva (1971), Romer (1986), Lucas (1988), Otani and Villanueva (1989), Grossman and Helpman (1990), and Becker et al. (1990). These approaches fall into the category of what has been termed "endogenous growth" models. A common feature of these models is the endogeneity of technological progress, particularly the rate of labor-augmenting or Harrod-neutral technical change.

2/ See, among others, Balassa (1978); Tyler (1981); Feder (1983); and Ram (1985). Balassa (1978, p. 185) argues that since "exports tend to raise total factor productivity, ... the inclusion of exports in a production function-type relationship is warranted... ."

function using cross-country data averaged over long periods. ^{1/} However, such long-run observations correspond more to the *asymptotic (or steady-state)*, than to the year-to-year, transitional growth rate of output. Long-run cross-sectional regressions are more appropriate in testing the asymptotic behavior of growth models. As will be shown below, in the long run, the growth rates of the capital stock and of the export input in a Feder-type model would be constrained by the constant rate of growth of the labor force, adjusted for exogenous labor-augmenting technical change. Feder (1983) argues that, given identical marginal factor productivities in both export and non-export sectors and in the absence of intersectoral externalities, the empirical growth equation reduces to the familiar neoclassical formulation without the export variable. Or does it?

1. The standard versus modified models: an overview

The Feder (1983) model may be simplified without sacrificing its main features. It can then be compared with the basic modified model proposed in this paper. Table 1 provides a summary of the two models, with the Feder-type model labeled as the standard one.

Both standard and modified models have a two-sector structure, involving two neoclassical production functions for exports and non-exports. For simplicity, it is assumed that the export sector employs a constant uniform rate, ϵ , of the total amounts of K and L, with $1-\epsilon$ being the employment rate prevailing in the non-export sector. ^{2/} Both models also assume significant inter-sectoral externalities involving exports and that the marginal productivities in the export sector are higher than those in the non-export sector. Reflecting these assumptions the production functions for non-exports in both the standard and the modified models include exports as a separate input (see equation (1) in Table 1). Both models measure the labor input in efficiency units (equation (3)), ^{3/} and employ the neoclassical capital accumulation function (equation (6)), where the net increase in the capital stock is equal to gross saving minus depreciation.

It turns out that the standard assumption of a direct effect of exports on the output of the non-export sector is not essential to the different equilibrium growth implications of the two models (compare the two expressions for the equilibrium growth rate in (12c) of Table 1). Rather, the critical differences between the standard and modified models lie in their alternative assumptions about the nature of labor-augmenting technical

^{1/} A similar approach is followed by many others. See, for example, Balassa (1978), Tyler (1981), and Ram (1985).

^{2/} The strict two-sector version of the modified model, characterized by different utilization rates of K and L, is discussed in detail below.

^{3/} If a 1990 man-hour is equivalent as an input in the production function to two man-hours in the base period, say 1960, then the ratio K/L is the amount of capital per half-hour 1990 or per man-hour 1960.

Table 1. The Standard and Modified Growth Models

<u>Standard model</u>	<u>Modified model</u>	
$Z = (1-\epsilon)Lf(k, x)$	$Z = (1-\epsilon)Lf(k, x)$	(1)
$X = \epsilon Lg(k)$	$X = \epsilon Lg(k)$	(2)
$L = EN$	$L = EN$	(3)
$k = K/L$	$k = K/L$	(4)
$x = X/L$	$x = X/L$	(5)
$\dot{K} = Sq - \delta K$	$\dot{K} = sQ - \delta K$	(6)
$\dot{E}/E = \lambda$	$\dot{E}N = h(X) + \lambda L; h' > 0$	(7)
$\dot{N} = nN$	$\dot{N} = nN$	(8)
$Q = Z + X$	$Q = Z + X$	(9)

Reduced model

$$\begin{aligned} \dot{k}/k &= sk^{-1}\{(1-\epsilon)f[k, \epsilon g(k)] + \epsilon g(k)\} - (\lambda+n+\delta); \\ &sk^{-1}\{(1-\epsilon)f[k, \epsilon g(k)] + \epsilon g(k)\} - h[\epsilon g(k)] - (\lambda+n+\delta). \end{aligned} \quad (10)$$

Equilibrium capital-labor ratio (k^*)

Root of the equation:

$$\begin{aligned} sk^{*-1}\{(1-\epsilon)f[k^*, \epsilon g(k^*)] + \epsilon g(k^*)\} - (\lambda+n+\delta) &= 0; \\ sk^{*-1}\{(1-\epsilon)f[k^*, \epsilon g(k^*)] + \epsilon g(k^*)\} - h[\epsilon g(k^*)] - (\lambda+n+\delta) &= 0. \end{aligned} \quad (11)$$

Equilibrium growth rate of output (\dot{Q}/Q)*

$$\begin{aligned} (\dot{Q}/Q)^* &= (\dot{K}/K)^* = sk^{*-1}\{(1-\epsilon)f[k^*, \epsilon g(k^*)] + \epsilon g(k^*)\} - \delta; & (12a) \\ &= (\dot{L}/L)^* = \lambda + n; & (12b) \\ \text{or } (\dot{Q}/Q)^* &= J(s, \epsilon, \delta, \lambda, n), & (12c) \\ \text{with signs: } &0, 0, 0, 1, 1 & +, +, -, +, + \end{aligned}$$

Notation:

