A discusión

# THE CURSE AND BLESSING OF FIXED SPECIFIC FACTORS IN SMALL-OPEN ECONOMIES*

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## ABSTRACT

This paper investigates how a country's specific-factors endowment affects its long-run economic performance. We build an open-economy version of the two-sector neoclassical growth model in which we introduce fixed industry-specific inputs in both activities. The model predicts the type of international factor-price equalization found by Trefler (1993). We show that, under factor price equalization, differences in input shares between sectors that only use mobile factors and industries that employ fixed specific inputs can explain why nations that seem to have similar factor endowments can show very different income levels. In particular, larger amounts of factors specific to the industry with a lower (larger) labor share lead the economy to enjoy larger (smaller) long-run income levels. The model can also account for overtaking episodes between countries along their development paths.

Keywords: Specific-factors, Long-run incomes, Small open economies

JEL Classification: O41, F43.

# 1 Introduction

This paper introduces fixed specific factors into an open-economy version of the standard two-sector neoclassical growth model. Two are the main contributions of the paper. First, we reconcile the importance of specific-factors with the type of cross-country factor-price equalization (FPE) found by Trefler (1993). Second, we provide conditions under which a larger endowment of an industry-specific factor has negative effects and conditions under which it has positive effects on the country's long-run income level. The paper can therefore explain why some nations that seem to have similar endowments can show very different income levels.[1] Our hypothesis is that one source of this difference can lie in the input intensities displayed by the industries to which these factors are specific.

We study a world-economy composed of a large number of small open nations. Each country has the production structure of a two-sector neoclassical growth model with consumption and investment goods in which the different industries have different input intensities. Technologies in both sectors require the use of capital and labor, which can freely move between sectors, and primary factors which are industry-specific. There is also a second investment good whose production requires only the mobile resources. All nations are populated by infinitely-lived agents, and posses identical preferences and production technologies, but they may differ regarding their specific-factors endowment. As a result of this specification the model exhibits both Heckscher-Ohlin and specific-factors properties.[2]

The importance of industry-specific factors has been recognized at least since the work of Ricardo (1871). Most natural resources are perfect examples. These include land in agriculture, water and coal in energy generation, and iron in equipment and structures production. Recent evidence also finds support for the specific-factors model of international trade.[3] However, the standard static specific-factors model

[1] History gives good examples that suggest that large factor endowments can sometimes be a *curse* in terms of income. For example, resource-poor economies such as the Netherlands and Japan outperformed resource-rich nations such as Spain and Russia. Sacks and Warner (2001) also argue that resource abundant countries lag, on average, behind countries with less resources. Some other times, on the other hand, natural-input abundant seems to be a *blessing*. World Bank (1994) finds at least five nations that belong to both the top eight regarding natural capital wealth and the top fifteen regarding per capita income.

[2] For differences between the Heckscher-Ohlin model and the standard specific-factors model of international trade, see for example Jones and Neary (1988).

[3] Kohli (1993) reports estimates of the specific factors and the Heckscher-Ohlin models of interna-

cannot predict the international FPE found by Trefler (1993). In particular, this author shows that the validity of the factor price equalization theorem and the prediction of the Heckscher-Ohlin-Vanek model about the factor content of trade are restablished once we control for productivity differences across countries.[4] Our paper presents a model with fixed specific-factors in several sectors and optimal accumulation of capital that predicts this weaker form of FPE. The model obtains international FPE in the long-run because it incorporates an industry that only employs the accumulable factor and intersectorally mobile inputs.

The paper shows that, under factor price equalization, differences in input shares between activities that only employ mobile inputs and those that require specific factors can represent a key element in explaining the effect of the specific-factors endowment in an open-economy's economic performance. More specifically, larger amounts of inputs that are specific to an activity with a smaller labor share lead the nation to enjoy higher long-run welfare levels. On the contrary, larger stocks of factors that are specific to the less capital intensive sector have a negative influence on capital accumulation. This negative influence can totally offset the positive effect of the larger specific-factor endowment and lead the economy to permanently lower income levels if the technology to which this input is specific possesses a larger labor share than the non-specific-factor technology. The negative effect of an increase in the specific-factor endowment disappears if the country specializes in the production of one good. Under specialization, a larger endowment always raises long-run capital and output. The model predicts as well overtaking episodes between nations along their development paths.

Our work is related to dynamic international trade models that determine savings from utility maximization. Eaton (1987) is the first to take the Jones-Samuelson specific-factors model to a dynamic setting. He considers that land (a fixed factor) is used specifically in the production of one commodity, that capital (an accumulable

tional trade for the US economy and finds that the former performs better than the latter, although US data display quite systematically some properties which are more in line with a Heckscher-Ohlin production structure. Rassekh and Thompson (1997) point out as well that a world in which each sector has some specific factor is at least as likely as one in which all inputs can freely move across activities.

[4] Although the empirical validity of the FPE is mixed, it has recently found considerable support. Besides Trefler (1993), Debaere (2003) finds very clear evidence in favor of the Heckscher-Ohlin-Vanek prediction about the factor content of trade, relaying on its standard set of assumptions which include identical technology and FPE; his results are slightly improved when these two assumptions are relaxed by adjusting the data for productivity differences across countries.

resource) is the specific input in the production of the other commodity, and that labor is used commonly in both production activities. Except in a very special case, Eaton's (1987) model does not predict international FPE because of its overlapping generations structure. As in our model, a land abundant country can have a lower steady state welfare but under different and more restrictive conditions.[5] Brock and Turnovsky (1993) use the same type of model as Eaton to study the impact of differential tariffs on welfare. Markusen and Manning (1993) embed the Jones specific-factors model into a representative-agent framework to include the optimal accumulation of (one or two) specific inputs. They find that the production structure in Eaton (1987) leads to FPE in the long-run, but they do not analyze the effects of larger endowments on long-run income.

Our mechanism to generate factor-price equalization is similar to that in Markusen and Manning's (1993). Optimal accumulation of capital implies that its long-run rental price is determined solely by the international relative price of commodities and the common subjective discount parameter, what triggers factor-price equalization under the usual diversification condition.[6] Unlike them, we allow for cross-country productivity differences and focus the analysis on the response of national income to changes in the fixed endowment of specific inputs. Our aim is to reconcile the kind of weak factor-price equalization found in Trefler (1993) with the importance of specific-factors endowments in the long-run performance of a small open economy.

The literature has studied the effect of specific factors on the evolution of output. Closed-economy models such as Kögel and Prskawetz (2001), Hansen and Prescott (2002), Galor, Moav and Vollrath (2002), and Gollin, Parente and Rogerson (2002), focus on the role of land in production. In these papers, a larger endowment of the specific factor retards the transition to the steady state, but it always increases the long-run income level. Within open-economy scenarios, Matsuyama (1992) and Galor and Mountford (2002), among others, emphasize that a larger natural endowment

[5] In the steady state, FPE holds in Eaton's (1987) model only when both sectors have identical labor shares in production. In that case, a land-abundant country can have a lower steady state level of capital, but the overall effect of land on long-run income is ambiguous. When FPE does not hold, a fall in steady state welfare from a larger natural resource endowment arises when the labor share of the land-using sector is lower than the labor share of the capital-using sector and the initial interest rate is high; but if the interest rate is initially low, more land always raises steady state welfare.

