Trade Liberalization, Paths of Development, and Income Distribution

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Abstract

The Stolper-Samuelson theorem predicts that since developing countries are relatively abundant in unskilled labor, trade liberalization would decrease the relative wage of skilled to unskilled workers. Empirical evidence shows that while this prediction holds for some developing countries, it does not for many others. To account for these different outcomes, this paper develops a dynamic, general equilibrium model where small developing economies differ in their factor endowments at the time of trade liberalization. These different "initial conditions", along with the impact of increased openness on the endogenous accumulation of factors of production, generate a rich set of outcomes that account for the diverse income-distribution patterns observed across developing countries. In the model, the existence of different initial conditions is explained by differences in trade policy and development strategies across countries. In particular, we consider both import substitution and subsidies to exports and education. Following trade liberalization, the behavior of the skill premium varies across countries because of the different paths of adjustment of both prices and factor endowments. In contrast to the existing literature on trade and wages in developing countries, this paper emphasizes the dynamic and general equilibrium aspects of trade. This paper also stresses the importance of a general equilibrium approach in the empirical work on trade and wages.
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1 Introduction

The impact of trade liberalization on the internal income distribution in developing countries has received wide attention in recent years. The focus has been on the contrast between what the standard theory predicts and what the empirical evidence suggests. On the one hand, according to the Stolper-Samuelson theorem, trade liberalization benefits a country's relatively abundant factor. When compared with developed economies, developing countries are relatively abundant in

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unskilled labor. We should then expect the relative wage of skilled to unskilled workers to decrease in developing economies following trade liberalization.

On the other hand, the empirical evidence is mixed. Wood (1997) documents a reduction in the relative wage of skilled workers following increased openness in East Asia, in contrast with an increase of this wage gap in Latin America.[1] Robbins (1996) studies several Latin American and Asian countries, where increases in the relative supply of skilled workers had large negative effects on the their relative wage. However, when these supply shifts are netted out to identify the relative demand shifts associated with trade liberalization, it turns out that in some of the countries studied increased openness led to rising relative wages of skilled to unskilled workers.[2] Finally, in a study for nineteen countries, Michaely, Papageorgiu and Choksi (1991) find that while income inequality decreased for some countries during the course of liberalization, it widened for others.[3]

How can we explain such different outcomes across developing economies? In the existing literature, the standard 2×2 Heckscher-Ohlin model has been modified in various ways to generate predictions contrary to the Stolper-Samuelson result. Among these modifications are the inclusion of nontraded goods, or addition of factors of production.[4] However, most of this analysis has been conducted in the context of static models. This paper argues that to understand why relative wages of skilled workers increased in some developing countries, and decreased in others following trade liberalization, it is necessary to develop a dynamic model that captures the impact of trade on factor prices, through its effect on the endogenous accumulation of factors of production.

The purpose of this paper is to explain the behavior of the skill premium in developing countries by building a dynamic, general equilibrium model in which small developing economies differ in their factor endowments at the time of trade liberalization. These different "initial conditions", along with the impact of increased openness on the endogenous accumulation of factors of production,

[1] East Asian countries include Korea, Taiwan, Singapore and Malaysia. Evidence for Latin America includes Argentina, Chile, Colombia, Costa Rica and Uruguay.

[2] In Chile, Colombia and Costa Rica, trade liberalization appears to generate a rise in the relative wages of skilled workers. This is not the case for Malaysia, Philippines and Taiwan.

[3] Following trade liberalization income inequality decreased in Colombia, Greece and Indonesia, but widened in Argentina, Chile and Israel. On the other hand, Singapore experienced decreased inequality first, followed by widened inequality. The opposite is documented for Sri Lanka.

[4] See Wood (1997).

generate a rich set of outcomes that can account for the diverse patterns of the relative wage of skilled workers observed across developing countries. Further, one of the contributions of this paper is to develop a *unified* framework in which developing countries differ only in their initial conditions, but the dynamic structure of the model naturally generates diverse income-distribution outcomes.

The dynamic approach of this paper is based on two key elements. First, to explain differences across developing countries we go beyond the common "North-South" distinction, and focus on the heterogeneity across countries in the "South", i.e. developing countries. These countries were heterogeneous in their initial conditions when they implemented trade liberalization. By initial conditions we mean the stocks of factor endowments such as physical capital, human capital, and raw labor at the time of liberalization. Initial conditions matter because they determine patterns of production and trade, which in turn affect factor prices.

Figures 1 and 2 illustrate the heterogeneity observed across developing countries along two dimensions. The horizontal axis displays the physical capital per worker, and the vertical axis a measure of human capital (average years of schooling) for developing countries in Latin America and Asia in 1965 (Figure 1) and 1985 (Figure 2). Both measures are normalized with respect to the corresponding average for developed countries, so that the point $(1,1)$ corresponds to the factor endowments in the "North".[5] These figures make apparent not only North-South differences, but also the heterogeneity observed within the South.[6]

Although we do not know whether this heterogeneity implies that these countries are in different cones of diversification,[7] what these Figures do suggest is that they were at different stages of development when trade liberalization was implemented. For instance, one striking difference can

[5] Data on non-residential capital per worker is from the World Penn Tables, and average years of schooling is from Barro and Lee (1994). The sample was selected on the basis of data availability for both series. Developed countries include Canada, U.S., Austria, Belgium, Denmark, Finland, France, West Germany, Iceland, Ireland, Italy, Netherlands, Norway, Sweden, Switzerland, U.K., Australia and New Zealand. For the purpose of comparison, this group of countries is the same for 1965 (Figure 1) and 1985 (Figure 2).

[6] Notice that both figures display a larger variation in the physical capital index across developing countries than in the human capital dimension. In fact, while the coefficient of variation on the physical capital axis is 58% in 1965 and 62% in 1985, that for the human capital axis is 33% in 1965 and 27% in 1985. Moreover, the heterogeneity across countries has changed between 1965 and 1985. For instance, while the correlation between the two indexes was 0.29 in 1965, it increased to 0.52 in 1985.

[7] Empirical work classifying developing economies in different cones of diversification is not available.

be seen when comparing East Asia and Latin America. Around 1965 the East Asian tigers increased openness through higher export growth. Notice from Figure 1 that in 1965, Taiwan, Korea and Hong Kong[8] had higher human capital indexes than most of the other developing economies. However, their indexes of physical capital per worker were no larger than any other country. On the other hand, 1985 represents a time of trade liberalization, through reductions in barriers to imports, for both Latin America and South Asia. Notice from Figure 2 that, in contrast with the East Asian case, some Latin American countries including Argentina, Colombia, Ecuador, Mexico, Panama, and Venezuela[9] liberalized when their physical capital index was larger than most of the other countries in the sample.

The second key element of this paper is that when factor endowments are accumulable, trade liberalization can be seen as a "change in regime" that affects the pattern of accumulation of these factors of production. For instance, as is natural to assume, if physical capital is traded and human capital is nontraded, openness has an asymmetric effect on their rate of accumulation. This affects the relative supply of factors through time, which in turn has an impact on the evolution of relative wages following increased openness.

Some empirical studies have highlighted the importance of changes in the relative supply of factors of production in explaining the evolution of the relative wage of skilled workers.[10] However, as Robbins (1999) argues, studies on the impact of trade liberalization on relative wages have not "explicitly considered human capital or formal education as determined endogenously within the trade process" [p.8].

In the model of this paper, initial conditions at the time of liberalization matter because there are multiple open-economy balanced growth paths. The existence of different initial conditions is explained by differences in trade policy across developing economies. In particular, we consider some types of policies that can account for the heterogeneity of initial conditions observed in

[8]The codes for these countries in the figures are respectively OAN, KOR and HKG.

[9]Codes for these countries are respectively ARG, COL, ECU, MEX, PAN, and VEN.

[10]Harrigan and Balaban (1999) show the importance of changes in relative factor supplies to explain the increase in the relative wage of college educated workers in the U.S.

Figures 1 and 2. For instance, countries that implemented subsidies to exports and education generated biased growth toward human capital, as in the case of East Asia. In contrast, countries that underwent import substitution, as in the case of Latin America, had relatively higher physical capital at the time of liberalization.

Following trade liberalization, the behavior of the skill premium varies across countries because of the different paths of adjustment of both prices and factor endowments. For instance, economies that start off with relatively high human capital experience faster growth in physical capital along the transition. In this case, skilled wages and the skill premium tend to increase along the transition. In contrast, countries with relatively high physical capital at the time of liberalization exhibit faster growth in human capital and a decreasing skill premium.

Moreover, the evolution of the skill premium also depends on the production technology. In fact, the framework of this paper allows us to evaluate the impact of capital-skill complementarity on the behavior of the skill premium. For instance, if the production function exhibits capital-skill complementarity, economies that underwent import substitution before liberalization, such as some Latin American countries, display rising skill premium at the beginning of the transition once tariffs are eliminated.

This paper offers a novel approach to the relationship between trade and the skill premium in developing countries. First, similarly to other papers that have modified the standard 2×2 Heckscher-Ohlin model, here we consider more than two factors of production and nontraded goods. However, we emphasize a channel that has been previously neglected: the impact that trade has on factor prices through its effect of the endogenous accumulation of physical and human capital. Further, trade liberalization is not studied in isolation, but rather is seen as a regime change that occurs at some point along the path of development of a country.

This paper is related to Davis (1996) in that both offer an explanation to the variety of income-distribution outcomes observed across developing countries following trade liberalization. Davis argues that while developing countries are relatively abundant in unskilled workers when compared to the "global economy", some of them are abundant in skilled workers in a "local sense", i.e.

when compared with countries with similar endowment proportions that produce the same range of goods. This implies that a developing country that is relatively abundant in skilled labor in a "local sense", should expect the relative wage of skilled workers to *rise* with trade liberalization.

Both this paper and Davis's (1996) point at the "local" relative abundance of factors observed across developing countries as a key ingredient for understanding the empirical evidence. However, the two approaches are different. Davis looks at "local abundance" in order to reinterpret Stolper-Samuelson in the context of a static model. Here, "local" differences are treated as different initial conditions in the context of a dynamic model. This allows us to solve for the full dynamic path of relative wages following increased openness.

This paper is also related to Findlay (1995). He discusses human capital, wage differentials and trade patterns in a model where young agents can choose to get educated, or to work as unskilled. Similar to Findlay, the model developed here allows for endogenous accumulation of human capital, but trade occurs due to differences in factor endowments, and not to differences in the rate of time preference. Finally, different from Findlay, here we solve for the transitional dynamics in order to characterize the full path of adjustment of prices and factor endowments following trade liberalization.