- Q: total output (GDP), constant dollars
 - X: output of the export sector, constant dollars
 - Z: output of the non-export sector, constant dollars
 - L: labor, in efficiency units, manhours
 - K: capital stock, constant dollars
 - E: technical-change or productivity multiplier, index number
 - N: population
 - f(.): production function for non-exports, intensive form
 - g(.): production function for exports, intensive form
 - h(.): a unit-homogeneous learning function
 - J(.): asymptotic (equilibrium) growth function
 - ϵ : rate of employment of capital and labor in the export sector
 - s: saving rate
 - δ : depreciation rate
 - λ : exogenous rate of labor-augmenting technical change
 - n: exogenous rate of population growth
-

change in relation to the size of the export sector (compare the equilibrium growth equations in (12b)). 1/ In particular, the standard model assumes that the rate of labor-augmenting technical change is independent of export activity. In contrast, the modified model formalizes the observation made by Keesing (1967) and Feder (1983) that the export sector tends to improve the quality (productivity) of the labor input by providing a valuable learning experience (compare the technical change functions in (7)). In other words, even if the modified model adopts the standard model's production function for non-exports, in which the export variable appears as another factor input, important differences in the implications of the two models will remain. The assumption about the rate of labor-augmenting technical change turns out to be crucial. The standard model's hypothesis that $h' = 0$ means that labor-augmenting technical change is not affected by export activity, and is taking place at an exogenous constant rate λ . In the real world, while a portion of technical change may indeed be exogenous, some technical change is clearly endogenous, partly labor-augmenting, and positively enhanced by the expansion of exports, as argued by Keesing (1967) and Feder (1983) and empirically verified by Romer (1990). 2/ That is, the hypothesis of this paper that $h' > 0$, as against the standard assumption that $h' = 0$, appears plausible and merits serious consideration.

Suppose that $h' = 0$, as assumed in the standard model. Where does this assumption lead? It is relatively straightforward to show that the equilibrium growth path would be one on which $\dot{Q}/Q = n + \lambda$ (see the standard model's equation (12b)). Per capita output grows at the exogenous rate of labor-augmenting technical change λ . The saving, factor utilization rates in the export sector, and depreciation rates do not affect the long-run growth rate of per capita output. This is inconsistent with the robust empirical result that saving behavior and export activity do influence the long-term growth rate of output. 3/ Again, the alternative hypothesis $h' > 0$ deserves to be considered. This hypothesis says that labor-augmenting technological innovations are transmitted to the domestic economy partly through the export sector. In the modified model the export variable has two effects on output. First through its role as a *factor input* in the production of non-exportables, and second through its influence on the rate of labor-augmenting *technical progress*. The first channel is a level effect (a one-time shift in the production function for non-exports). The second channel is a permanent growth effect. Of these two mechanisms, the second one on technical change is pivotal.

Reflecting this difference in assumptions about the presence or absence of any link between exports and technological progress, the conclusions regarding the long-run growth rate of output are strikingly dissimilar. In

1/ Notice that the two models are identical except for the technical change function.

2/ Romer (1990) finds that a high ratio of exports to GDP is associated with a higher rate of technological change in a cross-section of 90 industrial and developing countries over the period 1960-85.

3/ The hypothesis $h' = 0$ is directly tested and rejected in Romer (1990).

the standard model, as in the neoclassical model without exports, the steady-state growth rate of output is fixed by the constant growth rate of population, n , plus the exogenous rate of labor-augmenting technical change, λ . By contrast, in the modified model, in addition to being affected by λ and n , the steady-state growth rate of output can be raised by increasing the employment rate ϵ in the export sector and the aggregate saving rate s , and by lowering the rate of depreciation of capital δ (compare the signs of the partial derivatives of the growth functions in (12c) of Table 1).

Figure 1 illustrates the workings of the two models. The vertical and horizontal axes measure, respectively, the growth rates of capital and labor (in efficiency units) and the capital-labor ratio. Panels A and B, respectively, depict the standard and modified models. In either model the relationship between the rate of capital accumulation and the capital-labor ratio (the KK curve) is downward-sloping because of the diminishing marginal productivity of capital. In the standard model, the labor growth schedule (the $L_s L_s$ curve) is horizontal with vertical height equal to $\lambda + n$ for all levels of the capital-labor ratio because, by assumption, labor-augmenting technical change is independent of the export-labor ratio and thus of the capital-labor ratio (that is, $h' = 0$). In the modified model, the labor growth curve is now upward sloping because the rate of labor-augmenting technological progress is a positive function of output per unit of labor in the export sector and, hence, of the capital-labor ratio. 1/

Now, suppose that the rate of utilization of capital and labor in the export sector, ϵ , rises for some reason (for example, vigorous implementation of export promotion policies, including competitive exchange rate policy, trade liberalization, and tariff reform). In the standard model (see panel A of Figure 1), the higher value of ϵ shifts the KK curve to the right, to $K'K'$, and the new equilibrium is established at point $C(k^*_{s1}, \lambda+n)$, which is characterized by a higher capital-labor ratio but an unchanged growth rate of output. 2/ The transitional dynamics are traced

1/ The export employment rate ϵ itself may be made an increasing function of the capital-labor ratio k . Given reasonable assumptions that labor productivity in the export sector is higher than in the rest of the economy and that, as labor's productivity increases with a brisk pace of export activity (and a rise in capital intensity), the economy will devote a larger share of resources to expand the export sector and thus to augment the effective supply of labor.