[6] Ruffin (2001) also finds that FPE holds in a quasi-specific-factors model when the relative price of goods is either too high or too low. In that case, one of the two types of (primary) labor looses its Ricardian comparative advantage in the production of sector-specific inputs which, as a result, become non-specific.

reduces the incentives to allocate resources to more growth-enhancing activities such as manufacturing and education, and therefore decreases long-run output. We put forward a different channel through which a larger specific-resource endowment can reduce long-run income: the existence of different input intensities in different industries that sell their products in international markets and use immobile factors. In addition, we establish conditions under which specific inputs can become not only a curse but also a blessing.

The rest of the paper is organized as follows. Section 2 describes the economic environment. Section 3 studies the diversified production equilibrium. Section 4 analyzes how the composition of the factor endowment affects the steady-state outcome. Section 5 discuses the results. Section 6 concludes.

## 2 The economy

Consider a world economy consisting of a large number of small open economies that differ only in their factor endowment. There are three goods, one consumption good and two investment goods, and four inputs of production. The production of the consumption commodity and one of the investment goods require the use of capital and labor inputs, which can freely move across sectors, and also of a third factor which is sector-specific. The production of the second investment good only requires mobile inputs. We assume, for simplicity, that the two investment goods are perfect substitutes.[7] There is free trade in consumption and investment goods, but international movements of inputs are prohibited. All markets are perfectly competitive. Population is constant.

Specific factors are not produced and do not depreciate, their total amount is fixed over time. Given these special characteristics, we consider that specific factors are different types of natural resources. Some natural inputs such as land, large bodies of water, and renewed forests fulfill very well these features. Others, like copper, uranium and iron, are not produced but depreciate in the sense that they are depleted systematically. For these other natural inputs to be in fixed supply, their extraction level had to be constant; we assume this hereafter.[8]

[7] As will be clear later, this assumption has no impact on the main results of the paper. We could also consider two consumption-goods, one of them not requiring for its production a specific factor. This would not change either our main results.

[8] More generally, all inputs in some of their forms can be considered as specific factors. For example, following Ricardo's (1817) theory of rent and capital accumulation, Eaton (1987) looks at

Infinitely-lived consumers discount future utility at rate $\beta$, and have preferences only over consumption. In particular, their preferences are given by

$$\sum_{t=0}^{\infty} \beta^t \frac{c_t^{1-\sigma} - 1}{1-\sigma}, \quad \beta \in (0,1), \quad \sigma > 0. \tag{1}$$

Individuals offer labor services and rent capital and natural resources to firms. Natural resources in the economy are uniformly distributed across all individuals. Since in each period international trade must be balanced, consumers in each country face the following budget constraint

$$c_t + p_t x_t = r_{kt} k_t + r_{nct} \left( \frac{N_c}{L} \right) + r_{nxt} \left( \frac{N_x}{L} \right) + w_t, \tag{2}$$

where the evolution of capital is governed by

$$k_{t+1} = (1-\delta) k_t + x_t. \tag{3}$$

In the above expressions, $L$ represents the constant population size; $c_t$ is the per capita demand for consumption goods; $x_t$ is the per capita demand for investment goods, whose price is $p_t$; $r_{kt}$, $r_{nct}$, $r_{nxt}$, and $w_t$ are, respectively, the rental rates of capital, the consumption-goods specific factor, the investment-goods specific factor, and labor; $N_c$ and $N_x$ denote natural inputs specific to consumption-goods production and investment-products manufacturing, respectively; and $k_t$ is the capital stock own by the consumer at date $t$.[9] The consumption good is the numeraire.

Consumers in each country will maximize (1) subject to (2) and (3), taking as given the world output prices and the domestic rental rates for production factors. The Euler equation corresponding to this dynamic programing problem is

$$\frac{c_{t+1}}{c_t} = \left[ \frac{p_{t+1}}{p_t} \beta \left( \frac{r_{kt+1}}{p_{t+1}} + 1 - \delta \right) \right]^{1/\sigma}. \tag{4}$$

It is standard. It says that the growth rate of consumption depends on the present-utility value of the rate of return to saving. This return reflects that giving up a unit of present consumption allows today buying $1/p_t$ units of the investment goods

physical capital as an specific factor. Specialized labor can be also thought as an specific input, as in Dinopoulos and Sergerstrom (1999). Capital inputs, however, accumulate and are not in fixed supply. We leave incorporating these other type of specific factors for future research.

[9] For notational convenience, we do not allow trade in natural resources among individuals living in the same country. Notice that this assumption has no effect on our results because all individuals are alike in the model.

that, after contributing to the production process, will covert themselves tomorrow in $1 + r_{kt+1}/p_{t+1} - \delta$ units, which can be sold at a price $p_{t+1}$.

In each nation, production of the consumption good ($Y_{ct}$) is given by

$$Y_{ct} = AK_{ct}^{\alpha_k} \left(E_t N_c\right)^{\alpha_n} \left(E_t L_{ct}\right)^{1-\alpha_n-\alpha_k} = AE_t L_{ct} n_{ct}^{\alpha_n} \tilde{k}_{ct}^{\alpha_k}, \quad \alpha_n,\, \alpha_k \in (0,1)\,, \tag{5}$$

There are, in turn, two investment products, but only one of them employs natural resources. Their production technologies are

$$Y_{xt} = BK_{xt}^{\theta_k} \left(E_t N_x\right)^{\theta_n} \left(E_t L_{xt}\right)^{1-\theta_k-\theta_n} = BE_t L_{xt} n_{xt}^{\theta_n} \tilde{k}_{xt}^{\theta_k}, \tag{6}$$

$$\bar{Y}_{xt} = B\bar{K}_{xt}^{\theta_k} \left(E_t \bar{L}_{xt}\right)^{1-\theta_k} = BE_t \bar{L}_{xt} \tilde{\bar{k}}_{xt}^{\theta_k}, \quad \theta_k, \theta_n \in (0,1)\,. \tag{7}$$

Above, $E_t$ stands for an exogenous level of factor-augmenting efficiency in period $t$, common to labor and specific factors in all sectors, that grows at the constant rate $g$; $K_{it}$ and $L_{it}$ denote, respectively, the amount of capital and labor devoted in period $t$ to the production of good $i$ by the sectors that employ specific factors; $n_{it} = N_i/L_{it}$, $\tilde{k}_{it} = K_{it}/E_t L_{it}$, for all $i = x, c$; $Y_{xt}$ represents investment-goods production using a specific input in period $t$; and an upper bar ($^-$) denotes variables related to investment-goods production that does not use specific inputs. We assume that $N_c > 0$ and $N_x > 0$ in all economies.