The effects of international trade on the endogenous accumulation of factors of production has been formalized by Bond and Trask (1997). They develop an endogenous growth model of physical and human capital accumulation in a small open economy. In their model, trade affects the relative returns to investment in physical and human capital, as well as the long run factor stocks in the economy. Here we adopt a similar mechanism of endogenous accumulation of factors. One main difference between this paper and Bond and Trask's is that here we incorporate and additional factor of production: unskilled labor. This not only allows us to account for the dynamics of the relative wage of skilled workers, but it is also key to generate diverse paths of development.

The reminder of this paper is organized as follows. Section 2 presents the model and describes the balanced growth path for a small open economy. Section 3 discusses the transitional dynamics of a developing country after trade liberalization. In Section 4, we rationalize differences in initial conditions observed across developing countries as emerging from differences in their tariff structures. Section 5 discusses numerical examples that illustrate the transitional dynamics of the model, and Section 6 concludes.

2 A small open developing country

Consider a world economy composed by a group of developed countries and a set of small developing economies. Since we want to focus on developing countries, we follow Atkeson and Kehoe (1998) by assuming that all developed countries are identical in the sense that they all started developing at the same time and with the same initial factor endowments. Developed countries are all growing along a balanced growth path (BGP). The only role for developed countries in this model is to determine the world price of traded goods.

We now characterize the economy of a small developing country by specifying a production structure and solving the problem for the representative household. In this model all countries have access to the same technology and are identical in every respect, except that developing economies differ in their initial factor endowments.

2.1 Production structure

There are four goods in this economy: three of them traded, and one nontraded.[11] The three traded goods are an investment good X, a low-skill consumption good Z, and a middle-skill consumption good M. The nontraded good is education E. Each of the goods is produced using all of three factors of production: physical capital K, human capital H and unskilled labor L.

While the investment good is used to accumulate physical capital, education is used to accumulate human capital.[12] Unskilled labor grows exogenously at a constant rate n. We introduce growth through labor-augmenting technological progress, i.e., the efficiency units of unskilled labor

[11] We introduce 4 goods in this economy in order to be able to contrast import-substitution policies from those that subsidize exports and education in developing countries. This will become clear in Section 4 where such policies are discussed.

[12] In this model, as in Bond and Trask (1997), physical capital is traded, human capital is nontraded, and borrowing and lending are not allowed.

are given by AL. The parameter A grows at the exogenous rate g, which corresponds to the growth rate of per capita output in the BGP.

Technology exhibits constant returns to scale in every sector. A fraction $\theta_i > 0$ of total physical capital K is assigned to the production of each good $i = Z, M, X, E$. Similarly, a fraction $\mu_i > 0$ of H, and a fraction $\gamma_i > 0$ of AL are allocated to each good i. Using the constant returns to scale assumption we can express the production function of each sector in terms of variables that are constant along the BGP. Thus, technology for the low-skill consumption sector is $z = \gamma_z f_z(k_z, h_z)$; for the middle-skill consumption good $m = \gamma_m f_m(k_m, h_m)$; for the investment good $x = \gamma_x f_x(k_x, h_x)$; and for the education sector $e = \gamma_e f_e(k_e, h_e)$, where: $k_i = \frac{\theta_i K}{\gamma_i AL}$, $h_i = \frac{\mu_i H}{\gamma_i AL}$, $z = \frac{Z}{AL}$, $m = \frac{M}{AL}$, $x = \frac{X}{AL}$, $e = \frac{E}{AL}$.

Let good Z be the numeraire, p_m the relative price of the middle-skill consumption good, p_x the relative price of the investment good, and p_e the relative price of education. Following Bond, Wang and Yip (1996) and Bond and Trask (1997), one can use the static zero-profit conditions to determine factor prices as function of commodity prices. Let r be the rental rate of physical capital, w^H the rental rate of human capital, and $\widetilde{w}^L$ the wage of unskilled workers, all measured in terms of good Z. Then,

$$p_e = \Phi_e \left(r, w^H, w^L\right) \tag{1}$$

$$p_x \leq \Phi_x \left(r, w^H, w^L\right) \tag{2}$$

$$p_m \leq \Phi_m \left(r, w^H, w^L\right) \tag{3}$$

$$1 \leq \Phi_z \left(r, w^H, w^L\right) \tag{4}$$

where Φ_i are the unitary cost functions, and $w^L = \widetilde{w}^L / A$.[13] Notice that since education is nontraded in this model, the zero-profit condition for this sector holds with equality. In contrast, a small open may shut down the production of goods Z, M or X.

[13]We have divided $\widetilde{w}^L$ by A because due to unskilled-labor augmenting technological progress $\widetilde{w}^L$ grows at rate g, and so w^L is constant along the BGP.

Full employment of factors implies that at each point in time:

$$\gamma_z k_z + \gamma_m k_m + \gamma_x k_x + \gamma_e k_e \leq k$$

$$\gamma_z h_z + \gamma_m k_m + \gamma_x h_x + \gamma_e h_e \leq h$$

$$\gamma_z + \gamma_m + \gamma_x + \gamma_e \leq 1$$

where $k = \frac{K}{AL}$ and $h = \frac{H}{AL}$.

2.2 Representative household

A representative household is composed by N members, and offers labor through dual components: human capital H and unskilled labor L. We can think of the N members as the sum of unskilled workers L and skilled workers S. Only skilled workers are able to use the human capital available to the household in production. What matters for both households and producers is not the size of S, but the level of human capital H. To guarantee the existence of a BGP, S must grow at the same rate n as L. Households do not decide the split of the N members between L and S, but do decide the level of human capital that S members will contribute to the production of goods.[14]

The representative household decides on consumption, investment in human and physical capital, and the allocation of factors across sectors of production. Since there are two consumption goods Z and M we assume that a composite consumption bundle is given by: $c = \Psi(c_m, c_z)$, where $c = \frac{C}{AL}$. The representative household in the small open developing country solves the following dynamic problem, where time subscripts have been omitted wherever possible:

$$\max_{k_i, h_i, \gamma_i, c, k, h} \int_0^\infty e^{-(\rho-(1-\sigma)g-n)t} \frac{c(t)^{1-\sigma}}{1-\sigma} dt$$

[14] By modeling the representative household as offering dual components H and L we simplify the solution of the transitional dynamics because we do not need to keep track of the distribution of skilled and unskilled workers in the population.

subject to:

$$c = \Psi(c_m, c_z)$$

$$\dot{k} = \gamma_x f_x(k_x, h_x) - (\delta + g + n)k + \frac{1}{p_x}\left[\gamma_z f_z(k_z, h_z) - c_z\right] + \frac{p_m}{p_x}\left[\gamma_m f_m(k_m, h_m) - c_m\right]$$

$$\dot{h} = \gamma_e f_e(k_e, h_e) - (\delta + g + n)h$$

$$\sum_i \theta_i \leq 1 \text{ , } \sum_i \mu_i \leq 1 \text{ and } \sum_i \gamma_i \leq 1$$

$$\theta_i \geq 0, \; \mu_i \geq 0 \text{ and } \gamma_i \geq 0 \text{ for } i = z, x, e$$

$$h(0) = h_0 > 0 \text{ and } k(0) = k_0 > 0$$

where $\dot{k}$ is given by the market-clearing condition for traded goods, and $\dot{h}$ by that for the nontraded good. The pair (k_0, h_0) represents the initial conditions for the developing country when trade liberalization is implemented.

Static optimality conditions for the problem above imply the equalization of r, w^H and w^L across the active sectors of production. In particular, if all four sectors are active, these conditions read:[15]

$$r = f_z^k = p_m f_m^k = p_x f_x^k = p_e f_e^k \tag{5}$$

$$w^H = f_z^h = p_m f_m^h = p_x f_x^h = p_e f_e^h \tag{6}$$

$$\begin{aligned} w^L &= f_z - \left(f_z^k k_z + f_z^h h_z\right) = p_m\left[f_m - \left(f_m^k k_m + f_m^h h_m\right)\right] \\ &= p_x\left[f_x - \left(f_x^k k_x + f_x^h h_x\right)\right] = p_e\left[f_e - \left(f_e^k k_e + f_e^h h_e\right)\right] \end{aligned} \tag{7}$$

where all r , w^H and w^L are constant along the BGP. Dynamic optimality conditions for the

[15] We have written the static optimality conditions for the case in which all 4 sectors are active, just to avoid defining more multipliers to the restrictions, and save in notation. Keep in mind though, that the small developing country may not produce some of the traded goods.

representative household are given by:

$$\frac{\dot{\phi}}{\phi} = (\rho + \delta + \sigma g) - \frac{r}{p_x} \tag{8}$$

$$\frac{\dot{\pi}}{\pi} = (\rho + \delta + \sigma g) - \frac{w^H}{p_e} \tag{9}$$

$$\frac{\dot{c}}{c} = \frac{1}{\sigma}\left[\frac{r}{p_x} - (\rho + \delta + \sigma g)\right] \tag{10}$$

where ϕ and π are the multipliers associated with the state variables k and h respectively, and δ is the rate of depreciation of both human and physical capital, which has been assumed to be equal for simplicity.[16]

2.3 World prices

Let $\overline{p}_x$ and $\overline{p}_m$ be the world prices of traded goods X and M. A small open developing economy takes these prices as given, and cannot affect them. World prices are determined by the developed countries. Since by assumption they are growing along their BGP, these prices are constant. As in Atkeson and Kehoe (1998), since all developed countries are identical, in equilibrium they make the same choices and we can solve their BGP by assuming that they are a single large country that does not trade. This implies that developed countries produce all four goods.

Given the structure of the model described above, it turns out that factor prices and commodity prices can be solved for independently of factor endowments. This means that in a BGP where all four goods are produced, both developed and developing economies will share the same factor and commodity prices. This is so because countries are identical in every respect except in their factor endowments.

[16] In solving for dynamic optimality conditions we have used the current value Hamiltonian. We have also used the fact that the relative price of the education good in terms of good Z is $p_e = p_x\pi/\phi$, because π is the value of an increment of good E and ϕ/p_x is the value of an increment of good Z. Transversality conditions are given by: $\lim_{t\to\infty} e^{-(\rho-(1-\sigma)g-n)t}\phi(t)k(t) = 0$ and $\lim_{t\to\infty} e^{-(\rho-(1-\sigma)g-n)t}\pi(t)h(t) = 0$.

Since c, π and ϕ are constant along the BGP, using equation (10), we obtain

$$r = p_x(\rho + \delta + \sigma g) \tag{11}$$

and using equations (8) and (9), the following intertemporal arbitrage condition along the BGP can be derived:

$$\frac{r}{p_x} = \frac{w^H}{p_e} \tag{12}$$

which states the equalization of net returns on the investment of physical and human capital.