2/ In general the effects of a rise in ϵ on the KK curve work in opposite directions. On the one hand, an increase in ϵ means less resources are available for production in the non-export sector. On the other hand, this is offset by higher output in this sector induced by positive externalities generated by rising exports. Additional to this effect is a direct increase in the output of the export sector. Assuming with Feder (1983) that the export sector's marginal factor productivities are higher than those of the non-export sector, the net effect is to raise the economy-wide aggregate output and thus the savings needed for investment. The net effect is an upward shift of the KK curve in the northeast direction.

by the path A-B-C. The growth rate of the capital stock initially jumps to point B, exceeding that of the growth rate of the labor force by an amount equal to AB. This rise in the growth rate of the capital stock and, hence, of output, is only temporary and cannot be sustained over time, since the labor input ultimately becomes a bottleneck in the production process. 1/ As the capital-labor ratio rises from k^*_{s0} towards k^*_{s1} , the marginal productivity of capital declines and firms will slow the rate of investment until the growth rate of the capital stock is brought down to the constant rate of growth of the labor force at point C. Labor growth, being independent of the capital-labor ratio, slides horizontally from A to C. Thus, in the long run the rise in the export employment rate ϵ raises capital intensity and the level of exports and output, but leaves the growth rate of per capita output unaffected, this being fixed by the exogenous rate of labor-augmenting technical change λ . 2/

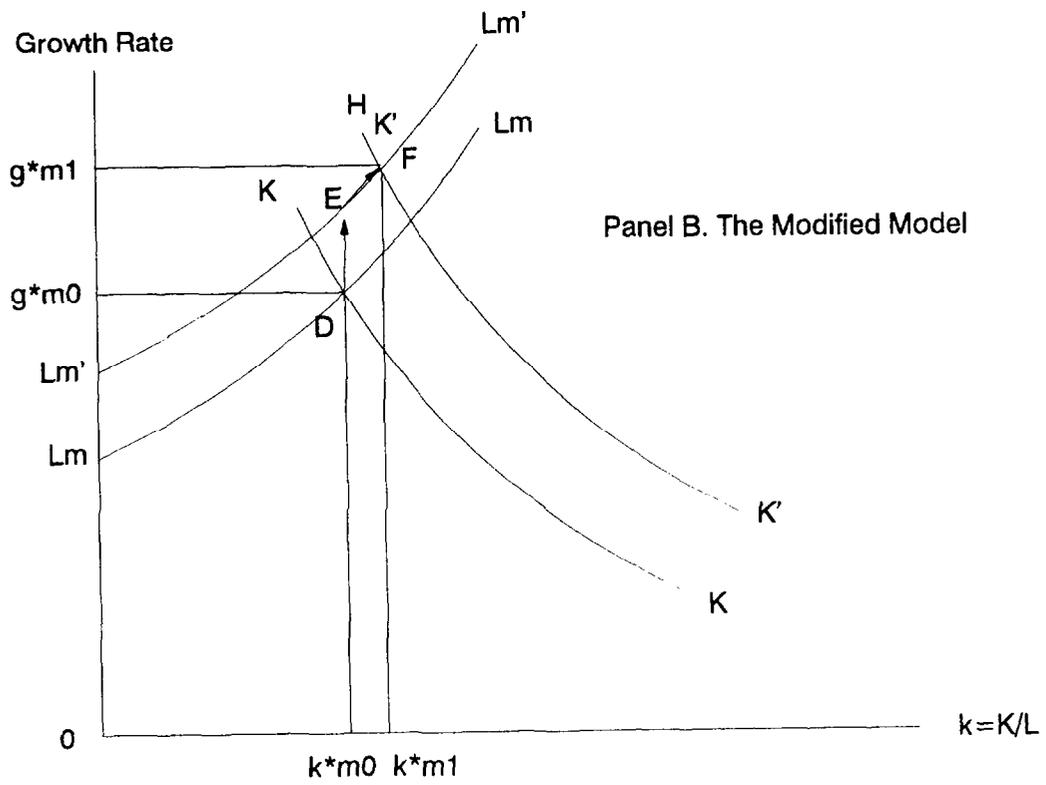
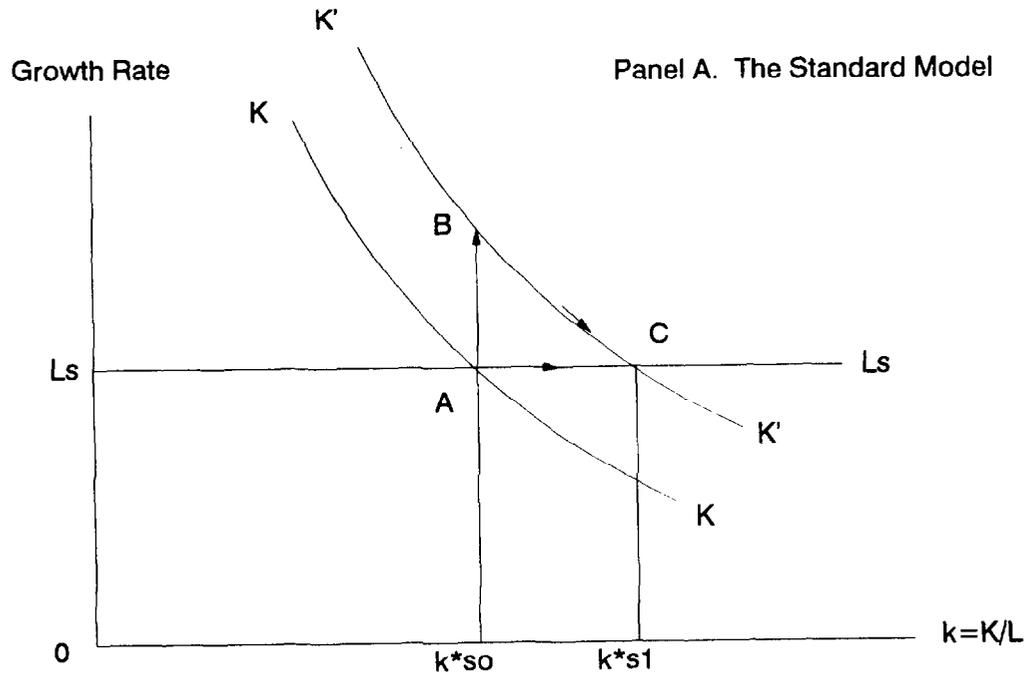
Turning to the workings of the modified model, the rise in the export employment rate ϵ shifts the KK curve to the right, to $K'K'$. However, the $L_m L_m$ curve also shifts upward to the left, to $L'_m L'_m$, intersecting the $K'K'$ at point F. As in the standard model the growth rate of the capital stock initially jumps to point H, exceeding labor growth by EH. But, in contrast to the standard model, the modified model exhibits a new equilibrium that is characterized by a higher growth rate of output (with the growth rate increasing from γ^*_{m0} to γ^*_{m1}). 3/ The main difference between two models lies in the behavior of the growth rate of labor. Referring to panel B, Figure 1, the initial rise in the capital-labor ratio resulting from the increase in the employment rate ϵ in the export sector leads to an increase in the growth rate of the labor input, instead of remaining constant as in the standard model, for two reasons. First, an increase in ϵ directly raises exports per unit of labor and thus the rate of labor-augmenting technical change (this is represented by the shift from $L_m L_m$ to $L'_m L'_m$), an