Denote the fraction of labor employed in the production of good $i$ by $l_{it} = L_{it}/L$, and the overall capital stock per efficiency unit of labor by $\tilde{k}_t$. Notice that because consumers are alike, the amount of capital own by each individual will equal the country's capital-labor ratio. Hence, the constraints on labor and capital within a country can be written as follows:

$$l_{ct} + l_{xt} + \bar{l}_{xt} = 1, \tag{8}$$

$$l_{ct}\tilde{k}_{ct} + l_{xt}\tilde{k}_{xt} + \bar{l}_{xt}\tilde{\bar{k}}_{xt} = \tilde{k}_t. \tag{9}$$

Firms in each country will maximize profits taking as given world prices and the domestic rental rates on production factors. Taking into account (5), (6), (7), and assuming that capital and labor can freely move across sectors, production efficiency

implies that

$$r_{kt} = \alpha_k A n_{ct}^{\alpha_n} \tilde{k}_{ct}^{\alpha_k - 1} = p_t \theta_k B n_{xt}^{\theta_n} \tilde{k}_{xt}^{\theta_k - 1} = p_t \bar{\theta}_k B \tilde{\bar{k}}_{xt}^{\theta_k - 1}, \quad (10)$$

$$r_{nct} = \alpha_n A E_t n_{ct}^{\alpha_n - 1} \tilde{k}_{ct}^{\alpha_k}, \quad (11)$$

$$r_{nxt} = \theta_n A E_t n_{xt}^{\theta_n - 1} \tilde{k}_{xt}^{\theta_k}, \quad (12)$$

$$w_t = (1\text{-}\alpha_k\text{-}\alpha_n)\, A E_t n_{ct}^{\alpha_n} \tilde{k}_{ct}^{\alpha_k} = (1\text{-}\theta_k\text{-}\theta_n)\, p_t B E_t n_{xt}^{\theta_n} \tilde{k}_{xt}^{\theta_k} = (1\text{-}\theta_k)\, p_t B E_t \tilde{\bar{k}}_{xt}^{\theta_k}. \quad (13)$$

Of course, these equalities will hold only for the technologies that coexist in equilibrium. The following two results establish the firms that open in equilibrium.[10]

**Proposition 1** *For any wage rate $w_t$ and capital rental rate $r_{kt}$, it is profitable to operate a technology that uses specific factors if these are found in the economy in a strictly positive amount.*

**Proposition 2** *Pick $N_x > 0$. Firms that use the technology that requires only mobile factors will enter the market if and only if*

$$\frac{K_t/L}{1 + mN_x/L} > \frac{\alpha_k}{1 - \alpha_k - \alpha_n} \frac{\hat{w}_t}{\hat{r}_{kt}} \qquad when \quad \tilde{k}_x > \tilde{k}_c, \quad (14)$$

$$\frac{K_t/L}{1 + mN_x/L} < \frac{\alpha_k}{1 - \alpha_k - \alpha_n} \frac{\hat{w}_t}{\hat{r}_{kt}} \qquad when \quad \tilde{k}_x < \tilde{k}_c, \quad (15)$$

*where* $m = \left[\frac{\theta_k(1-\alpha_k-\alpha_n)}{\alpha_k(1-\theta_k-\theta_n)} - 1\right] \left(\frac{1-\theta_k-\theta_n}{1-\theta_k}\right)^{\frac{1-\theta_k}{\theta_n}}$ *; and $\hat{w}_t$ and $\hat{r}_{kt}$ are equilibrium factor prices when we assume that only the technologies that employ specific factors operate.*

Therefore, an economy that possesses positive endowments of both kinds of natural resources will use the specific-factor technologies at all times. However, whether the technology that requires only mobile inputs is operated will depend on the degree of congestion in the use of the natural resource $N_x$, the economy's capital-labor ratio, and the factor shares in investment-goods production. Note that the constant $m$ is positive when the investment good produced with specific inputs is more capital intensive than the consumption good, and is negative otherwise. Therefore, in either case, given the capital stock and factor prices, no firm will produce the investment good that requires only mobile inputs if $N_x/L$ is sufficiently large. Whereas, given $N_x/L$ and factor prices, larger (smaller) stocks of capital will make more likely to operate that technology when the $N_x$-using investment good is more (less) capital intensive than the consumption good.

[10] The proofs of the propositions presented in the paper are contained in appendix A.

## 3 A diversified-production equilibrium

Assume that all except for one of the nations share the same resource endowments. In particular, they possess $N_x > 0$ and $N_c > 0$ such that either condition (14) or (15) holds, and there are firms that operate the non-specific input technology at all times. Next, we study the balanced-growth path equilibrium allocations that these identical countries reach.

In equilibrium, the identical countries will make the same choices, and the world economy will behave the same as a single large and closed economy, not being affected by the behavior of the different small-open nation. Therefore, we can write the world market clearing conditions for final goods as

$$c_t = AE_t l_{ct} n_{ct}^{\alpha_n} \tilde{k}_{ct}^{\alpha_k}, \tag{16}$$

$$x_t = BE_t l_{xt} n_{xt}^{\theta_n} \tilde{k}_{xt}^{\theta_k} + BE_t \bar{l}_{xt} \tilde{\bar{k}}_{xt}^{\theta_k}. \tag{17}$$

The world economy will produce, in equilibrium, positive amounts of the three goods.

Let us denote by an asterisk (*) steady-state outcomes. The consumers' optimality condition (4) and the world's market clearing condition (16) imply

$$r_k^* = p^* \left[\beta^{-1}(1+g)^{\sigma} + \delta - 1\right]. \tag{18}$$

Defining the wage-capital rental ratio measured in efficiency units as $\tilde{\omega}_{kt} = \frac{w_t}{E_t r_{kt}}$, the efficiency conditions in production (10) and (13), and (18) determine the optimal amount of capital in efficient-labor units in each industry as a function of this relative factor price:

$$\tilde{\bar{k}}_{xt} = \left(\frac{\theta_k}{1-\theta_k}\right)\tilde{\omega}_{kt}, \tag{19}$$

$$\tilde{k}_{ct} = \left(\frac{\alpha_k}{1-\alpha_n-\alpha_k}\right)\tilde{\omega}_{kt}, \tag{20}$$

$$\tilde{k}_{xt} = \left(\frac{\theta_k}{1-\theta_k-\theta_n}\right)\tilde{\omega}_{kt}. \tag{21}$$

Using the expression for $r_k^*$ and condition (10), we obtain the steady-state relative amount of inputs allocated to firms that do not employ specific factors as

$$\tilde{\bar{k}}_x^* = \left[\frac{\theta_k B}{\beta^{-1}(1+g)^{\sigma} + \delta - 1}\right]^{1/(1-\theta_k)}. \tag{22}$$

Equations (19) to (22) determine the values of the relative factor prices and capital-labor ratios along the balanced-growth path. Notice that, at the world's diversified-production equilibrium, the steady-state capital-labor ratios across sectors do not depend on the natural resource endowments. This occurs because these ratios are a function of factor intensities and the relative factor price $\tilde{\omega}_{kt}$, but at steady state $\tilde{\omega}_k^*$ is exclusively determined by consumers' preferences and factor intensities in the sector that does not use specific inputs.

We next determine the labor allocations. Conditions (13), (19) and (21) imply that

$$l_{xt} = \left(\frac{1-\theta_k-\theta_n}{1-\theta_k}\right)^{\frac{1-\theta_k}{\theta_n}} \frac{N_x}{L}. \tag{23}$$

It states that, along a diversified production equilibrium where all available technologies are used, the amount of labor allocated to the factor-specific production of investment goods is fixed and positively related to the endowment of the immobile resource $N_x$, and to the labor intensity in this technology relative to the labor intensity in the production that only uses mobile inputs. Hence, the steady-state labor allocation in the factor-specific production of investment goods, $l_x^*$, must be given by equation (23) if all available technologies are used. From conditions (13), (19) and (20), we derive the labor allocation to consumption-goods manufacturing as

$$l_{ct} = \left[\frac{A\alpha_k^{\alpha_k}\left(1-\alpha_n-\alpha_k\right)^{1-\alpha_k}}{B\theta_k^{\theta_k}\left(1-\bar{\theta}_k\right)^{1-\theta_k}}\left(\frac{\tilde{\omega}_{kt}^{\alpha_k-\theta_k}}{p_t}\right)\right]^{\frac{1}{\alpha_n}} \frac{N_c}{L}. \tag{24}$$

So the fraction of labor employed in the $c$ sector depends positively on the specific factor endowment to this sector and inversely on the relative price of investment goods $p_t$. The relation between $l_{ct}$ and the relative input price $\tilde{\omega}_{kt}$ will be determined by the sign of $\alpha_k - \theta_k$. When the production of good $x$ is the most capital intensive activity – i.e., $\theta_k > \alpha_k/(1-\alpha_n)$ – that sign will be negative and so $l_{ct}$ will depend inversely on $\tilde{\omega}_{kt}$. Otherwise, for example when the production of good $c$ is the most capital intensive – i.e., $\theta_k/(1-\theta_n) < \alpha_k/(1-\alpha_n)$ – we cannot guarantee the sign of this relation. Finally, once we know the labor allocations to the sectors that employ immobile resources (equations (23) and (24)), the economy's labor constraint (expression (8)) delivers $\bar{l}_{xt}$ as a residual.