Equations (12), (11), (1), (2), (3), and (4) form a block of equations, which we call the *"first block of equations"*, that solves for BGP prices in the developed world: $\overline{p}_e$, $\overline{p}_x$, $\overline{p}_m$, $\overline{r}$, $\overline{w}^H$ and $\overline{w}^L$.[17] This first block of equations resembles Samuelson's nonsubstitution theorem but in the context of a dynamic model: in a world with four goods and three factors of production, we have four competitive profit conditions. Since two of the goods are accumulable as factors of production, we need to determine 6 prices. This can be achieved independently of factor endowments by using the four competitive profits conditions and two equations, (12) and (11), from the dynamic optimality conditions for consumers.

2.4 Balanced growth path

We now describe the BGP for the small open economy. By "open" we mean the absence of tariffs or any other type of trade restrictions. Recall that along the BGP since L grows at rate n, and A grows at rate g, then K and H grow at rate $g + n$. Also, total output Y grows at rate $g + n$, and per capita output Y/N grows at rate g.

It turns out that while there exists a BGP along which the small open economy produces all four goods (z, m, x, e), there are also BGPs along which three goods are produced, and even others in which only two sectors are active. BGPs with three goods are (z, m, e), (z, x, e) and (m, x, e); and BGPs with only two goods are (z, e), (m, e) and (x, e). As will become clear below, factor prices

[17] Uniqueness of the solution is guaranteed because the unit cost functions Φ_i exhibit constant returns to scale.

and commodity prices are the same in any of the BGPs described above. Among the differences across the BGPs are the pairs (k, h), per capita output, and the composition of production and trade. Further, the skill premium will also differ across BGPs because even though w^H and w^L are the same, h is different.

2.4.1 Prices

Let p_e^*, r^*, w^{H*} and w^{L*} be BGP prices for the small developing economy. Recall that the small open developing economy takes $\overline{p}_x$ and $\overline{p}_m$ as given. First notice that since countries are assumed to be identical in every respect except in factor endowments, equation (11) automatically implies that along the BGP, the rental rate of physical capital for the developing country r^* is identical to that of the developed world $\overline{r}$. This is true regardless of the number of goods produced along the BGP. Since $r^* = \overline{r}$, then from equation (12), we have that $w^{H*}/p_e^* = \overline{w}^H/\overline{p}_e$. This means that once the rate of return of investment in physical capital in the developing country is equalized to that of the developed world, the incentives for accumulation of *both* physical and human capital at rates different from BGP growth rates would cease. Again, this holds regardless of the number of traded goods produced by the developing country along the BGP.

From the independence of factor and commodity prices from factor endowments, it is immediate that when all four goods are produced $r^* = \overline{r}$; $w^{H*} = \overline{w}^H$; $w^{H*} = \overline{w}^L$; and $p_e^* = \overline{p}_e$. Further, it turns out that this also holds when three goods are produced or when only two goods are produced. To see this, consider for instance the case in which (z, m, e) are produced. Since $r^* = \overline{r}$ always holds, equations (1), (3), and (4) form a system in three unknowns w^{H*}, w^{H*} and p_e^*. However, we know that $w^{H*}/p_e^* = \overline{w}^H/\overline{p}_e = \rho + \delta + \sigma g$ must also be satisfied. The only way this could happen is if $w^{H*} = \overline{w}^H$; $w^{H*} = \overline{w}^L$; and $p_e^* = \overline{p}_e$.

Finally, to illustrate the two-good case, consider the pair (z, e). Equations (1) and (4) form a system in three unknowns w^{H*}, w^{H*} and p_e^*. In this case, to complete the system we add the restriction $w^{H*}/p_e^* = \rho + \delta + \sigma g$. Thus, $w^{H*} = \overline{w}^H$; $w^{H*} = \overline{w}^L$; and $p_e^* = \overline{p}_e$ is a solution.[18]

[18] Since the system is linear, and the number of equations equals the number of unknowns, if a solution exists, it must be unique.

To summarize, we have shown that regardless of the number of goods that the small open developing economy produces along the BGP, it is always the case that factor and commodity prices are equalized to those of the developed world. This long-run "factor price equalization" property greatly simplifies the solution of the model. At the same time, as will become clear below, factor price equalization does not hold along the transition to the BGP, so that the dynamic paths of k and h affect factor prices along the transition. Further, in this model even if BGP factor prices are equalized, the BGP skill premium will differ across countries.

2.4.2 Factor intensities

We have solved for p_e^*, $\overline{p}_x$, $\overline{p}_m$, r^*, and w^{H*} from the first block of equations. We now proceed to solve for BGP factor intensities k_i^*, and h_i^*. Consider first the case in which all four goods (z, m, x, e) are produced. It is easy to see that a *"second block"* of 8 equations from (5) and (6) solves for the BGP factor intensities k_z^*, k_m^*, k_x^*, k_e^*, h_z^*, h_m^*, h_x^* and h_e^*.[19] Notice that these factor intensities would be the same as the ones for the developed world's BGP.

When only three goods are produced, say (z, m, e), we can form a system of 6 equations from (5) and (6) by simply excluding sector x. Since factor and commodity prices are the same as in the four-good case, then k_z^*, k_m^*, k_e^*, h_z^*, h_m^*, and h_e^* are clearly solution for this system. Finally, when only two goods are produced, say (z, e), we form a system of four equations from (5) and (6) by excluding both sectors m and x. Again, k_z^*, k_e^*, h_z^*, and h_e^* are the solution for this system.

2.4.3 Third block of equations

We now complete the solution of the BGP by finding the allocations of unskilled labor across sectors: γ_z^*, γ_m^*, γ_x^*, γ_e^*; the stocks of physical and human capital k^*, h^*; and consumption c_m^*.[20]

[19] Constant returns to scale in technologies makes the second block of equations linear. Also notice that the 4 equations in (7) are automatically satisfied because zero profit conditions are all included in the first block of equations.

[20] Once c_m^* is known, c_z^* can be solved for from the static optimality condition for consumption.

The solution for these variables is found from the *"third block of equations"* given by:

$$\gamma_z k_z^* + \gamma_m k_m^* + \gamma_x k_x^* + \gamma_e k_e^* = k$$

$$\gamma_z h_z^* + \gamma_m k_m^* + \gamma_x h_x^* + \gamma_e h_e^* = h$$

$$\gamma_z + \gamma_m + \gamma_x + \gamma_e = 1$$

$$(\delta + g + n)k = \gamma_x f_x(k_x^*, h_x^*) + \frac{1}{\overline{p}_x}\left[\gamma_z f_z(k_z^*, h_z^*) - c_z\right] + \frac{\overline{p}_m}{\overline{p}_x}\left[\gamma_m f_m(k_m^*, h_m^*) - c_m\right]$$

$$(\delta + g + n)h = \gamma_e f_e(k_e^*, h_e^*)$$

where the first three equations are full-employment conditions, and the last two are market-clearing conditions for traded and nontraded goods respectively. The number of goods produced along the BGP becomes relevant at this point, because the restrictions $\gamma_i > 0$ are satisfied with equality for certain goods across the different cases. This is the most interesting part of the model since it describes the BGP heterogeneity across different developing economies.

Consider first the BGP in which (z, e) are produced. In this case, $\gamma_m = \gamma_x = 0$, and the third block of equations solves for the following 5 unknowns: $\gamma_z^{(ze)*}$, $\gamma_e^{(ze)*}$, $k^{(ze)*}$, $h^{(ze)*}$ and $c_m^{(ze)*}$, where a superscript has been included to distinguish this BGP from others. Thus, a feature of this case is the existence of a unique BGP pair $(k^{(ze)*},\, h^{(ze)*})$. Similarly, the BGPs for the cases of goods (m, e) and (x, e) are characterized by unique pairs $(k^{(me)*},\, h^{(me)*})$ and $(k^{(xe)*},\, h^{(xe)*})$ respectively.

In contrast, this uniqueness does not hold anymore when three goods are produced along the BGP. For instance, consider the BGP in which (z, m, e) are produced. In this case, $\gamma_x = 0$ and the third block of equations is under-identified because now we have 6 unknowns: $\gamma_z^{(zme)*}$, $\gamma_m^{(zme)*}$, $\gamma_e^{(zme)*}$, $k^{(zme)*}$, $h^{(zme)*}$ and $c_m^{(zme)*}$. This implies that for each $k^{(zme)*}$ we choose, the system has a solution. In this case, there exist multiple BGP pairs $\left(k^{(zme)*}, h^{(zme)*}\right)$. In fact, there is a continuum of them and we can write a linear function of the form $h^{(zme)*}(k^{(zme)*})$. Proposition 1 below summarizes this result and uses the following assumption:

Assumption 1. Balanced growth path factor intensities satisfy:

$$k_z^* < k_m^* < k_e^* < k_x^*$$

and

$$h_z^* < h_m^* < h_x^* < h_e^*$$

This assumption is helpful in characterizing both the BGPs where three or two goods are produced, as well as the transitional dynamics of the model. It indicates two things. First, it says is that while investment good x is relatively intensive in physical capital, the education good e is relatively intensive in human capital. This plays an important role in the adjustment of prices and quantities along the transition. Second, it ranks good z as a "low-skill" consumption good, and good m as a "middle-skill" consumption good. Notice that this ranking includes both dimensions k and h.

Proposition 1. *When the small open economy produces only three goods (z, m, e), there are multiple levels of k^* and h^* consistent with the BGP along which prices are $(r^*, w^{H*}, w^{L*}, \overline{p}_m, p_e^*, \overline{p}_x)$ and factor intensities are $(k_z^*, k_m^*, k_e^*, h_z^*, h_m^*, h_e^*)$. In particular,*

(i) for each BGP level $k^{(zme)*}$, there exist BGP functions for unskilled labor allocations $\gamma_z^{(zme)*}(k^{(zme)*})$, $\gamma_x^{(zme)*}(k^{(zme)*})$, $\gamma_e^{(zme)*}(k^{(zme)*})$, and for human capital $h^{(zme)*}(k^{(zme)*})$;

(ii) under Assumption 1, a sufficient condition for the slope of the linear function $h^{(zme)*}(k^{(zme)*})$ to be positive is that $\left(\frac{f_e(k_e^*, h_e^*)}{\delta+g+n} - h_e^* + h_z^*\right) > 0$.

Proof: See Appendix.

Notice that the level of $k^{(zme)*}$ satisfies certain restrictions. In particular, to have a BGP with $\gamma_i^{(zme)*} > 0$ for all $i = z, m, e$, it must be the case that $k_z^* < k^{(zme)*} < k_m^*$. Any other $k^{(zme)*}$ will generate one $\gamma_i^{(zme)*} < 0$ and we would be in a BGP where only two goods are produced.

The idea of multiple BGP pairs $\left(k^{(zme)*}, h^{(zme)*}\right)$ in this model is simply associated to the fact that when more than one traded good is produced, relative supply is determined by comparative advantage according to the relative abundance of factors of production. For instance, a country with a lower pair $(k^{(zme)*}, h^{(zme)*})$ would export z and import some m, while a country with a higher pair $(k^{(zme)*}, h^{(zme)*})$ would export m and import some z. This happens as long as $k_z^* < k^{(zme)*} < k_m^*$.