1/ This temporary growth effect of the export parameter ϵ is basically the exports-growth relationship emphasized in standard theoretical models, such as Feder's (1983). Standard empirical growth models, such as Knight, Loayza and Villanueva (forthcoming), also find that opening up the domestic economy through reductions in import-weighted average tariffs on intermediate and capital goods tends to raise the transitional growth rate of per capita output.

2/ The levels of exports and output per labor are higher because of the higher capital intensity. The result on a higher output per labor is Solow's (1956) conclusion that changes in saving rates--and for that matter, changes in the parameter ϵ in the context of standard neoclassical growth models with exports--are level, not growth, effects.

3/ The new equilibrium capital-labor ratio may be higher or lower, depending on the magnitudes of the relative shifts in the KK and LL curves. Panel B of Figure 1 assumes that the shift in the KK curve is larger, resulting in a higher equilibrium capital-labor ratio. If the shift in the KK curve were smaller than the shift in the LL curve, the new equilibrium growth rate of output would still be higher, but the new equilibrium capital-labor ratio would be lower.

Figure 1. Long-Run Growth Equilibrium





increase shown by the distance DE. Second, as the capital-labor rises a proportion of the increase is used to raise the output of the export sector further, providing an additional boost to the rate of labor-augmenting technological progress (this is represented by the *movement* along the new $L_m'L_m'$ curve), an increase traced by E-F. 1/ While the growth of the capital stock declines after an increase in capital-labor ratio (from H to F, owing to diminishing marginal productivity of capital), the growth rate of the labor input rises from D to E to F. After adjustments are completed, the growth rates of capital and labor converge at some point such as F. Therefore, in the modified model with endogenous technical change the long-run growth rate of per capita output increases when the rate of employment in the export sector is raised.

The available long-run cross-sectional empirical studies reviewed in Khan and Villanueva (1991) find that the saving rate (or investment rate) and some measure of export activity do indeed influence positively and significantly the growth rate of potential output. These findings are consistent with the steady-state behavior of our modified model. They do not support the hypotheses of the standard model that ϵ and s exert no long-run effects on output growth.

To sum up, the restrictive assumption behind most export-cum-growth models is that technical change is given exogenously, typically as a constant rate of labor-augmenting, or Harrod-neutral, technical change λ . The modified model allows for an export-induced endogenous component of technical change 2/, in addition to an exogenous component. While the inclusion of exports in the standard neoclassical model enriches the transitional growth dynamics, the (asymptotic) long-run growth rate of per capita output remains fixed by the rate λ . 3/ Thus, the robust empirical result that exports and the growth rate of output are positively correlated in the long run appears to be consistent with our modified model, whereas it is not consistent with those of standard theoretical models formulated to underpin existing empirical work.

2. A two-sector modified model

The foregoing discussion suggests the irrelevance of exports as a third factor of production to the *steady-state* behavior of the growth rate of output, and the crucial importance of exports as a determinant of the rate

1/ There is a third reason. An improvement in labor productivity induced by an increase in output of the export sector provides an incentive to raise the share ϵ of capital and labor utilized in this important sector. This would mean another round of increases in the rate of growth of output.

2/ This is supported by empirical work done by Romer (1990).

3/ As mentioned earlier, including exports directly in the production function for non-exports represents a static, one-time upward shift in the production possibilities curve. A 10 percent increase in the level of output induced by export expansion, though seemingly large, translates into a small annual growth of only half of a percentage point over 20 years.

of Harrod-neutral technological progress. This subsection develops a modified two-sector neoclassical growth model in which exports enhance the rate of labor-augmenting technical change. This is essentially a formalization of the mechanism identified by earlier authors, notably Keesing (1967). Consider the following model, summarized in Table 2. The sectoral production functions for non-exports and exports, respectively, are given in equations (13) and (14). These functions are assumed to satisfy the Inada (1963) conditions. 1/ As before, labor is measured in efficiency units. The sectoral resource allocation coefficients, μ and θ , are assumed to be given in (15) and (16), subject to changes resulting from policy shifts and, possibly, by relative profitability in the two sectors. The sectoral stocks of capital and quantities of labor services add up to the economy-wide totals in (17) and (18). Constant proportions of sectoral outputs are saved and invested in (19) and (20), where the net increases in the sectoral capital stocks are equal to sectoral gross saving less depreciation (the same depreciation rate is assumed to apply to the capital stock in each sector). 2/

Equation (21) says that the export sector is at least as technologically advanced as the non-export sector, such that the labor-augmenting technical change multiplier E_x is at least as large as E_z . This is a very plausible assumption.