Conditions (19) and (22) determine the steady-state relative input price. The only remaining task to pin down the labor allocations along the balanced-growth path is

then deriving the steady-state relative output price. In order to do this, we first obtain the steady-state stock of capital per unit of efficiency labor. Using equations (3), (10), (17) and (18), we can write the steady-state stock of capital as

$$\tilde{k}^* = \left[\frac{\beta^{-1}(1+g)^{\sigma} + \delta - 1}{\bar{\theta}_k(\delta + g)}\right]\left(l_x^* \tilde{k}_x^* + \bar{l}_x^* \tilde{\bar{k}}_x^*\right). \tag{25}$$

Clearly, the stock of capital must be completely split among its different uses given, in relative terms, by equation (9). This market-equilibrium condition determines $p^*$. More specifically, combining equations (8), (9), (13), (19) to (22), (23) and (25), we find that

$$p^* = \quad \cdot \left[\frac{\frac{N_x}{L}}{1 + \gamma\frac{N_x}{L}}\right]^{\alpha_n}, \tag{26}$$

where and $\gamma$ are positive constants.[11]

The result is quite intuitive. When the stock of the factor specific to the production of consumption goods rises, the economy devotes relatively more resources to the production of these goods, making investment products relatively more scarce and, as a consequence, more expensive. Exactly the opposite takes place if the amount of the factor specific to the investment-goods sector increases.

Therefore, a larger endowment of any given natural factor raises the amount of labor devoted to the firms that employ it as an input, and decreases the labor allocation to the sector that operates with only immobile inputs. In addition, a larger $N_x$ also increases the steady-state labor allocation to the consumption-goods sector. This indirect effect takes place because the increase in the supply of investment goods makes their price decline, which raises the relative value of the marginal labor productivity in the consumption-goods sector.

## 4 The effect of differences in factor endowments

In this section, we deal with the nation that differs from the others only on the endowment of specific factors. We still assume that its input endowment is such that the three industries produce output. We show that the steady state income level that it achieves critically depends on the factor intensities of the different industries.

[11] $= \dfrac{\frac{A}{B}\left[1+\left(\frac{\alpha_k}{1-\alpha_n-\alpha_k}\right)\frac{(1-\theta_k)\ \theta_k\delta}{\theta_k\left(\beta^{-1}+\delta-1-\theta_k\delta\right)}\right]^{\alpha_n}}{\left(\frac{1-\theta_k}{1-\alpha_n-\alpha_k}\right)^{1-\alpha_k}\left(\frac{\theta_k}{\alpha_k}\right)^{\alpha_k}\left(\frac{\beta^{-1}+\delta-1}{\theta_k\delta}\right)^{\frac{\alpha_k-\theta_k}{1-\theta_k}}}$, and $\gamma = \frac{\theta_n}{1-\theta_k-\theta_n}\left(\frac{1-\theta_k-\theta_n}{1-\theta_k}\right)^{\frac{1-\theta_k}{\theta_n}}$.

Note that equations (18) to (24) describe the behavior of all our economies, regardless of their resource endowment. Under perfectly competitive markets, all the small-open economies face at steady-state the international output price $p^*$. Therefore, an open-economy that owns resources of the $N_x$ and $N_c$ types diversifies production and accumulates capital until its rental rate falls down to the world's rate $r_k^*$, which is by equation (18) exclusively determined by consumers' preferences, the growth rate of technological progress, and $p^*$. Let us remove the time subscript to denote the balanced-growth values for the different country. Along the balanced growth path, expressions (19) to (22) imply that $\tilde{\tilde{k}}_x = \tilde{\tilde{k}}_x^*$, $\tilde{\omega}_k = \tilde{\omega}_k^*$, $\tilde{k}_c = \tilde{k}_c^*$, and $\tilde{k}_x = \tilde{k}_x^*$. And from expressions (10) to (13), $n_c = n_c^*$, $n_x = n_x^*$, $r_{nxt}/E_t = r_{nxt}^*/E_t^*$, $r_{nct}/E_t^* = r_{nct}^*/E_t^*$, and $w_t/E_t = w_t^*/E_t^*$. In sum, in the long run, factor efficiency-price equalization will hold, and the country will be using the same techniques as the rest of nations. Notice that we obtain factor efficiency-price equalization because of the mobile-factors firms, which pin down the relative factor prices for the whole economy.[12]

The difference with the other nations will come regarding the overall capital efficiency-labor ratio and labor allocations. Notice that the equality $n_i = n_i^*$, for all $i = x, c$, implies that a lower endowment of a given natural resource will make optimal to allocate a lower fraction of labor to the sector that employs this specific factor. That is, defining $\nu_i = N_i/L$ as the per capita amount of natural factor $i$ for $i = c, x$, and denoting with an asterisk the average world's endowments, if $\nu_i < \nu_i^*$ then $l_i < l_i^*$ and vice versa.

Regarding the economy's capital stock, we can use equations (8) and (9), and (19) to (21) to write

$$l_{ct} = \frac{\theta_k (1 - \alpha_k - \alpha_n)}{\theta_k (1 - \alpha_n) - \alpha_k} \left[ 1 + l_x \frac{\theta_n}{1 - \theta_k - \theta_n} - \left( \frac{1 - \theta_k}{\theta_k} \right) \frac{\tilde{k}_t}{\tilde{\omega}_{kt}} \right] \tag{27}$$

where $l_x$ is the constant labor share employed in investment-goods production with specific inputs that we obtained in (23).

At the steady state, the efficiency-wage capital rental ratio equals the international relative factor price, $\tilde{\omega}_k = \tilde{\omega}_k^*$, which is independent of factor endowments. If the difference in relative endowments comes only from the specific-factor in the consumption-goods sector, then $l_x = l_x^*$ and the effect on the long-run capital stock

[12] Factor prices per efficiency unit are equalized, as the Trefler's (1993) and Debaere's (2003) empirical evidence suggests.

will depend on the relative capital intensities across sectors. In particular, if the investment sector is more capital intensive (i.e., $\theta_k(1-\alpha_n)-\alpha_k>0$), we have a positive relationship between $\tilde{k}$ and $\nu_c$. That is, $\nu_c>\nu_c^*$ will imply that $l_c>l_c^*$ and from (27) we obtain that $\tilde{k}<\tilde{k}^*$; and viceversa, $\nu_c<\nu_c^*$ will imply that $\tilde{k}>\tilde{k}^*$. But if the consumption sector is more capital intensive than the production of investment goods under the non-specific-factors technology, we get the opposite, $\tilde{k}$ is positively related to $\nu_c$.