This multiplicity is interesting for at least two reasons. First, higher pairs $\left(k^{(zme)*}, h^{(zme)*}\right)$ are associated with higher per capita output. This indicates that this model is able to generate the prediction that countries converge to different *levels* of per capita output, even if they converge to the same *growth rates*. This prediction is based only on differences in factor endowments across countries, and it emerges naturally from considering more than one good and the possibility of trading. This suggests the potential of trade models in shedding light on the issues of convergence that have traditionally been the focus of one-good growth models.

Second, from the perspective of a dynamic model, this multiplicity allows initial conditions to play an important role. In particular, for each different initial pair (k_0, h_0) there exists a unique pair $\left(k^{(zme)*}, h^{(zme)*}\right)$ to which the open economy will converge. Thus, different initial conditions imply different long-run per capita outputs and, as will be explained below, different skill premia. This feature makes the model appropriate for our purpose of explaining different income-distribution outcomes across developing countries as resulting from differences in the initial conditions at the time of trade liberalization.

Under Assumption 1, and for sufficient conditions similar to those derived in Proposition 1 *(ii)*, the BGP for goods (z, x, e) is characterized by a linear, positively sloped function $h^{(zxe)*}(k^{(zxe)*})$; and that for goods (m, x, e) by $h^{(mxe)*}(k^{(mxe)*})$. Figure 3 illustrates these functions. Each side of the triangle represents one of the functions that relates h^* with k^* along the BGP when three goods are produced. Thus, one side of the triangle corresponds to (z, m, e), the other to (z, x, e) and the last one to (m, x, e). Further, each vertex of the BGP triangle corresponds to one of the two-good cases. For instance, points $(k^{(ze)*}, h^{(ze)*})$ and $(k^{(me)*}, h^{(me)*})$ correspond to the extreme points of function $h^{(zme)*}(k^{(zme)*})$, which characterizes the BGP for (z, m, e). The intuition is clear because under the factor intensity ranking from Assumption 1, any country with factor endowments (k, h) just above point $(k^{(ze)*}, h^{(ze)*})$ will be able to diversify producing (z, m, e).

Figure 3 shows how this simple model, where all countries have access to the same technology and are identical in every respect except in their initial conditions (k_0, h_0), is able to generate a rich set of outcomes. There are two main elements that generate such richness. First, this is a 3×4 model, with four goods and three factors of production. Leamer (1987) shows that the $3 \times n$ model, $2 < n$, with three factors of production and n commodities, is the smallest model that is sufficiently rich to allow for more than one path of development. The second key element is that the model is "two-dimensional" in the sense that two of the factors of production are accumulable. If only one factor was accumulable, say physical capital, then the only transition path for a developing economy would be one in which physical capital per worker increases.

Finally, when all four goods (z, m, x, e) are produced, the third block of equations is again under-identified. In particular, in this case we need to choose a pair (k^*, γ_e^*) in order to find a BGP function of the form $h^*(k^*, \gamma_e^*)$. Points strictly inside the BGP triangle in Figure 3 correspond to the four-good case.[21] Therefore, there are no transitional dynamics for the four-good case: the only way a small developing economy is going to converge to a BGP in which all four goods are produced is if the initial conditions given by a point (k_0, h_0) is strictly inside the triangle. In contrast, developing economies with initial conditions outside of the triangle will converge to a BGP where either two or three goods are produced.[22]

2.4.4 Skill premium

We have shown that both commodity and factor prices are equalized across the different BGPs discussed above. In this section we construct the measure for skill premium implied by the model, and show how the long-run skill premium is not equalized across countries because h is different

[21] Since the function $h^*(k^*, \gamma_e^*)$ is of higher dimensionality, the BGP triangle in Figure 3 can be seen as a cross section of the function for a given γ_e^*.

[22] Recall that as soon as any transitional path reaches the triangle, the incentives for accumulation of both physical and human capital at rates different than the BGP rates stop because $r^* = \overline{r}$, which implies that $r^*/\overline{p}_x = w^{H*}/p_e^* = \rho + \delta + \sigma g$, as in the developed world.

across them. In fact, it turns out that countries with higher h will have higher BGP skill premium.

In the model, w^H measures the rental rate of H, and $\widetilde{w}^L$ is the wage of unskilled workers L. Since there are S members in the representative household who are able to use H, the wage of a skilled worker is given by $w^H \frac{H}{S}$. Recall that in the model skilled workers enter in production through the units of H the representative household has invested in. Thus, the BGP skill premium ω^* is given by:

$$\omega^* = \frac{w^H \frac{H}{S}}{\widetilde{w}^L} = \frac{w^H}{w^L} h^* \frac{L}{S}$$

where the first ratio $\frac{w^H}{w^L}$ is equalized across different BGPs, while h^* varies all across the surface of the BGP triangle in Figure 3. Regarding the ratio $\frac{L}{S}$, the only assumption we have made so far is that both L and S grow at the same exogenous rate n, so that this ratio is constant. Thus, this ratio does not play any role in the model, except to indicate that for given w^H, w^L and h^*, the larger $\frac{L}{S}$, the larger the skill premium. This is reasonable since a larger $\frac{L}{S}$ means that less members of the representative household are able to use the stock H in production, and so the higher the wage of a skilled member is.

Since this model emphasizes the accumulation of human capital, the important component of the skill premium is h^*. We can think of this variable as some measure of "quality" of the skilled. In the model, H is a "stock of education good", which can be thought of as the total years of secondary and higher schooling in a country. Thus, countries with higher H would have skilled workers of higher "quality", and thus a higher skill premium.

We have now fully described the BGP for a small open economy. Two questions are in order. First, how do we characterize the transitional dynamics that lead to such path? Section 3 addresses this question. The second question is: in a model in which all countries are otherwise identical, how do we rationalize the different initial conditions (k_0, h_0) across developing economies? This is fundamental since the different paths of development in Figure 3 depend on countries having different pairs (k_0, h_0). Section 4 addresses this second question.

3 Transitional dynamics

Since, as explained above, there are no transitional dynamics for the four-good case, we describe two scenarios: one is when the developing country is diversified along the transition path, i.e., it produces either (z, x, e), (z, m, e) or (m, x, e). The other scenario is when the economy is completely specialized, i.e., it produces either (z, e), (m, e) or (x, e).

The dynamic system of equations for a small open economy that takes as given prices $\bar{p}_m$ and $\bar{p}_x$is given by:

$$\frac{\dot{p_e}}{p_e} = \frac{r}{\bar{p}_x} - \frac{w^H}{p_e}$$

$$\frac{\dot{c}}{c} = \frac{1}{\sigma}\left[\frac{r}{\bar{p}_x} - (\rho + \delta + \sigma g)\right]$$

$$\frac{\dot{k}}{k} = \frac{\gamma_x f_x(k_x, h_x)}{k} - (\delta + g + n) + \frac{[\gamma_z f_z(k_z, h_z) - c_z]}{\bar{p}_x k} + \frac{\overline{p}_m [\gamma_m f_m(k_m, h_m) - c_m]}{\bar{p}_x k}$$

$$\frac{\dot{h}}{h} = \frac{\gamma_e f_e(k_e, h_e)}{h} - (\delta + g + n)$$

where the first equation states that the price of the nontraded good p_e adjusts along the transition to equalize the returns to investment in human and physical capital.[23] The second equation is simply the optimal rate of consumption derived above. The third equation is the market clearing condition for traded goods. Recall that either γ_x, γ_z, or γ_m could be zero depending on the pattern of production along the transition. The last equation is the market-clearing condition for the nontraded good.

To analyze the stability properties of the system above we linearize it around the open-economy BGP. But, which BGP? This is precisely one of the interesting features of this model. Countries with different initial conditions (k_0, h_0) may converge to different BGPs. Figure 4 illustrates some possibilities for countries whose initial conditions allow them to produce either (z, m, e), (z, x, e) or (z, e). More interestingly, note that two countries with different initial conditions, but both

[23]This equation is obtained by deriving $p_e = \overline{p}_x \pi / \phi$ with respect to time and using the dynamic optimality conditions for the representative household in equations (8) and (9).

producing the same three goods, say (z, m, e), will converge to a BGP where also (z, m, e) are produced, but they will converge to different BGP pairs (k^*, h^*).

To simplify matters, assume that the set of goods produced when trade liberalization takes places at time $t = 0$ is the same as the set of goods the country will produce when it converges to the open-economy BGP.[24] We now discuss separately the transitional dynamics for the two scenarios indicated above: when three goods are produced, and when two goods are produced.

3.1 Three-good case

Consider the case of a small open economy that produces goods (z, x, e).[25] In this case, as shown in the Appendix, the linearized system of equations exhibits block recursivity. In particular, $r(t)$ and $w^H(t)$ do not depend on $k(t)$, $h(t)$, or $c(t)$, but only on $p_e(t)$. Recall that this is so because there are three factors of production, and only three goods are produced.

Using an argument similar to that of Bond, Wang and Yip (1996), and Bond and Trask (1997), it is easy to see that under Assumption 1, the dynamic system exhibits saddle-path stability. Bond, Wang and Yip (1996) analyze the case of a closed economy with two sectors of production and endogenous accumulation of physical and human capital. Their dynamic model exhibits saddle-path stability because when the adjustment of prices is stable, the adjustment of quantities is not, and vice versa. For instance, they show that if the investment sector is physical-capital intensive then the adjustment of prices back to the steady state is stable, and then the adjustment for quantities is unstable. The idea is that in this case, an increase in the physical capital stock increases the output of the investment good x and decreases the output of education, leading to a further increase in the stock of physical capital.

Assumption 1 allows us to extend this logic to our case. In fact, under Assumption 1 the investment sector is physical-capital intensive and the education sector is human-capital intensive. This makes the adjustment of both k and h unstable, and the adjustment of p_e stable. Further, this adjustment path is monotonic (see details in the Appendix). This is also true for all other variables

[24] We discuss this assumption in detail in Section 4.

[25] The analysis is similar for the other cases in which three goods are produced.

in the three-good case. What this suggests is that along the transition, either k or h must be decreasing. In fact, when (z, x, e) are produced, h decreases along the transition, while k increases, as illustrated in Figure 4, while when (z, m, e) are produced, the opposite occurs. The intuition for this is that if, for instance, p_e is increasing along the transition, since the prices of traded goods are given, then the relative supply of good e would be low at the beginning, and would gradually increase. This is consistent with h decreasing and k increasing monotonically along the transition, because the relative supply of good x would be high at the beginning. Numerical examples in Section 5 illustrate these paths of adjustment.