Equation (22) is the most important relationship in the modified model. It hypothesizes that, as a form of inter-sectoral externality, the productivity of labor employed in the non-export sector is influenced positively by export activity ($h' > 0$), and also by exogenous factors. The modified model collapses to the standard Feder-type model if it is assumed that $h' = 0$; that is, assuming that labor productivity in the non-export sector is independent of export activity. As demonstrated earlier, inter-sectoral externalities that assign exports the role of an additional input in the production function of the non-export sector (à la Feder) make no difference to the asymptotic behavior of the growth model. Finally, equation (24) defines a new variable k' as the ratio of K to $E_z N$. Equations (23) and (25) are the same as in Table 1.

1/ That is, with reference to a production function $F(K,L) = Lf(k)$, where K is capital, L is labor, and k is the ratio of K to L , the Inada conditions can be summarized as follows: $\lim \partial F/\partial K = \infty$ as $K \rightarrow 0$; $\lim \partial F/\partial K = 0$ as $K \rightarrow \infty$; $f(0) \geq 0$; $f'(k) > 0$, and $f''(k) < 0$, for all $k > 0$.

2/ The assumption of a uniform depreciation rate simplifies the mathematics and does not change the main thrust of the analysis.

Table 2. The Modified Two-Sector Model

$Z = F(K_Z, E_Z N_Z)$	(13)
$X = G(K_X, E_X N_X)$	(14)
$K_X/K_Z = \mu$	(15)
$N_X/N_Z = \theta$	(16)
$K = K_X + K_Z$	(17)
$N = N_X + N_Z$	(18)
$\dot{K}_X = \chi X - \delta K_X$	(19)
$\dot{K}_Z = \eta Z - \delta K_Z$	(20)
$E_X/E_Z = 1 + \alpha; \alpha \geq 0$	(21)
$\dot{E}_Z N_Z = h(X) + \lambda E_Z N_Z; \quad h' > 0$	(22)
$\dot{N} = nN$	(23)
$k' = K/E_Z N$	(24)
$Q = X + Z$	(25)

Reduced model

$$\dot{k}'/k' = \chi G[(\mu/(1+\mu)), (1+\alpha)/(1+\theta^{-1})k'] + \eta F[(1/(1+\mu)), 1/(1+\theta)k'] - h[G[(\mu/(1+\mu))(1+\theta)k', (1+\alpha)\theta] - (\lambda + n + \delta)] \quad (26)$$

Equilibrium capital-labor ratio (k'*)

Root of the equation:

$$\chi G[(\mu/(1+\mu)), (1+\alpha)/(1+\theta^{-1})k'^*] + \eta F[(1/(1+\mu)), 1/(1+\theta)k'^*] - h[G[(\mu/(1+\mu))(1+\theta)k'^*, (1+\alpha)\theta] - (\lambda + n + \delta)] = 0 \quad (27)$$

Equilibrium growth rate of output (\dot{Q}/Q)*

$$[(\dot{Q})/Q]^* = (\dot{K}/K)^* = \chi G[(\mu/(1+\mu)), (1+\alpha)/(1+\theta^{-1})k'^*] + \eta F[(1/(1+\mu)), 1/(1+\theta)k'^*] - \delta \quad (28a)$$

$$[(\dot{Q})/Q]^* = (\dot{E}_Z/E_Z)^* + (\dot{N}/N)^* = h[G[(\mu/(1+\mu))(1+\theta)k'^*, (1+\alpha)\theta] + \lambda + n \quad (28b)$$

Notation:

The notation is identical for the same variables appearing in Table 1. The subscripts x and z refer to exports and non-exports, respectively. Other variables and parameters are defined as follows.

- k' : ratio of K to $E_Z N$
- χ : saving rate of the export sector
- η : saving rate of the non-export sector
- μ : ratio of sectoral capital stocks
- θ : ratio of sectoral labor services
- α : a proportional factor by which E_X exceeds E_Z

a. Equilibrium behavior

The growth rate of the effective capital stock, denoted $\omega(k')$, may be derived by differentiating equation (17) with respect to time and substituting (13)-(16), (19)-(21), and (24):

$$\omega(k') = \chi G[(\mu/(1+\mu)), (1+\alpha)/(1+\theta^{-1})k'] + \eta F[(1/(1+\mu)), 1/(1+\theta)k'] - \delta \quad (29)$$

Similarly, the growth rate of the effective labor input, denoted $\psi(k')$, may be derived by differentiating equation (18) with respect to time and substituting (13), (15)-(16), and (21)-(24):

$$\psi(k') = h(G[(\mu/(1+\mu))(1+\theta)k', (1+\alpha)\theta] + \lambda + n \quad (30)$$

The growth rate of the capital-labor ratio, k' , is thus equal to (see equation (26), Table 2):

$$\dot{k}'/k' = \omega(k') - \psi(k') \quad (31)$$

The reduced model, equation (31), is a single equation involving the variables \dot{k}'/k' and k' alone. Given the assumed properties of the neoclassical production function (the Inada (1963) conditions), equation (31) graphs as in Figure 2, Panel A. The downward slope of the \dot{k}'/k' equation follows from the assumption of positive but diminishing marginal productivities of capital in the two sectors. The reasons why the curve representing equation (31) lies partly in the first quadrant and partly in the fourth quadrant are given by the other Inada (1963) conditions--for some initial values of the capital-labor ratio it is possible for capital to grow either faster or slower than labor.