On the other side, when the difference in relative endowments comes only from the specific-factor in the investment-goods sector, we have the following. If $\nu_x>\nu_x^*$, then $l_x>l_x^*$ and, everything else equal, expression (27) implies that $\tilde{k}>\tilde{k}^*$; and the other way round if $\nu_x<\nu_x^*$. At first sight, this result seems independent of the input shares across activities.[13] However, the result rests on the assumption that the capital shares are the same in technologies (6) and (7); which implies that the industry that produces investment goods using specific inputs is more capital intensive than the one that only employs mobile factors.

In sum, a small economy that differs from the rest of the world in the amount of $N_c$ will have its long-run capital stock above the world's average if and only if (i) its endowment is above the world's average and (ii) the cosumption-goods sector is more capital intensive than the production of the investment good that does not use specific-factors. On the contrary, given that we suppose that investment-goods production with specific factors is relatively capital intensive, a larger endowment of the natural input $N_x$ will always increase long-run capital.

Changes in the stock of the natural inputs have a similar effect on long-run per capita income $y_t$. To see this, notice that using expressions (5) to (7) and (8), we can write the level of GDP per capita $y_t=E_t[l_{c_t}y_{c_t}+p_t(l_{xt}y_{xt}+\bar{l}_{xt}\bar{y}_{xt}]$ as

$$y_t=E_t\left\{l_{c_t}An_{ct}^{\alpha_n}\tilde{k}_{ct}^{\alpha_k}+p_tB\left[l_{xt}n_{xt}^{\theta_n}\tilde{k}_{xt}^{\theta_k}+(1-l_{c_t}-l_{xt})\tilde{\bar{k}}_{xt}^{\theta_k}\right]\right\}.$$

When the increase is in $N_x$, $l_x$ will rise exactly in the same proportion (to restore $n_x=n_x^*$), and this increase will be exactly equal to the decrease in $\bar{l}_x$ because $l_c$ remains constant. Since all relative uses of inputs will remain unchanged, we have that output in the consumption sector will not change, $dy_c=0$, and the change in overall income will be determined by the following expression:

[13] Notice that because $p^*$ is exogenous to the different economy, $l_c$ becomes independent of $N_x$. Hence, regardless of the factor intensities, $\tilde{k}$ has to move always inversely with $l_x$ when $\nu_x$ varies in order to keep the equality $l_c=l_c^*$ in equation (27).

$$dy = E_t p^* B(n_x^{\theta_n} k_x^{\theta_k} - \tilde{\bar{k}}_x^{\theta_k}) dl_x = E_t p^* B \tilde{\bar{k}}_x^{\theta_k} \left( \frac{1-\theta_k}{1-\theta_k-\theta_n} - 1 \right) \frac{dN_x}{L}. \qquad (28)$$

The last equality comes from the equalization of labor productivity across sectors and the fact that $dn_x = 0$. Notice that the denominator and numerator inside the parentheses equal, respectively, the labor shares in investment-goods production with and without specific factors. Therefore, the sign of $dy/dN_x$ is positive because the technology using only mobile inputs has a larger labor share than the specific-factor technology to produce $x$ goods.

Similarly, when the change comes only from the specific factor $N_c$, output of firms producing the investment goods with the specific-factor technology will not change, $dy_x = 0$, and the increase in $y_c$ will come at the expense of a reduction in $\overline{y}_x$. The increase in $l_c$ will be exactly equal to the decrease in $\bar{l}_x$. Following the same steps as in (28) we find that the change in overall income per capita is

$$dy = E_t p^* B \tilde{\bar{k}}_x^{\theta_k} \left( \frac{1-\theta_k}{1-\alpha_k-\alpha_n} - 1 \right) \frac{dN_c}{L}. \qquad (29)$$

Thus, an increase in $N_c$ will increase overall output if and only if the technology that uses only mobile inputs possesses a larger labor share than the production of $c$ goods (i.e.: $\theta_k < \alpha_k + \alpha_n$).

The next proposition summarizes the main results.

**Proposition 3** *A small open economy that has $N_x > 0$ and $N_c > 0$ such that either condition (14) or (15) holds for all $t$ stays in a diversified-production equilibrium at all times and accumulates capital until factor efficiency-price equalization holds. The country's steady-state income level will increase with $N_x$, because investment-goods production with specific inputs is more capital intensive than manufacturing with only mobile factors. On the contrary, long-run income will decrease (increase) with $N_c$ if the consumption-goods sector has a relatively larger (smaler) labor share.*

The lesson from this section is that the impact on the economy's income level of the factor endowment that is specific to a given activity critically depends on the input elasticities of this activity. Note that this implication follows from *Rybczynski-type* effects which are underlying in the production structure. To illustrate this point,

suppose that our small economy is identical to the rest of the world and has already reached the steady state. Then, given the steady state prices, an increase in the small economy's endowment of a specific-factor $N_i$ will imply an increase in the share of labor employed by firms that use this specific input and, as a result, an increase in their output. This is done through a shift of labor and capital from firms that use the mobile inputs technology and so it is done at the expense of a fall in their investment-goods output.

In summary, output prices are determined by international markets and this equalizes input-efficiency-rental rates across nations; as a result the fraction of labor employed by the small economy in an activity that uses a specific factor is solely determined by the world's technique $n_i^*$ and its own endowment of the specific factor $N_i$. Any change in $N_i$, everything else constant, implies a reallocation of labor (and capital) between the specific-factor activity $i$ and the activity that only requires mobile inputs. Whether the overall change in aggregate production translates into more income relative to the world's average relies on the relative labor shares between these two production activities. A small-open economy with a larger endowment of a factor specific to an activity that is more capital intensive than the mobile inputs technology will accumulate more capital, and will enjoy larger long-run income. But a larger endowment of a factor specific to an activity that is less capital intensive than the mobile inputs technology will lead the economy to a lower capital stock in the long-run that will offset the benefits of the larger endowment if the specific-factor technology has a larger labor elasticity, leading the economy toward a balanced-growth path characterized by smaller income levels.

## 5 Discussion of results

The model predicts that possessing a relatively high aggregate endowment of fixed specific inputs such as natural resources can be a curse in terms of long-run income, but also a blessing depending on the differences in labor shares across the industries to which these inputs are specific relative to the mobile-inputs technology. For example, if the investment-goods sector that uses specific factors is relatively capital intensive, and the consumption goods industry has the largest labor share, then a larger $N_x$ leads to a higher long-run income level, whereas a bigger $N_c$ generates a lower steady-state income. Therefore, the model can explain why some nations that seem to have

similar resource endowments can show very different income levels.

Findings are conditioned on the assumptions made. One that is clearly critical for our results is the existence in equilibrium of firms that exclusively operate with mobile factors. Their existence is important to reconcile specific-factors models with the evidence presented by Trefler (1993) in favor of FPE across nations. However, there might be still economies that are far away from the average, and in which factor prices are not equalized. Appendix B shows that if this is the case and all sectors use specific inputs, the main consequence is that opposing effects of the specific factors model are less likely. We have also assumed that countries possess resources specific to both industries. In Appendix C, we show that when countries do not possess resources specific to one sector, production specialization is possible, and that under specialization a larger natural endowment always leads the economy to higher capital stocks and income levels in the long-run. The intuition is simple. Under specialization, a larger specific-factor endowment no longer induces a resource stealing effect on other sectors. As a consequence, for a sufficiently large specific-input endowment, the specialized country can accumulate enough capital so that its long run income will be above the world's average.