One final remark. It would seem that in this three-good case, since $r(t)$ and $w^H(t)$ do not depend on $k(t)$ or $h(t)$, but only on $p_e(t)$, the accumulation of factors would not affect the evolution of factor prices following trade liberalization. In other words, it would seem as if the only effects of trade on factor prices would come from shifts in the relative demand of factors, as in Stolper-Samuelson. This view is not correct though. Think of trade liberalization as a "change in regime" that occurs when the country is endowed with (k_0, h_0). In the three-good case, say (z, x, e), this change in regime is basically going to determine a particular open-economy BGP value $(k^{(zxe)*}, h^{(zxe)*})$ to which the economy will converge. This in turn determines a unique $p_e(0)$, which affects the whole dynamic path of factor prices. In other words, $p_e(0)$ captures the effect of trade liberalization on the accumulation of factors. This shows the difficulty in disentangling the "demand-side" effects of trade on wages, from those effects due to accumulation of factors of production, which are in turn induced by trade.

3.2 Two-good case

As shown in the Appendix, when only two goods are produced block recursivity of the linearized dynamic system no longer holds. Since there are three factors of production, but only two goods are produced, now $r(t)$ and $w^H(t)$ depend on $k(t)$, $h(t)$, and $p_e(t)$. One implication of the absence of block recursivity is that the dynamic adjustment for $p_e(t)$ may now be non-monotonic. This in turn implies that now both k and h may increase along the transition, as illustrated in Figure 4.

Further, this non-monotonicity in the adjustment of $p_e(t)$ opens the possibility that the dynamics of factor prices are non-monotonic as well. This is an interesting possibility because some of the empirical evidence suggests non-monotonic paths for the relative wage of skilled workers following trade liberalization. Again, as explained above, Assumption 1 guarantees that the adjustment of k and h is unstable, while that of p_e is stable.[26]

Comparison of the transitional dynamics of the three-good and two-good cases illustrates the importance of initial conditions for the adjustment of factor prices following trade liberalization. In particular, the adjustment of k and h varies substantially across the different cases discussed above. For instance, for the case (z, m, e), where h increases while k decreases along the transition, we expect w^H to decrease and w^L to increase. For the case (z, x, e) we would have the opposite. Finally for (z, e), since both k and h may be increasing, it is more difficult to predict what would happen to factor prices. These cases give us a variety of implied paths for the skill premium following trade liberalization. We now turn to the determination of the initial condition (k_0, h_0).

4 Before trade liberalization

How do we characterize a small developing country before trade liberalization takes place? The simplest way to proceed is to assume that the country is growing along some BGP prior to liberalization. Thus, the effects of trade liberalization can be seen as a change in regime that takes the economy from an initial BGP to a new open-economy BGP, i.e., to one of the BGPs described above. We are interested not only in comparing the initial and the final BGP, but also in the transitional dynamics, since the evolution of factor prices following trade liberalization is affected by the rate of accumulation of k and h along the transition. This is one of the mechanisms we want to emphasize, since it captures the way in which trade endogenously affects the level of human capital, and so the skill premium.

In principle, assuming that the small developing country was closed before trade liberalization

[26] Given the algebraic complexity of the system, we do not have analytical proofs to establish that the system has two positive and two negative roots, even though the intuituion indicates that this must be the case. Numerical simulations in Section 5 verify this claim.

is not proper for at least two reasons. First, from the perspective of the model, the BGP of a closed economy would be identical to that of the developed world.[27] Second, in reality, when developing countries liberalized trade, they were actually not moving from being closed to open, but from being "semi-closed" to being open. By semi-closed we simply mean a country that is trading but that has some tariffs in place. Moreover, we adopt a posture similar to Davis (1996) in that trade liberalizations in practice have limited scope, and in principle do not fundamentally alter the sectors of production that are active, but they do affect their levels of output. In other words, our theoretical experiment would be one of an economy moving from being semi-closed to open, and one in which there is no change in the sectors of production that are active.

We now describe the semi-closed BGPs for a small developing economy. In this model, what makes small developing economies heterogeneous in initial conditions (k_0, h_0) when trade liberalization takes place is their different tariff structure. This story seems a plausible one, as these differences in tariff structure, and more generally in development strategies, have been widely documented. Wood (1997) comments on the difference in trade policy instruments in East Asia and Latin America. For instance, Korea and Taiwan implemented subsidies to exports and kept high levels of protection against imports. On the other hand, Latin America increased openness to trade by abandoning the import-substitution policy, and reducing drastically tariffs, as well as other barriers to imports.

Since we think of developing countries as those with either relatively low k_0, low h_0 or both, we only discuss here the semi-closed BGP where either (z, m, e), or (z, x, e) or (z, e) are produced. Inspecting Figure 3, these would be plausible cases of BGPs for developing countries. We now describe three different interesting scenarios that resemble some of the policies followed by developing economies. Section 5 provides numerical examples that illustrate each of these scenarios.

[27] This is so because of the assumption of identical technologies across countries, and because there is a unique closed-economy BGP pair $(\overline{k}, \overline{h})$. This unique point will certainly lie somewhere strictly inside the BGP triangle in Figure 3, which implies that no transitional dynamics would be observed when trade liberalization occurs.

4.1 An import-substitution case

Area A in Figure 5 illustrates some initial conditions (k_0, h_0) consistent with a semi-closed BGP in which goods (z, m, e) are produced. We have called this experiment an "import-substitution" case because in area A countries are exporting good z, producing and importing good m, importing good x, and imposing tariffs on imports of both good m and good x. Let τ_m and τ_x be the tariffs imposed on imports of goods m and x respectively. First notice that at least one of these tariffs cannot be arbitrary. To see this, recall that the first block of equations that solves for BGP factor and commodity prices for the case (z, m, e) when tariffs are in place would be given by:

$$r = \overline{p}_x(1 + \tau_x)(\rho + \delta + \sigma g)$$

$$\frac{r}{\overline{p}_x(1 + \tau_x)} = \frac{w^H}{p_e}$$

$$p_e = \Phi_e(r, w^H, w^L)$$

$$\overline{p}_m(1 + \tau_m) = \Phi_m(r, w^H, w^L)$$

$$1 = \Phi_z(r, w^H, w^L)$$

where the small developing economy continues to take as given world prices $\overline{p}_m$ and $\overline{p}_x$. For an exogenously given tariff τ_x, the system above can be viewed as one solving for r, w^H, w^L, p_e and the tariff τ_m consistent with the production of (z, m, e) as a semi-closed economy.[28] In other words, an arbitrary pair (τ_m, τ_x) would most likely imply that the semi-closed economy produces two, rather than three goods.

We do not repeat here the solution of the rest of the variables along the semi-closed BGP, since the procedure is the same as the open-economy case. In particular, there are multiple semi-closed BGP pairs (k_0, h_0) consistent with a function $h_0^{(zme)*}(k_0^{(zme)*}, \tau_x)$, i.e. each exogenous level of tariff τ_x generates a different BGP function relating k_0 and h_0.[29]

[28] We assume that the government rebates the proceeds of the tariff to the representative household.

[29] We do not provide here any further analytical characterization of this semi-closed BGP. Numerical examples

Empirical work classifying developing economies in different cones of diversification is not available, and we do not intend to test the model here. However, notice that countries in area A are relatively physical-capital abundant when compared with countries in areas B and C in Figure 5. Further, as shown in Figure 2, many countries in Latin America including Argentina, Colombia, Ecuador, Mexico and Venezuela turned out to be relatively physical-capital abundant at the time of liberalization. This suggests some consistency between the initial conditions we observe in the data, and those associated with import-substitution policies in the model. Recall that in the model, countries with initial conditions in area A exhibit increasing h and decreasing k along the transition. Numerical examples in Section 5 will illustrate transitional dynamics, including the behavior of the skill premium.

4.2 Subsidizing exports and education

Area B in Figure 5 illustrates some initial conditions (k_0, h_0) consistent with semi-closed BGP in which goods (z, x, e) are produced. Contrary to the import-substitution case, here the initial conditions are *above*, and "close enough" to the function $h^{(zxe)*}(k^{(zxe)*})$. In the model, to generate initial conditions above this function we need a combination of a subsidy to exports, and a subsidy to education. In fact, in area B the semi-closed developing economy exports good z and subsidizes this exports; produces and imports good x; imports good m and subsidizes education e.[30] This is intuitively clear, as being above function $h^{(zxe)*}(k^{(zxe)*})$ means having either a relatively higher k_0, or a higher h_0, or both. Subsidizing the nontraded good education accounts for a higher h_0.

Let τ_z and τ_e be the subsidies to exports of good z and to the production of the education good e respectively. As in the import-substitution case, the choice of τ_z and τ_e is not arbitrary. In particular, for a given τ_e the first block of equations allows us to solve for prices and a subsidy τ_z for which (z, x, e) are produced. Finally, we can obtain a function $h_0^{(zxe)*}(k_0^{(zxe)*}, \tau_e)$ that characterizes multiple pairs of (k_0, h_0) consistent with the BGP of the semi-closed economy.

presented in Section 5 will illustrate the ideas presented here for this import-substitution case.

[30] In principle, we could also add a tariff for imports of good m. This would not affect the determination of factor prices along the BGP because good m is not produced, but it would have some effect in the level of imports. We restrict attention to the simplest cases here in order to emphasize the mechanisms at work in the model.

Countries with initial conditions in area B are relatively human-capital abundant when compared with countries in areas A and C, and they resemble the case of East Asian economies in Figure 1. The model predicts that once these countries eliminate subsides to exports and education, the transition to the open-economy BGP involves decreasing h and increasing k. The qualitative behavior of the skill premium in this case is illustrated in Section 5.[31]

4.3 Other tariff structures

As explained above, the choice of the tariff structure for both the import-substitution and the export-subsidy cases is not arbitrary. The model imposes some restrictions on the set of prices that are consistent with a semi-closed BGP where either (z, m, e) or (z, x, e) are produced. This implies that arbitrary set of tariffs would more likely generate cases where the country is completely specialized along the semi-closed BGP. In this section we describe the case in which (z, e) are the only goods produced. Area C in Figure 5 illustrates initial conditions consistent with this case. Notice that countries in this area resemble the case of South Asian and some Latin American countries in Figures 1 and 2.

We restrict the discussion to tariff structures that are such that the country continues to be specialized in goods (z, e) along the transition, and converges to an open-economy BGP where also (z, e) are produced. In other words, we are looking at countries whose initial conditions (k_0, h_0) are "low enough" that it would remain specialized along the transition.[32] It turns out that this case can be achieved with either a tariff on imports of good x; or with a combination of a subsidy to exports of good z and a tariff on imports of x. Intuitively, a tariff on imports of good x would depress the level of k.[33]

[31]Here we present the results for an experiment in which countries in area B eliminate subsidies to exports and education. We have to be aware though that around 1965, East Asia increased openness precisely through subsidies to exports. In the context of the model, this would imply that East Asian countries in 1965 moved higher up in area B, and farther away from the open-economy BGP. In this case, the skill premium would be even lower, which is consistent with what is documented in the empirical literature.