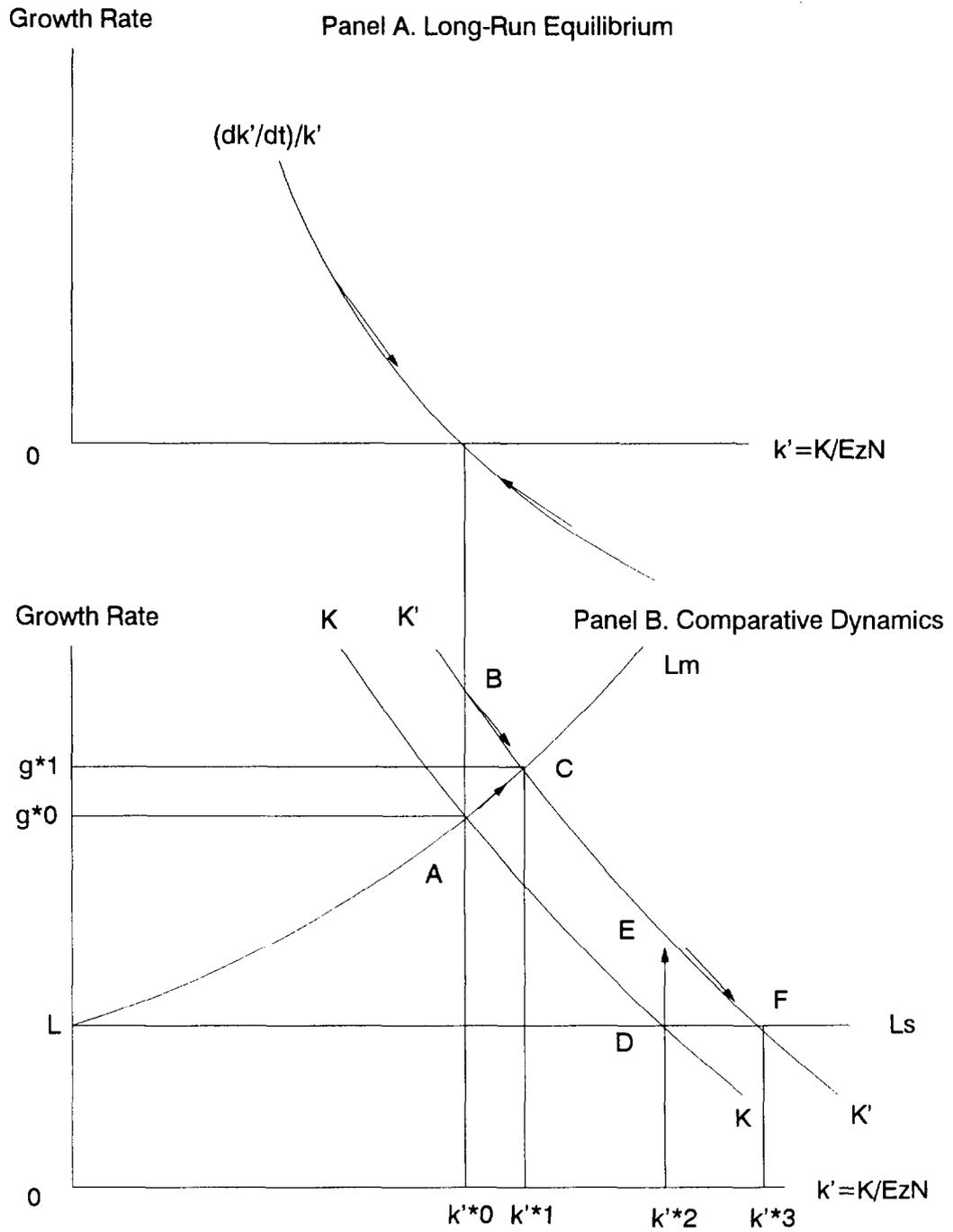
It is obvious by inspection that, at any point on the \dot{k}'/k' curve, the economic system would move in the direction indicated by the arrows. Thus, k' tends to settle at an equilibrium value k'^* . At this point, K and $E_z N$ would grow at the same rate and, by the constant returns assumption, output Q also would grow at this rate. Indicating this equilibrium growth rate γ :

$$\gamma(k'^*) = \chi G[(\mu/(1+\mu)), (1+\alpha)/(1+\theta^{-1})k'^*] + \eta F[(1/(1+\mu)), 1/(1+\theta)k'^*] - \delta \quad (28a)$$

$$\gamma(k'^*) = h(G[(\mu/(1+\mu))(1+\theta)k'^*, (1+\alpha)\theta] + \lambda + n \quad (28b)$$

Given the production functions F , G , and the learning function h , and since k'^* is a function of the structural parameters of the model, γ is in general a function of χ , η , μ , θ , α , δ , n , and λ . Note that this function $\gamma = \gamma(\chi, \eta, \mu, \theta, \alpha, \delta, n, \lambda | G, F, h)$ has partial derivatives with signs +, +, +, +, +, -, +, +. The exact form of the growth rate γ -function is implied by the production functions G , F and the learning function h . However, even for a simple Cobb-Douglas production function and a linear learning function, an explicit solution for the γ -function is generally difficult, if at all possible.