The findings presented in proposition 3 imply that the model can also predict overtaking episodes along the adjustment path. Suppose that all nations begin their development path at time *zero* with the same levels of capital per capita $k_0 < k_c^*$ (if investment goods are more capital intensive), or $k_0 < k_x^*$ (if consumption goods are more capital intensive), and the same levels of efficiency $E_0$, labor $L$ and $N_x > 0$. Nevertheless, the different economy owns a smaller $N_c$.[14] It is straightforward that, at the initial time, the country with a smaller natural-input stock will have a lower income level because it has the same amounts of the other three inputs. From proposition 3, we know that the natural resource-poorer economy will accumulate capital faster and, at some point along the development path, will overtake the resource-richer economy if the consumption-goods sector has a higher labor share, ending up

[14] Actually, the initial capital-labor ratio $k_0$ should be a function of the other factor endowments. In order to generate overtaking, we need that the resource-poorer economy enjoys a smaller initial income level. Equation (29) says that when $k_0$ is endogenous this occurs if $\theta_k < \alpha_k + \alpha_n$. We could think that the economies start at time *zero* from a preindustrial steady-state in which firms use different technologies than in the new long-run situation towards which the development path converges. In particular, preindustrial technologies make relatively bigger use of animal power and people's labor. As a consequence, capital intensities in the preindustrial era are smaller, and more similar across sectors than in technologies (5) to (7) so the above inequality holds.

having higher income levels.

Allowing for differences in the initial levels of efficiency across countries has no effect on the qualitative results presented in the paper, provided that these differences are not too large. But cross-nation productivity disparities would certainly affect the specific-factor endowment threshold level that determines when long-run income is above the world's average. For example, if a small economy starts up with a lower efficiency level, it will need a smaller endowment of the input specific to the industry with a larger labor share to be able to overcome the world-economy's long-run income. This is so because in our model efficiency grows at the same exogenous rate everywhere and initial productivity differences will persist.

Some of our results have the flavor of the immiserizing-growth literature: Edgeworth (1894) showed that under international trade, it does not always pay to rely solely on the *invisible hand* of the market. More specifically within our Walrasian model, *laissez faire* leads agents to invest in the consumption-goods sector when the stock of its specific factor rises. Unfortunately, if the production of investment goods is more capital intensive, these short-run gains can come at a cost of lower future capital and income levels. A benevolent central planner might then be tempted to intervene if present gains are more than outweighed by future losses in present value terms; then the increase in the natural input stock would be both long-run income and welfare reducing. More specifically, growth *immiserizes* in our model because the country with a larger stock of $N_c$ resources, specific to the less capital intensive activity, can enjoy, under incomplete specialization, a larger real income at the steady state if it applies an optimal tariff. In this case, the domestic price of imported investment goods will be larger than the international price and so will be the domestic rate of return on capital, factor price equalization will not hold, but the steady state level of capital associated to a larger stock of $N_c$ resources will be higher.

It is clear therefore that besides the positive implications of the model, it also has normative ones. If the goal of policymakers is to permanently increase income, subsidizing the exploitation or accumulation of factors that are specific to less capital-intensive activities can be mistaken. For this reason, before implementing this type of policies, it seems important to study the input intensities in the different industries and whether factors are mobile across sectors. More case studies in line with the work of Kohli (1993) for the US economy but including natural resources should be most helpful.

# 6 Conclusion

The paper has presented an open-economy version of the two-sector neoclassical growth model in which investment- and consumption-goods are produced using fixed specific factors. Our model differs from the dynamic specific-factors model of international trade in that we allow capital to move freely across sectors and have a technology to manufacture one of the investment goods that requires only intersectorally mobile factors. It is the inclusion of this technology what induces factor-price equalization across open economies that produce within the diversification cone.

The model predicts that nations that possess a relatively low endowment of factors can outperform countries with a larger natural-resource endowment. This is the case if those countries diversify production and their relatively scarce endowment is specific to an industry with a relatively low labor share. The reason is that a larger specific-input endowment in the less capital intensive sector drives the economy towards a long-run allocation with a lower capital stock, which can completely offset the positive effects of the resource increase. Quite the contrary, if two nations only differ in their input endowment specific to the more capital intensive industry, the resource-richer nation also becomes the per capita output-richer economy.

Our model has a clear implication for empirical research. The above findings suggest that in order to disentangle the impact of fixed specific-factors and, in particular, natural resources on income levels and growth rates, it is important to carry out the investigation at the sectoral level.

# Appendix

## A Proofs

**Proof of proposition 1.** Suppose that a technology that requires an immobile factor is not used. The firms that have access to this technology will like to open if they make profits for the prices (say $\hat{r}_k$, $\hat{w}_t$, $\hat{r}_{nx}$, $\hat{r}_{nc}$ and $\hat{p}$) that prevail in the equilibrium where the economy is located. In particular, given $N_c > 0$, a firm in the consumption-goods sector chooses $K_{ct}$ and $L_{ct}$ to maximize its profits $\Pi_{ct}$, which is equivalent to maximizing

$$A\left(\frac{K_{ct}}{E_t N_c}\right)^{\alpha_k}\left(\frac{L_{ct}}{N_c}\right)^{1-\alpha_k-\alpha_n} - r_{kt}\frac{K_{ct}}{E_t N_c} - w_t\frac{L_{ct}}{E_t N_c} - r_{nct}\frac{1}{E_t}. \tag{30}$$

The maximum level of profits, per efficiency unit of the specific factor, then equals

$$\frac{\Pi_{ct}}{E_t N_c} = \alpha_n A^{\frac{1}{\alpha_n}}\left(\frac{1-\alpha_k-\alpha_n}{w_t/E_t}\right)^{\frac{1-\alpha_k-\alpha_n}{\alpha_n}}\left(\frac{\alpha_k}{r_{kt}}\right)^{\frac{\alpha_k}{\alpha_n}} - r_{nct}/E_t. \tag{31}$$

In an equilibrium in which these type of firms do not operate, it must be true that $\hat{r}_{nct} = 0$. Hence, in expression (31) maximum profits are strictly positive, for all $t$. Given that this problem is identical to the one of the investment-goods sector, firms that use specific factors will always have incentives to open. ■

**Proof of proposition 2.** These firms' profits equal

$$\bar{\Pi}_{xt} = p_t B \bar{K}_{xt}^{\theta_k}\left(E_t \bar{L}_{xt}\right)^{1-\theta_k} - r_{kt}\bar{K}_{xt} - w_t \bar{L}_{xt}. \tag{32}$$

At the maximum, it must hold that

$$\max_{\substack{0\leq \bar{K}_{xt}\leq K_t \\ 0\leq \bar{L}_{xt}\leq L}} \bar{\Pi}_{xt} = \bar{K}_{xt}\left[r_{kt}\left(\frac{1-\theta_k}{\theta_k}\right) - \frac{w_t}{E_t}\left(\frac{r_{kt}}{\theta_k p_t B}\right)^{\frac{1}{1-\theta_k}}\right], \tag{33}$$

since $(E_t\bar{L}_{xt}/\bar{K}_{xt})^{1-\theta_k} = r_{kt}/p_t B\theta_k$. Let $\hat{r}_{kt}$, $\hat{w}_t$, and $\hat{p}_t$ be the equilibrium market prices when only firms that use specific inputs operate. Given $E_t$, $\hat{r}_{kt}$, $\hat{w}_t$, and $\hat{p}_t$, firms that do not use natural resources will want to enter the market if and only if they make profits, that is, if and only if

$$\hat{p}_t B > \left(\frac{\hat{r}_k}{\theta_k}\right)^{\theta_k}\left(\frac{\hat{w}_t/E_t}{1-\theta_k}\right)^{1-\theta_k}, \tag{34}$$