[32]The numerical examples presented below in Section 5 are constructed to satisfy these conditions.

[33]It may seem surprising that a country that does not produce good x and imports it, would impose a tariff on these imports. We can argue though, that even if in practice tariffs on investment good x may not be as high as tariffs on other consumption goods, many developing economies do collect tariffs in a variety of investment goods, and in fact this tax collection represents an important source of income for government.

5 Numerical examples

This section presents the results of numerical simulations. We discuss the transitional dynamics of developing economies that were initially semi-closed, and underwent trade liberalization. In particular, we illustrate each of the three cases explained above: import-substitution, export-subsidies and other tariff structures. For this purpose we have to choose specific production functions, as well as values for the different parameters. The attempt here is not to calibrate or estimate the model, but only to illustrate the qualitative behavior of variables of interest.

The simplest choice for technology is a constant returns to scale Cobb-Douglas. It is well known that this technology avoids factor intensity reversals, and conforms with the assumptions of the model. The production function for the low-skill consumption good is given by:

$$Z = (\theta_z K)^{\alpha_z} (\mu_z H)^{\eta_z} (\gamma_z AL)^{1-\alpha_z-\eta_z}$$

Other sectors of production operate similar technologies. Sectors differ in the pairs (α_i, η_i), and the choice of these parameters generates a factor intensity ranking consistent with Assumption 1. For the numerical simulations we choose: $\alpha_z = 0.2$, $\alpha_e = 0.25$, $\alpha_m = 0.3$, $\alpha_x = 0.55$; and $\eta_z = 0.2$, $\eta_m = 0.2$, $\eta_x = 0.3$, $\eta_e = 0.55$. The rate of time preference is set to $\rho = 0.04$ and the rate of depreciation δ is chosen to have an annual rate of return in the investment of physical capital of around 4%. Long-run per capita growth rate g is set to 2%, and labor force growth n to 1%. The composite consumption bundle is: $c = c_m^{\beta} c_z^{1-\beta}$, where the parameter β is set to 0.6. Finally, the elasticity of marginal utility σ is set to 0.5.

The ratio L/S is set to 4. Notice that in the model, this number can vary across countries and is only relevant to compute the level of the skill premium. Since this ratio is constant, it does not affect the transitional dynamics in the model. To set this number we simply define L/N as the fraction of people with either no education or that have completed primary school, while S/N includes the rest, i.e., people who have attained secondary or higher level of schooling. Although in the data this measure varies across developing countries, we choose 4 as a rough approximation, but again this just affects the level of the skill premium.[34]

Figure 6 shows an example of the import-substitution case. This economy is initially growing along a semi-closed BGP producing (z, m, e), and taxing imports of both good m and good x. In the example $\tau_x = 10\%$ and the implied $\tau_m = 1.4\%$. Trade liberalization occurs at time $t = 6$ and consists of the elimination of tariffs. Recall that in this case the dynamic system is block recursive, and the transition involves decreasing k and increasing h. Block recursivity implies that the paths of r, w^H and w^L depend only on p_e. However, the adjustment of p_e reflects the open-economy BGP levels of (k, h) through $p_e(0)$. This is precisely the sense in which trade liberalization affects factor prices through its effect on the endogenous accumulation of factors.

Since h is increasing along the transition, p_e is decreasing, w^H is also decreasing, and w^L increasing. This is consistent with sector e being human-capital intensive, and sector z unskilled-labor intensive. What happens to the skill premium in this case? As observed in the graphs, it turns out that the wage for skilled workers decreases along the transition. This results in a decreasing skill premium, even when h is increasing. Overall, in the long run, this economy ends up with a higher h, but with lower relative wage for skilled workers.

We have associated the import-substitution case to some relatively physical-capital abundant, Latin American countries in Figure 2. However, it seems that the qualitative behavior of the skill premium in Figure 6 contradicts the empirical evidence of rising skill premium following trade liberalization in Latin America. As shown below though, if the production function exhibits capital-skill complementarity, we can generate rising skill premium at the beginning of the transition for the import-substitution case.

Figure 7 shows an example for the case of subsidies to exports and education. This economy is initially growing along a semi-closed BGP producing (z, x, e), and subsidizing both exports of z and education. In the example $\tau_e = 1\%$ and the implied $\tau_z = 1.2\%$. In this case, the change in regime

[34] With the chosen parameters, the BGP physical capital to output ratio at the 3 vertices of the triangle in Figure 3, i.e. for the cases where there is complete specialization in (z, e), (m, e), and (x, e) are respectively: 0.74, 0.98 and 1.50. In the data, the average capital output ratio for the developed world is around 1.25.

involves both the elimination of subsidies to exports and to education.[35] Results are the opposite to the import-substitution case because transitional dynamics involve increasing k and decreasing h. On impact, p_e falls, but consistent with the decreasing h, p_e increases monotonically during the rest of the transition. This increase in p_e makes w^H increase, and w^L decrease. Finally, the skill premium increases along the transition.

To summarize, what we learn from Figures 6 and 7 is how the dynamic nature of this model changes our understanding of the way trade affects wages. Due to block recursivity, the full path of factor prices depends only on the price of the nontraded good p_e. However, even in this case the supply of factor endowments (k, h) plays a role because trade liberalization has changed the open-economy BGP levels of both k and h. Trade liberalization is more than just a change in relative commodity prices that generates sectoral reallocations of factors. When we think of trade liberalization in the context of a growing economy, the picture is richer because trade changes the long run prospects. It is even richer in this model due to the multiplicity of BGP levels (k, h).

Figure 8 shows trade liberalization for the case of an economy that starts off on a semi-closed BGP producing (z, e) and with a tariff on imports of good x. In the example shown $\tau_x = 10\%$. Recall that in this case block recursivity of the dynamic system does not hold anymore, and that transitional dynamics involve increasing both k and h. One first observation from Figure 8 is that on impact, trade liberalization boosts production in sector z, exports of good z, and imports of good x. This accounts for a rapid accumulation of k in the first periods after the reform. On the other hand, this comes at the cost of an initial reduction in the output of nontraded education e, which decreases the level of h in period $t = 7$. However, the non-monotonic path of p_e guarantees that after period $t = 7$ output of good e would increase. In fact, p_e increases between periods $t = 6$ and $t = 8$. After that, p_e decreases to the open-economy BGP level.

Unskilled wages w^L rise sharply on impact, and continue to increase further along the transition. This initial impact effect is purely due to the sharp expansion of sector z, which represents increased relative demand for unskilled workers. In contrast, skilled wages decline on impact, but

[35] In the experiment we also eliminate the subsidy to education τ_e in order to make the different simulations comparable, i.e. in order to have all small open economies completely undistorted.

increase after that. The initial decrease is associated with the decline in output of sector e, and the corresponding demand shift for human capital. Finally, the skill premium decreases on impact, but increases subsequently. This increase is mainly explained by the increase in h.

The comparison of Figures 6 and 8 illustrates the importance of initial conditions. Even if we observe two countries in which trade liberalization allowed for increasing h and decreasing w^L the initial condition (k_0, h_0) makes a difference on the pattern of skill premia because these countries are simply at different "cones of diversification". This suggests another lesson for the empirical literature on trade and wages: not only does the accumulation of human capital matter for relative wages, but so too does the cone of diversification in which a country is located.

5.1 A role for capital-skill complementarity

Capital-skill complementarity has been highlighted as a potential explanation for the rising trend of the skilled-wage premium in some developed and developing economies. For instance, O'Connor and Lunati (1999) argue that capital-skill complementarity may be responsible for the increase in the wage of skilled workers as developing economies start importing skill-intensive capital from developed economies. Capital-skill complementarity implies that the elasticity of substitution between capital and unskilled labor is higher than that between capital and skilled labor. Then, as the stock of physical capital grows, the marginal product of skilled labor increases, relative to the marginal product of unskilled labor. This effect would explain the widening of the skill premium as growth occurs.

We now illustrate how the patterns of skill premia change in the model when we consider capital-skill complementarity. For the numerical examples, instead of using a Cobb-Douglas technology, we use a nested CES production function of the form:

$$Z = \left[\mu_z(\gamma_z L)^{\psi} + (1-\mu_z)\left[\lambda_z(\theta_z K)^{\varepsilon} + (1-\lambda_z)(\mu_z H)^{\varepsilon}\right]^{\frac{\psi}{\varepsilon}}\right]^{\frac{1}{\psi}}$$

where $\frac{1}{1-\varepsilon}$ is the direct elasticity of substitution, within the "nest", between human and physical capital $\varepsilon \in (-\infty, 1)$, and $\frac{1}{1-\psi}$ that between human or physical capital and unskilled labor $\psi \in$

$(-\infty, 1)$.[36] For the purpose of illustration, we parameterize $\psi = 0.2$ and $\varepsilon = -0.4$. Figure 9 shows the dynamics of factor prices and the skill premium for the import-substitution case, i.e. for the case of an economy producing (z, m, e). The main qualitative difference between the Cobb-Douglas case in Figure 6 and the nested CES in Figure 9 is on the "impact effect" observed at the beginning of the transition when trade liberalization is implemented. When there is capital-skill complementarity, the skill premium increases on impact, but then decreases along the rest of the transition. This is explained by the jump in the wage of skilled workers, and seems to be consistent with the empirical evidence of rising skill premium in some Latin American countries following trade liberalization.

Finally, Figure 10 shows the case of an economy producing (z, e). Notice that in Figure 8, even if the skill premium initially decreases and then increases along the transition, it is always below its open-economy BGP value. In contrast, in Figure 10, where there is capital-skill complementarity, the skill premium initially decreases, but then increases along the transition to a higher open-economy BGP level. This is explained by the fact that skilled wages grow much more than unskilled wages.

6 Concluding comments

This paper offers an explanation for the fact that the relative wage of skilled workers increased in some developing countries, and decreased in others, following trade liberalization. Unlike other papers in the literature, this is done using a model in which the transitional dynamics induced by trade liberalization can differ dramatically across countries with different initial conditions. In the model, trade liberalization not only changes the relative demand of skilled workers, as emphasized in the Stolper-Samuelson result, but it also changes the endogenous accumulation of factors of production. Further, since trade liberalization can be seen as a "change in regime", it affects the long-run prospects of the country in terms of the BGP levels of physical and human capital, as well

[36] Many studies in the literature have estimated these elasticities of substitution and report evidence consistent with the capital-skill complementarity hypothesis. For instance, Krusell, Ohanian, Rios-Rull and Violante (1997) estimate $\varepsilon = -0.495$ and $\psi = 0.401$ using U.S. data from 1963 to 1992.

as the per capita output for the open economy.