Figure 2. The Two-Sector Model





b. The dynamic effects of exports on economic growth

With the aid of Figure 2, Panel B the effects of an increase in the rate of investment in the export sector on the equilibrium growth path can be analyzed in greater detail. In Figure 2, Panel B the initial equilibrium position is indicated by point A, characterized by equilibrium values of capital intensity, k^*_0 , and the growth rate of output, γ_0 . An increase in χ from χ_0 to χ_1 shifts the KK curve upward to $K'K'$. The next equilibrium position is indicated by point C, characterized by a higher growth rate of output, γ_1 , and a higher capital-labor ratio, k^*_1 . How does the system move from A to C?

An increase in χ has direct and indirect effects on the growth rate of the capital stock. An increase in χ directly raises the rate of investment in the export sector, by the amount AB (reflected in the upward shift of the $\omega(k')$ schedule from KK to $K'K'$). The indirect effect is transmitted via a change in investment behavior induced by changes in the marginal product of capital as the level of capital intensity adjusts to the new value for χ (a movement along the $K'K'$ curve), a point elaborated below.

Following an increase in χ , the economy finds itself momentarily at point B where capital grows faster than labor. Consequently, the ratio of capital to labor begins to rise from k^*_0 toward k^*_1 . As this happens the marginal product of capital falls, slowing investment per unit of capital. The dynamic adjustment of the growth rate of capital is traced by the path A-B-C. Similarly, there is an indirect effect on the growth rate of the labor input. As the capital-labor ratio rises, the output-labor ratio increases and with it, exports per unit of labor. A higher value of exports per unit of labor, given that $h' > 0$, means an increase in the rate of labor-augmenting technical change along the stationary LL_m -schedule, thereby raising the growth rate of the labor force. The dynamic adjustment is traced by the path A-C. This process continues until the growth rates of capital and labor are equalized by a continuous increase in the capital-labor ratio to the new equilibrium level k^*_1 at point C. At this point, capital growth has decelerated to the new and higher growth rate of labor, and the equilibrium growth rate of output has gone up to γ_1 .

For comparison, the standard model may be described by the horizontal line LL_s whose vertical height is equal to $n + \lambda$. The initial equilibrium is at point D($k^*_2, \lambda+n$). An increase in χ shifts the capital growth rate schedule upward as before, and the new equilibrium is established at F, characterized by a higher equilibrium capital-labor ratio, but an unchanged equilibrium growth rate of output. However, in the short and medium run-- between E and F--the rate of growth of output is momentarily higher than $n + \lambda$, because of a higher rate of capital accumulation (by the amount DE) induced by the expansion of the export sector. 1/ As capital intensity

1/ This is the growth effect alluded to by Feder (1983) and others resulting from increased export activity, and by Knight et al. (1992) as a consequence of lower tariffs on imported intermediate and capital goods.

rises from k^*_2 to k^*_3 , the marginal product of capital falls, slowing the rate of investment. Capital growth decelerates, traced by the path E-F. In the long run, the labor input becomes a bottleneck, and the equilibrium growth rate of output converges to a constant rate $n + \lambda$; the effect of an increase in χ is merely to raise the equilibrium capital-labor ratio owing to a higher investment rate in the export sector.

3. Some extensions

The basic growth model (see the modified model, Table 1) can be extended in several directions. Maizels (1968) has argued that the marginal propensity to save in the export sector could be larger than elsewhere, in which case the overall saving-income ratio, s , would increase with an expanding export sector. This hypothesis can be incorporated in the model by assuming that $s = s(\chi)$, with $s' > 0$. The growth effects of export expansion would be magnified by this extension, because of an additional channel (via a higher overall saving-income ratio) through which increased export activity raises the growth rate of the capital stock.

The model can also be extended to incorporate fiscal variables by disaggregating total domestic saving into private and government saving: $S = SP + \tau Q - CE$, where τ is the average income tax rate, and CE is government real current expenditure on goods and services. Allowing for a degree of debt neutrality or incomplete Ricardian equivalence 1/, private saving can be assumed to be a constant fraction of disposable income: $SP = \sigma(1-\beta\tau)Q - (1-\beta)(\tau Q - CE)$, where σ is the private saving ratio, $1-\beta$ is the proportion of a change in government saving offset by an opposite change in private saving ($\beta = 0$ means full debt neutrality or complete Ricardian equivalence). 2/ Assuming that $CE = \Gamma Q$, where Γ is a policy parameter, the aggregate saving ratio now becomes: $s = [\sigma(\chi)(1-\beta\tau) + (\tau - \Gamma)\beta]$, with $\sigma'(\chi) > 0$. As explained in the preceding paragraph, an increase in χ would have a magnified growth effect through an increase in the private saving rate $\sigma(\chi)$. The growth effects of changes in the average income tax rate τ and the current expenditure ratio Γ can also be analyzed in this extended model. As long as Ricardian equivalence is incomplete, that is, β is non-zero, an increase in the tax-income ratio would raise the overall domestic saving ratio and thus the equilibrium growth rate of output. 3/ The opposite effects would be brought about by an increase in the current government expenditure rate Γ .

1/ For a review of the general literature on debt neutrality or Ricardian equivalence, see Leiderman and Blejer (1987). For empirical evidence on incomplete Ricardian equivalence in developing countries, see Haque and Montiel (1989).

2/ See IMF (1989), Chapter IV, Appendix.

3/ Strictly speaking, the growth effects of an increase in the tax rate can go either way, depending on the distortionary cost of taxation, the relative productivities of private and public capital, whether the tax revenues are applied to government consumption or investment, etc.