>From optimality conditions (10) and (13) for investment-goods producers that use specific factors, expression (34) becomes

$$\hat{p}_t B > \left(\frac{\hat{p}_t\theta_k B n_{xt}^{\theta_n}\tilde{k}_{xt}^{\theta_k-1}}{\theta_k}\right)^{\bar{\theta}_k}\left[\frac{(1-\theta_k-\theta_n)\,\hat{p}_t B n_{xt}^{\theta_n}\tilde{k}_{xt}^{\theta_k}}{1-\theta_k}\right]^{1-\theta_k}, \tag{35}$$

which reduces to

$$\hat{l}_{xt} > \left(\frac{1-\theta_k-\theta_n}{1-\theta_k}\right)^{\frac{1-\theta_k}{\theta_n}} \frac{N_x}{L}. \tag{36}$$

Or equivalently, from (9) and (8) evaluated at $\bar{l}_{xt} = 0$, we have that $l_{xt} = \left(\tilde{k}_t - \tilde{k}_{ct}\right) / \left(\tilde{k}_{xt} - \tilde{k}_{ct}\right)$. And from (10) and (13) we get that $\tilde{k}_{ct} = \frac{\alpha_k w_t / E_t}{(1-\alpha_k-\alpha_n) r_{kt}}$ and $\tilde{k}_{xt}/\tilde{k}_{ct} = \frac{\theta_k(1-\alpha_k-\alpha_n)}{\alpha_k(1-\theta_k-\theta_n)}$. Using these expressions, condition (36) becomes (14) and (15). ■

**Proof of proposition 3.** It directly follows from the text. ■

**Proof of proposition 4.** Applying the same reasoning as in the proof to proposition 2, the result follows from optimality conditions (10) and (13) for the consumption-goods sector, and expression (34). ■

# B When all firms use specific factors

Obviously, proposition 3 holds as long as $\bar{l}_x > 0$. Above some value of $N_x$ and $N_c$, the economy will achieve the corner solution in which firms that use the technology that only requires mobile factors will shut down. Suppose that condition (36), equivalently (14) or (15), does not hold at steady state. In particular, suppose that the sign of the inequality is reversed,

$$\hat{L}_x < \left(\frac{1-\theta_k-\theta_n}{1-\theta_k}\right)^{\frac{1-\theta_k}{\theta_n}} N_x, \tag{37}$$

Under condition (37), the country will still accumulate capital until its rental rate is the same as in the world economy, but the rest of factor prices will remain different. At the steady state, the firms' efficiency conditions (10) (taking $\bar{l}_{xt} = \bar{\tilde{k}}_{xt} = 0$), (19) and (21) imply that

$$\tilde{\omega}_k = \left(\frac{1-\theta_k-\theta_n}{1-\theta_k}\right) n_x^{\theta_n/(1-\theta_k)} \tilde{\omega}_k^*. \tag{38}$$

Which in turn implies that $\tilde{\omega}_k > \tilde{\omega}_k^*$ under condition (37). Since the capital labor ratios in both sectors are proportional to the relative factor price $\tilde{\omega}_k$, it follows that the country will be using in the long-run more capital intensive techniques than the other economies, $\tilde{k}_x > \tilde{k}_x^*$ and $\tilde{k}_c > \tilde{k}_c^*$, and that $w > w^*$.

>From equations (10) and (13), we can obtain the following relationship between the labor allocation and the specific-factors endowment:

$$\left(\frac{1-\alpha_k-\alpha_n}{1-\theta_k-\theta_n}\right) \frac{(\alpha_k/r_{kt})^{\frac{\alpha_k}{1-\alpha_k}}}{(\theta_k/r_{kt})^{\frac{\theta_k}{1-\theta_k}}} \frac{(A\nu_c^{\alpha_n})^{\frac{1}{1-\alpha_k}}}{\left(p^* B \nu_x^{\theta_n}\right)^{\frac{1}{1-\theta_k}}} = \frac{(1-l_{xt})^{\frac{\alpha_n}{1-\alpha_k}}}{l_{xt}^{\frac{\theta_n}{1-\theta_k}}}. \tag{39}$$

Therefore, when only the technologies that use specific factors operate, $l_{xt}$ varies inversely with $\nu_c$ and positively with $\nu_x$ and $\tilde{k}_{xt}$. The last relationship follows because $r_{kt}$ and $\tilde{k}_{xt}$ are inversely related (see equation (10))

Along the balanced-growth path, $r_{kt} = r_k^*$ for all $t$. Expression (39) then implies that a larger $\nu_c$ decreases the steady-state allocation of labor $l_x$ and, therefore, increases $l_c$. Because the allocation of labor to the investment-goods sector goes down, the capital-labor ratio in this activity must rise to maintain the interest rate invariant (see expression (10)). The increase of $\tilde{k}_x$, in turn, implies that $\tilde{k}_c$ also rises because, by optimality conditions (10) and (13), the ratio of $\tilde{k}_c$ to $\tilde{k}_x$ is constant. The same type of reasoning says that an increase in $\nu_x$ decreases $l_c$ and raises $l_x$, $\tilde{k}_c$ and $\tilde{k}_x$. Equation (10) also implies that if $\tilde{k}_i$ rises, so does $n_i$, for all $i = x, c$.

Hence, unlike in the case with the three firm types, an increase in any specific-factor endowment now raises the capital-labor ratios of both production activities. This contributes to raise income. However, the impact on the economy's long-run output of an increase in any specific-input endowment can be negative under certain restrictive conditions. Using production functions (5) and (6), conditions (10) and (8) with $\bar{l}_{xt} = 0$, and expressions (20) and (21), the steady-state income per capita level $y$ can be written as

$$y = E_t \left[ p^* n_x^{\theta_n} \left( \frac{\theta_k}{r_k^*} \right)^{\theta_k} \right]^{\frac{1}{1-\theta_k}} \left[ \frac{(1-\theta_k-\theta_n) + l_x\,(\theta_k+\theta_n-\alpha_k-\alpha_n)}{1-\alpha_k-\alpha_n} \right]. \qquad (40)$$

As we saw in the previous paragraph, when the relative endowment $\nu_x$ rises, the steady-state labor allocation $l_x$ and the value of $n_x$ increase. Then, expression (40) implies that if the consumption-goods sector has a larger labor share ($\theta_k + \theta_n > \alpha_k + \alpha_n$), the steady-state income level rises with $\nu_x$; the effect is ambiguous otherwise. On the other hand, an increase in $\nu_c$ provokes a decline in $l_x$ and a larger $n_x$. Differentiating in (40), we find that the sign of $\partial y/\partial l_x$ is negative if and only if $l_x < \theta_n/(\theta_k + \theta_n - \alpha_k - \alpha_n)$, that is, if and only if $\theta_n > \alpha_n(1-\theta_k)$ and the investment-goods sector has a labor intensity sufficiently similar to the consumption goods sector.

The following proposition states the main findings.