The analysis presented here has implications for the empirical literature on trade and wages. It suggests the importance of a general equilibrium approach in which the accumulation of factors of production is endogenous, and responds to changes in the trade regime. In the model, trade has an impact on the relative demand of skilled workers, but it also has an impact on the accumulation of human and physical capital. Further, since the model analyzed here is dynamic, when trade liberalization occurs at some period $t = 0$, agents in the economy adjust their consumption and investment plans according to the new long-run balanced growth path. This implies that at time $t = 0$ changes in factor prices would also reflect this adjustment. It is therefore difficult, from the perspective of the model, to disentangle the role of each effect.

Testing this model is desirable, but empirical work classifying developing economies in different cones of diversification is not available. Testing would also require information on factor intensity ranking. Recall that Assumption 1 restricts the analysis of the model to one particular case, but other factor intensity ranking may give rise to other predictions. In particular, the factor intensity ranking across goods is important for the dynamic adjustment of k, h and p_e along the transition.

The model presented here can be a useful benchmark to analyze policy issues for developing countries. Since the model displays path dependence, and in the model countries converge to different levels of per capita output, policy may play a role in changing the long-run prospects of a country.

The model can be extended in at least two ways. First, we did not exploit the possibility that along the transition, the small developing economy might shift from one cone of diversification to another one, as suggested by Deardorff (1999). Second, in terms of factors of production, we did not consider here natural resources, for instance land. Leamer et. al. (1999), and Mayer and Wood (1999) consider the role of natural resources on development paths and income inequality. These extentions are left for future research.

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A Proof of Proposition

(i) Full employment and market clearing conditions along the BGP when only (z, m, e) are produced are:

$$\gamma_z k_z^* + \gamma_m k_m^* + \gamma_e k_e^* = k$$

$$\gamma_z h_z^* + \gamma_m k_m^* + \gamma_e h_e^* = h$$

$$\gamma_z + \gamma_m + \gamma_e = 1$$

$$(\delta + g + n)k = \frac{1}{\overline{p}_x}\left[\gamma_z f_z(k_z^*, h_z^*) - c_z\right] + \frac{\overline{p}_m}{\overline{p}_x}\left[\gamma_m f_m(k_m^*, h_m^*) - c_m\right]$$

$$(\delta + g + n)h = \gamma_e f_e(k_e^*, h_e^*)$$

which constitutes a system of 5 equations in 6 unknowns: $\gamma_z^{(zme)*}$, $\gamma_m^{(zme)*}$, $\gamma_e^{(zme)*}$, $k^{(zme)*}$, $h^{(zme)*}$ and $c_m^{(zme)*}$, and where a superscript has been included to distinguish this BGP from others. As in the four-good case, this is again an under-identified system, but now we only need to choose $k^{(zme)*}$ in order to find a solution. For given $k^{(zme)*}$, notice that one can use the last equation above, i.e. the market clearing for the nontraded good, to solve for h and substitute it in the second equation. Then, using the first three equations, which are the three full employment conditions we can solve for $\gamma_z^{(zme)*}$, $\gamma_m^{(zme)*}$ and $\gamma_e^{(zme)*}$ as linear functions of only $k^{(zme)*}$. Linearity relies on the fact that in the BGP, factor intensities are independent of $k^{(zme)*}$. This guarantees the existence of BGP functions for unskilled labor allocations $\gamma_z^{(zme)*}(k^{(zme)*})$, $\gamma_m^{(zme)*}(k^{(zme)*})$ and $\gamma_e^{(zme)*}(k^{(zme)*})$. Finally, use $\gamma_e^{(zme)*}(k^{(zme)*})$ in the market clearing condition for the nontraded good the to find the following linear BGP function that relates the two accumulable factors of the economy $h^{(zme)*}$ and $k^{(zme)*}$:

$$h^{(zme)*}(k^{(zme)*}) = \frac{f_e(k_e^*, h_e^*)}{\delta + g + n}\gamma_e^{(zme)*}(k^{(zme)*}).$$

This function summarizes the multiplicity of BGP pairs $(h^{(zme)*}, k^{(zme)*})$. Linearity guarantees its existence.

(ii) Notice that $h^{(zme)*}$ depends on $k^{(zme)*}$ only via $\gamma_e^{(zme)*}(k^{(zme)*})$. To better characterize the function $h^{(zme)*}(k^{(zme)*})$, use the three full employment conditions to obtain:

$$\gamma_e^{(zme)*}(k^{(zme)*}) = \xi k^{(zme)*} + \zeta$$

where:

$$\xi = \frac{(h_m^* - h_z^*)}{\left(\frac{f_e(k_e^*, h_e^*)}{\delta+g+n} - h_e^* + h_z^*\right)(k_m^* - k_z^*) + (k_e^* - k_z^*)(h_m^* - h_z^*)}$$

and ζ is some other function of the values $(k_z^*, k_e^*, k_m^*, h_z^*, h_e^*, h_m^*)$. It is easy to see that under Assumption 1, if $\left(\frac{f_e(k_e^*, h_e^*)}{\delta+g+n} - h_e^* + h_z^*\right) > 0$ then $\xi > 0$ and the slope of $h^{(zme)*}(k^{(zme)*})$ is positive. ■

B Linearization of dynamic system

Linearization of the dynamic system around the open-economy BGP when (z, x, e) are produced yields:

$$\begin{bmatrix} \dot{p}_e \\ \dot{c} \\ \dot{k} \\ \dot{h} \end{bmatrix} = \begin{bmatrix} a_{11} & 0 & 0 & 0 \\ a_{21} & 0 & 0 & 0 \\ a_{31} & a_{32} & a_{33} & a_{34} \\ a_{41} & 0 & a_{43} & a_{44} \end{bmatrix} \begin{bmatrix} p_e - p_e^* \\ c - c^{(zxe)*} \\ k - k^{(zxe)*} \\ h - h^{(zxe)*} \end{bmatrix}$$

where a_{ij} are the coefficients of the Jacobian evaluated at the BGP. For the system above, two of the associated roots are a_{11} and 0. Recall that $k^{(zxe)*}$ can take several values. In principle, for given initial conditions (k_0, h_0) we do not know to which pair $(k^{(zxe)*}, h^{(zxe)*})$ the economy will converge. As will become clear below, the existence of a zero eignevalue allows us to solve the indeterminancy of $\left(k^{(zxe)*}, h^{(zxe)*}\right)$. The other two roots are those associated with the following reduced Jacobian:

$$J_2^* = \begin{bmatrix} a_{33} & a_{34} \\ a_{43} & a_{44} \end{bmatrix}.$$

Under Assumption 1, these two roots are positive, and root $a_{11} < 0$, so that the adjustment of p_e is described by:

$$\frac{p_e(t) - p_e^*}{p_e(t)} = \frac{p_e(0) - p_e^*}{p_e(0)} \exp(a_{11} p_e^* t)$$

where: $a_{11} = \frac{r(p_e^*)}{\bar{p}_x} + \frac{p_e^*}{\bar{p}_x}\frac{\partial r(p_e^*)}{\partial p_e} - \frac{\partial w^H(p_e^*)}{\partial p_e}$, and $p_e(0)$ is the initial condition. Next, to find the saddle-path equilibrium, we need to find the unique values $p_e(0)$ and $c(0)$ that guarantee convergence to the BGP. For given initial conditions we have:

$$k_0 = k(0) = k^{(zxe)*} + vec_k^1 \tau^1$$

$$h_0 = h(0) = h^{(zxe)*} + vec_h^1 \tau^1$$

where vec_j^1 is the element of the eigenvector associated to root a_{11} and variable j, and τ^1 is a constant to be determined using initial and transversality conditions. The two equations above provide restrictions to uniquely determine $k^{(zxe)*}$ and $h^{(zxe)*}$. In particular, using the BGP function derived above we can write:

$$h^{(zxe)*}(k^{(zxe)*}) = \frac{f_e(k_e^*, h_e^*)}{\delta + g + n} \left[\xi k^{(zxe)*} + \zeta\right].$$

Replacing this condition in the equation for $h(0)$ we have a system to solve for two unknowns: τ^1 and $k^{(zxe)*}$. Once we solve for $k^{(zxe)*}$, we know $h^{(zxe)*}$ and also $c^{(zxe)*}$, so that we can find the unique values for $p_e(0)$ and $c(0)$.

Finally, when only two goods are produced the linearized dynamic system becomes more complicated because block recursivity does not hold anymore. In fact, when (z, e) are produced, the linearized system is:

$$\begin{bmatrix} \dot{p}_e \\ \dot{c} \\ \dot{k} \\ \dot{h} \end{bmatrix} = \begin{bmatrix} a_{11} & 0 & a_{13} & a_{14} \\ a_{21} & 0 & a_{23} & a_{24} \\ a_{31} & a_{32} & a_{33} & a_{34} \\ a_{41} & 0 & a_{43} & a_{44} \end{bmatrix} \begin{bmatrix} p_e - p_e^* \\ c - c^{(ze)*} \\ k - k^{(ze)*} \\ h - h^{(ze)*} \end{bmatrix}$$