III. Optimal Saving

Long-run output per unit of effective labor in the basic modified growth model (Table 1) is $q^* = (1-\epsilon)f(k^*, \epsilon g(k^*)) + \epsilon g(k^*) = j(k^*)$. If we take the level of q^* as a measure of the standard of living, and since $j'(k^*) > 0$ 1/, it is possible to raise living standards by increasing k^* . This can be done by adjusting the saving rate s , either directly by raising the government saving rate or by providing incentives to increase the private saving rate. If we take consumption per unit of effective labor (or any monotonically increasing function of it) as a measure of the social welfare of the society, we can determine the domestic saving rate that will maximize social welfare by maximizing the level of long-run consumption per effective labor. 2/

Consumption per unit of effective labor is $c = C/L = Q/L - (\dot{K} + \delta K)/L$, where the last term is gross investment per unit of effective labor. Q/L is $j(k)$ and $(\dot{K} + \delta K)/L$ is equal to $k(\dot{K}/K + \delta)$. In long-run equilibrium, $\dot{K}/K = h(\epsilon g(k^*)) + n + \lambda$. Thus, we have the equilibrium level of consumption per unit of effective labor:

$$c^* = j(k^*) - [h(\epsilon g(k^*)) + n + \lambda + \delta]k^* \quad (32)$$

Maximizing c^* with respect to s :

$$\partial c^*/\partial s = [j'(k^*) - \gamma^* - \delta - k^*h'(\epsilon g(k^*))]\partial k^*/\partial s = 0 \quad (33)$$

where $\gamma^* = h(\epsilon g(k^*)) + n + \lambda$ is the equilibrium growth rate of output. Since $\partial k^*/\partial s > 0$, the Golden Rule condition is 3/:

$$j'(k^*) = \gamma^* + \delta + k^*h'[\epsilon g(k^*)] \quad (34)$$

Note that in the standard model, since the parameter $h' = 0$ (that is, export expansion has no effects on human resource development), the Golden Rule condition reduces to the familiar one: The gross marginal product of capital, $j'(k^*)$, should be equal to the steady-state growth rate of output, $\gamma^* = n + \lambda$, plus the depreciation rate, δ .

The revised condition (34) says that when an expanding export sector continuously improves human skills and productivity, the optimal gross rate of return to capital should be set at a rate higher than the standard magnitude $n + \lambda + \delta$ for two basic reasons. First, when the saving rate is raised, the steady-state growth rate of output will be higher than $n + \lambda$ (the rate obtained from the standard models). Second, capital should be compensated for its additional effect on the equilibrium growth rate of

1/ This follows from the assumptions that $f_{k^*}, g_{k^*} > 0$.

2/ Phelps (1966) refers to this path as the "Golden Rule of Accumulation."

3/ The second-order condition for a maximum is satisfied as long as $h'' < 0$, which implies diminishing returns to the learning function.

output through what Keesing (1967, p. 305) has termed "the learning effects and improvement of human resources" (that is, the h-function) involved in the mutually reinforcing stages of export expansion and capital accumulation. In view of the positive externalities of export activities and their interaction with capital accumulation, the social marginal of capital exceeds the private marginal product of capital. If capital is paid only the standard rate $n+\lambda+\delta$, its indirect effect on output through the human resource development associated with export expansion, which is in turn dependent on capital accumulation, is not compensated for. One way to deal with this problem is to pay capital and labor a proportion ζ of the corresponding marginal product, where ζ is determined so as to exhaust total output:

$$\zeta = j(k^*)/[j(k^*) + h'\epsilon g'(k^*)\{j(k^*) - k^*j'(k^*)\}] \quad (35)$$

Since ζ is a function of k^* only, it is stationary in the steady state, and so is the share of capital in output. Rents will remain constant and wages per worker L will rise at the rate $h[\epsilon g(k^*)] + \lambda$.

IV. Conclusions

This paper has explored several mechanisms through which exports affect, and are affected by, long-term economic growth--production and demand linkages, learning effects and improvement of human resources, adoption of superior technology embodied in foreign produced capital goods, and the general easing of the foreign exchange constraint associated with the expansion of the export sector. Of these various elements, the learning effects that lead to human capital improvements were introduced into a formal growth model via the dependence of technological progress on exports and vice versa. A key analytical result is that, both in the short run and in the long run, an increase in resources devoted to expanding the export sector will raise the growth rate of output. The long-run result is at variance with the standard theoretical result that the growth rate of output is independent of export activity. Another important analytical result is that, for long-run consumption per effective labor to be maximized, the optimal rate of return to capital should be established at a rate higher than the standard population growth rate adjusted for any exogenous labor-augmenting technical change partially to compensate capital for its additional effect on the long-run growth rate of output through the learning effects and improvement of human resources associated with export activities and their interaction with the saving-investment process. The empirical literature on the growth-exports nexus favors the modified over the standard model.

Because of the central role of exports in the absorption of the latest technology, and the interdependence of investment, technical change, and the size of the export sector, there are several important policy implications that can be drawn from the analysis.

1. A key policy objective should be to adopt an outward-looking strategy to stimulate exports, especially of manufactures, early in the process of industrial development. High protective tariffs tend to create an inefficient industrial sector, prevent the introduction of modern techniques, and stunt factor productivity. This paper has provided a theoretical rationale for such an outward-looking strategy in the light of recent developments in "new growth theory" characterized by the improvement of human resources and advances in technology.

2. A crucial policy instrument is a competitive, market-determined or at least market-related level of the real exchange rate, complemented by low, non-discriminatory tariffs and the elimination of non-tariff import barriers. A competitive exchange rate, combined with the protection afforded by transport cost, should reduce the need for tariff protection of domestic consumer goods industries, but more importantly will eliminate anti-export bias.

3. Strong anti-inflationary financial policies are essential to keep local input prices and wages low, so as to maintain external competitiveness. These policies would necessitate strict limits on fiscal subsidies, tax exemptions, and credit expansion.

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