**Proposition 4** *Fix $p_t = p^*$, and $N_x > 0$ such that condition (36) does not hold at steady-state. The country's steady-state capital-labor ratios increase in both sectors with the stock of any specific factor. In addition, an increase in a specific-factor stock raises the country's steady-state income level if the sector to which the input is specific has a lower labor share; the effect is ambiguous otherwise.*

# C Investment-goods production without specific inputs

When the country does not find in its territory natural resources specific to the investment-goods production activity, production takes place using only technologies (5) and (7). Given that $N_x$ equals zero, specialization in consumption-goods production is a possible equilibrium outcome. The next proposition establishes conditions under which this is the case.

**Proposition 5** *Fix $N_x = 0$. The investment-goods sector will open if and only if*

$$p_t > \frac{A}{B} \left( \frac{\alpha_k}{\theta_k} \right)^{\theta_k} \left( \frac{1-\alpha_k-\alpha_n}{1-\theta_k} \right)^{1-\theta_k} \nu_c^{\alpha_n} \hat{\tilde{k}}_t^{\alpha_k-\theta_k} \qquad (41)$$

*where $\hat{\tilde{k}}_t$ denotes the equilibrium stock of capital per efficiency unit of labor when only consumption-goods are manufactured.*

Implicitly, expression (41) determines a minimum price above which it becomes profitable for investment-goods producers to enter the market. This minimum price depends on the relative endowment of the specific factor $\nu_c$, the capital/labor ratio, and factor intensities, let us denote it by $p_{\min}(\tilde{k}_t; \nu_c)$. The country then specializes in the production of consumption goods if $p_{\min}(\tilde{k}_t; \nu_c)$ is greater than or equal to $p_t$. More specifically, closing the investment-goods sector becomes more appealing as $\nu_c$ increases and as $\tilde{k}_t$ and $p_t$ decline or, in other words, as the consumption-goods sector becomes relatively more productive.

Suppose first the situation where the small country's factor endowments are such that it produces only consumption goods, remaining specialized in the long run. The economy accumulates capital through imports of investment goods, with $\tilde{k}_t = \tilde{k}_{ct}$ and $l_{ct} = 1$ for all $t$, until the domestic rate of return on capital reaches $r_k^*$. At that point, the firms' efficiency conditions (10), (11) and (13), and the world's production steady state techniques, $n_c^*$ and $\tilde{k}_c^*$, pin down $\tilde{k}$ as

$$\tilde{k} = [(\nu_c/\nu_c^*)\, l_c^*]^{\frac{\alpha_n}{1-\alpha_k}}\, \tilde{k}_c^*. \tag{42}$$

The same conditions imply that unlike in the diversified-production scenario, factor efficiency-prices in the specialized economy do not converge to the ones of the rest of the world. In particular, the relative factor price $\tilde{\omega}_k$ goes up with $\nu_c$.

However, for (42) to be a steady-state equilibrium, it must be true that it is not profitable to operate in the investment-goods sector. That is, that condition (41) does not hold when capital is given by (42). Substituting (42) into (41), we can easily find that the country will not diversify production in the long-run if its relative endowment of the factor specific to the production of consumption goods satisfies

$$\nu_c \geq \nu_c^*/l_c^* = n_c^*. \tag{43}$$

Under (43), expression (42) implies that $\tilde{k} \geq \tilde{k}_c^*$. Moreover, long-run capital is now positively related to $N_c$. The reason is that an increase in the specific-factor endowment no longer induces a resource stealing effect on other sectors. Unlike in the diversified-production scenario, when the country specializes its long-run income level rises with the endowment of the specific factor. As a consequence, for $\nu_c$ sufficiently large, the specialized country can accumulate enough capital so that its long run income, $y = A\nu_c^{\alpha_n}\tilde{k}^{\alpha_k}$, will be above the world's average.

If, on the other hand, the country has $\nu_c < n_c^*$, it produces inside the diversification cone at the steady state, and it is straightforward that factor prices and income then behave as in proposition 3.

The following proposition summarizes these results.

**Proposition 6** *A small open economy with $N_x = 0$ and $\nu_c < n_c^*$ diversifies production at the steady state, and its long-run income and factor prices behave as in proposition 3. If, on the other hand, its endowment $\nu_c$ is larger or equal than $n_c^*$, the economy specializes in consumption-goods production in the long-run, its efficiency-factor prices do not converge to the world's prices, and its income level along the balanced-growth path increases with the endowment specific to the consumption sector.*

## References


Brock, P.L., and S.J. Turnovsky, "The growth and welfare consequences of differential tariffs," *International Economic Review* 34:765-794, 1993.

Debaere, P., "Relative factor abundance and trade", *Journal of Political Economy* 111, 5: 589-610, 2003.

Dinopoulos, E., and P. Segerstrom, "The dynamic effects of contingent tariffs," *Journal of International Economics* 47:191-222, 1999.

Eaton, J., "A dynamic specific-factors model of international trade," *Review of Economic Studies* 54:325-338, 1987.

Edgeworth, F.Y., "The theory of international values I," *Economic Journal* 4:35-50, 1894.

Galor, O., O. Moav and D. Vollrath, "Divergence and Overtaking: Land Abundance as a Hurdle for Education Reforms," *mimeo*, Brown University, 2002.

Galor, O., and A. Mountford, "Trade, Demographic Transition, and the Great Divergence: Why are a Third of People Indian or Chinese?" *mimeo*, Brown University, 2003.

Gollin, D., S.L. Parente and R. Rogerson, "Structural Transformation and Cross-Country Income Differences," *mimeo*, Arizona State University, 2002.

Hansen, G.D., and E.C. Prescott, "Malthus to Solow," *American Economic Review*, 1205-1217, September 2002.

Jones, R.W., and J.P. Neary, "The positive theory of international trade," in R.W. Jones and P.B. Kenen, eds., *Handbook on International Economics* (North Holland, Amsterdam), 2nd edition, 1988.

Kögel, T., and A. Prskawetz, "Agricultural Productivity Growth and Escape from the Malthusian Trap," *Journal of Economic Growth* 6:337-357, 2001.

Markusen, J.R., and R. Manning, "Long-run production frontiers for the Jones specific-factors model with optimal capital accumulation", in W.J. Ethier, E. Helpman and J.P. Neary, eds, *Theory, Policy and Dynamics in International Trade: Essays in honor of Ronald Jones*, 1993.

Matsuyama, K., "Agricultural productivity, comparative advantage, and economic growth," *Journal of Economic Theory* 58: 317-334, 1992.

Rassekh, F., and H. Thompson, "Adjustment in general equilibrium: Some industrial evidence," *Review of International Economics* 5: 20-31, 1997.

Ricardo, D., *On the Principles of Political Economy and Taxation* (John Murray, London), 1817. Reprinted in P. Sraffa, ed., *The Works and Correspondence of David Ricardo*, Vol. 1 (Cambridge University Press, Cambridge).

Ruffin, R.J., "Quasi-specific factors: worker comparative advantage in the two-sector production model", *Journal of International Economics* 53: 445-461, 2001.

Sachs, J.D., and A.M. Warner, "The curse of natural resources," *European Economic Review* 45:827-838, May 2001.

Trefler, D., "International factor price differences: Leontief was right!" *Journal of Political Economy* 101(6):961-987, 1993.

World Bank, "Expanding the measure of wealth: Indicators of environmentally sustainable development," *Environmentally sustainable development studies and monographs series* no. 7, 1994.