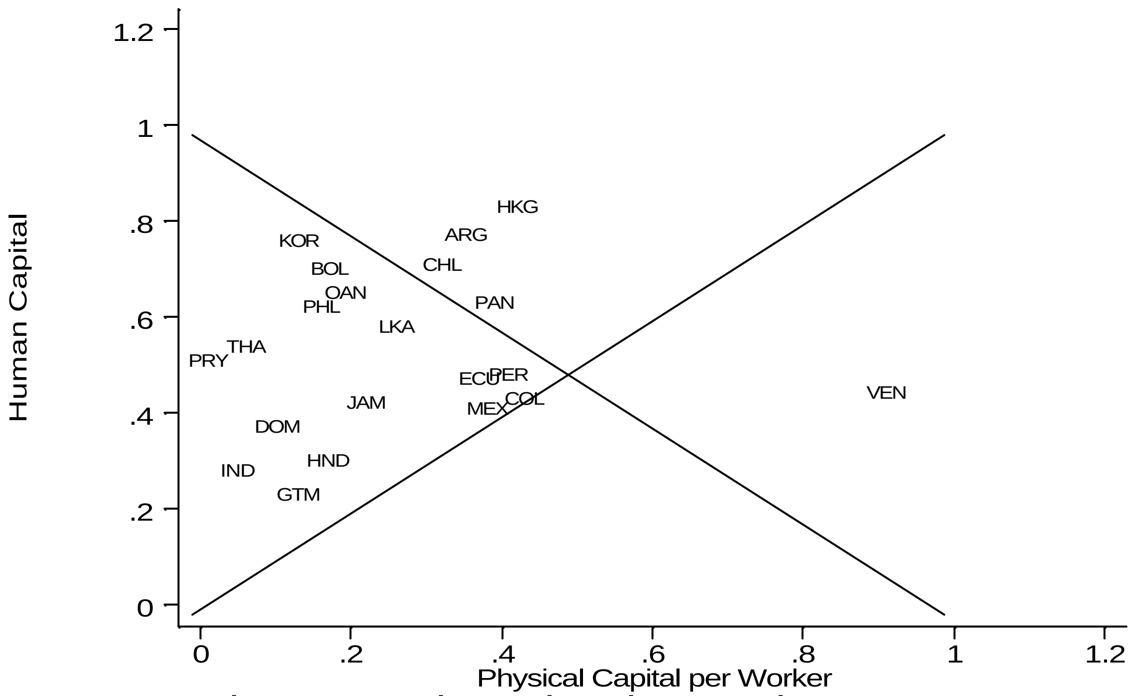


Figure 1. Asia and Latin America, 1965

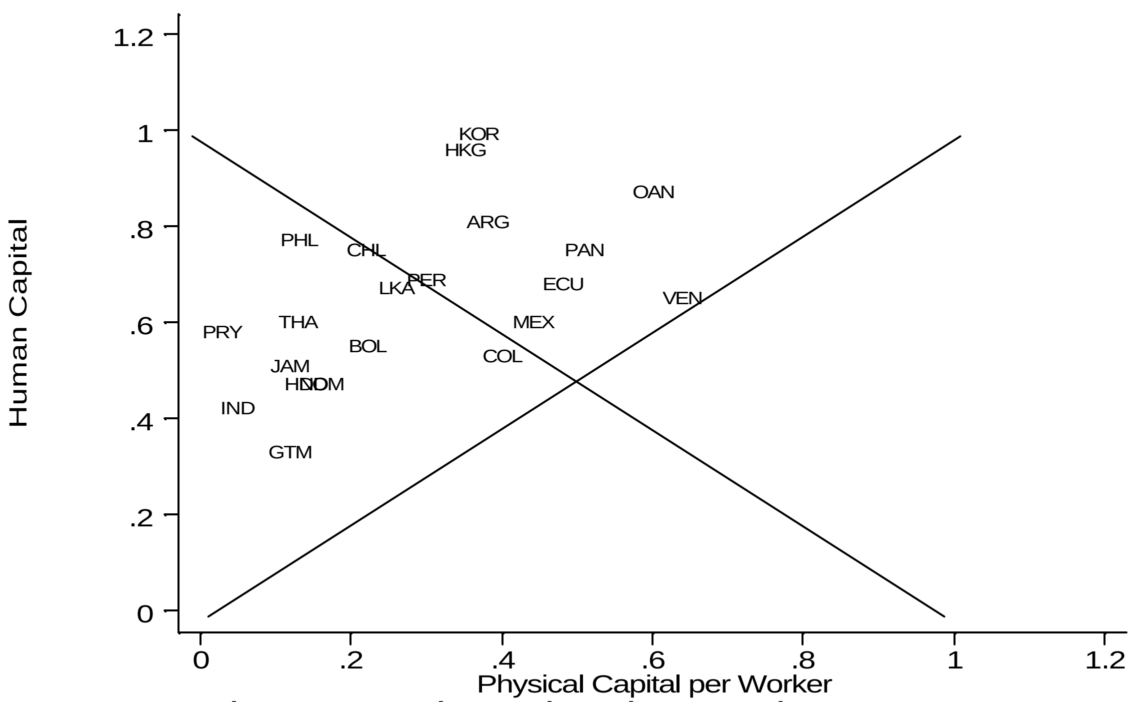


Figure 2. Asia and Latin America, 1985

Figure 3
BGPs for small open developing economy

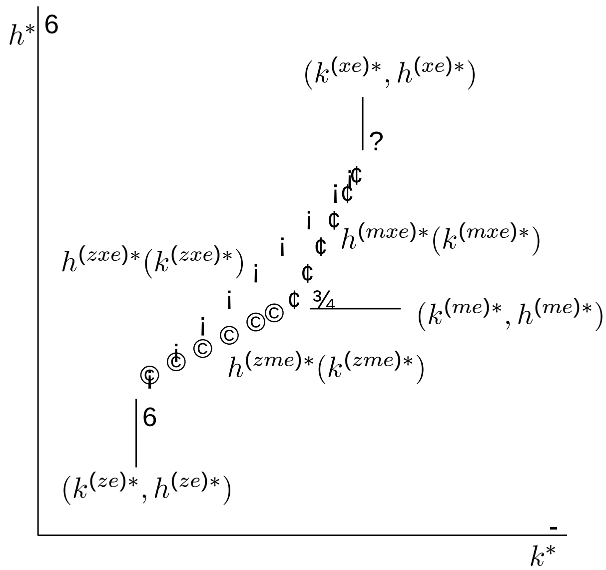


Figure 4
Transitional Dynamics

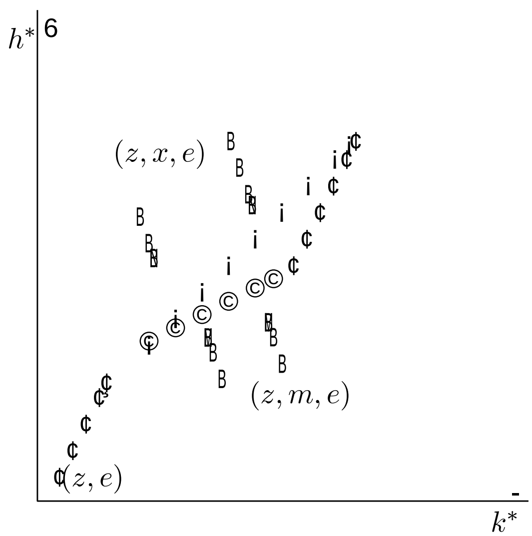
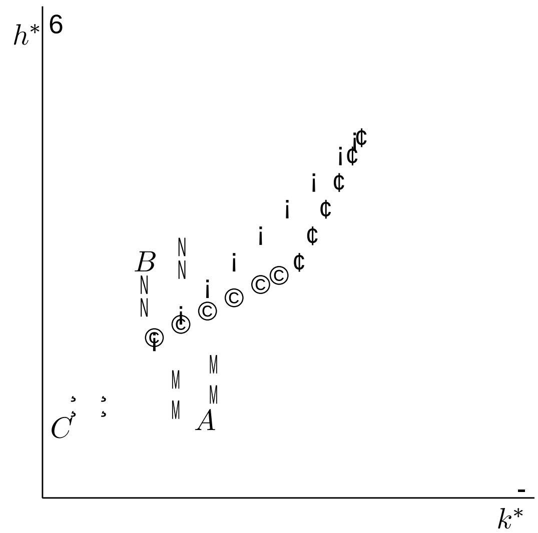


Figure 5
Trade policy and initial conditions



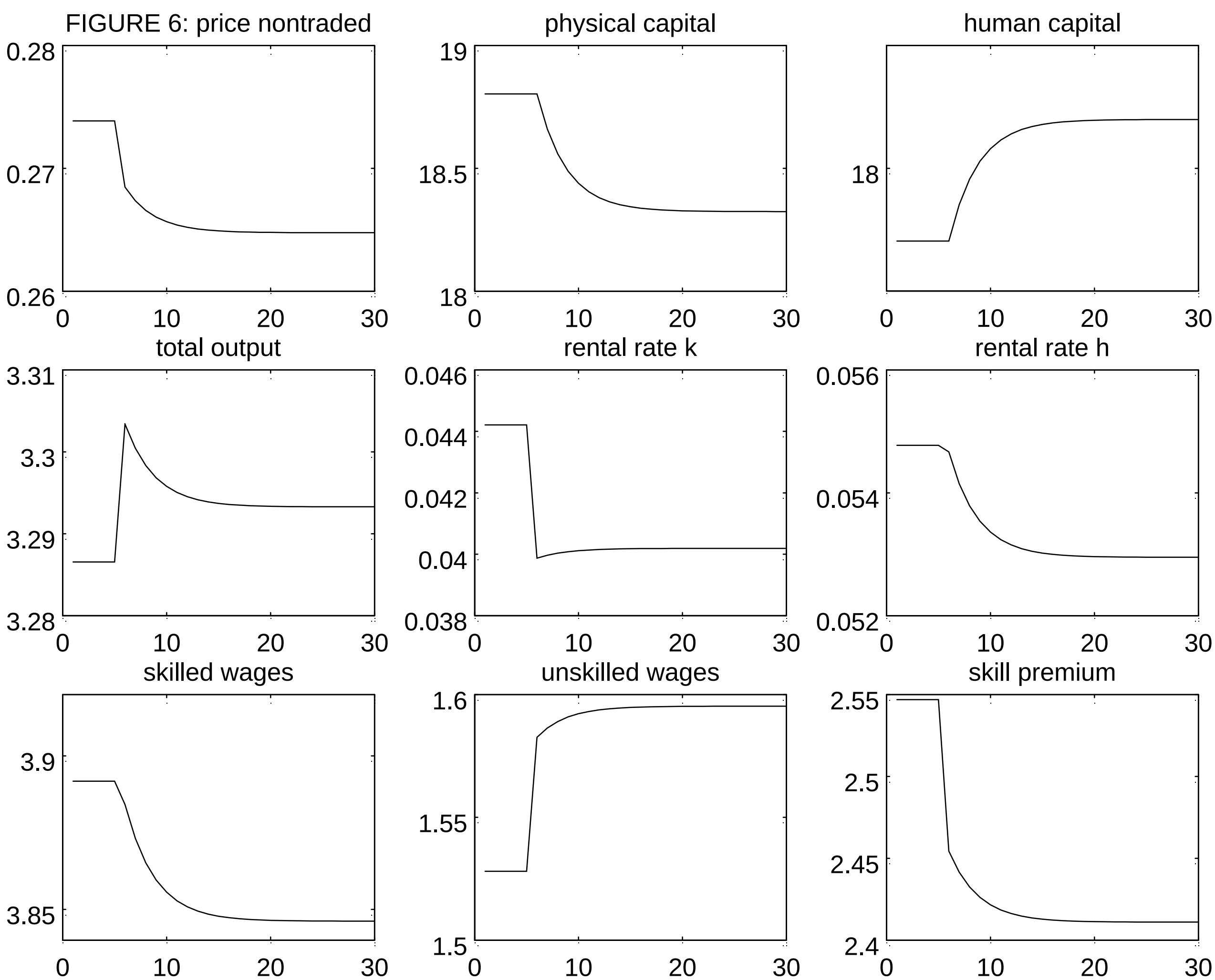


FIGURE 6: price nontraded
physical capital
human capital
total output
rental rate k
rental rate h
skilled wages
unskilled wages
skill premium

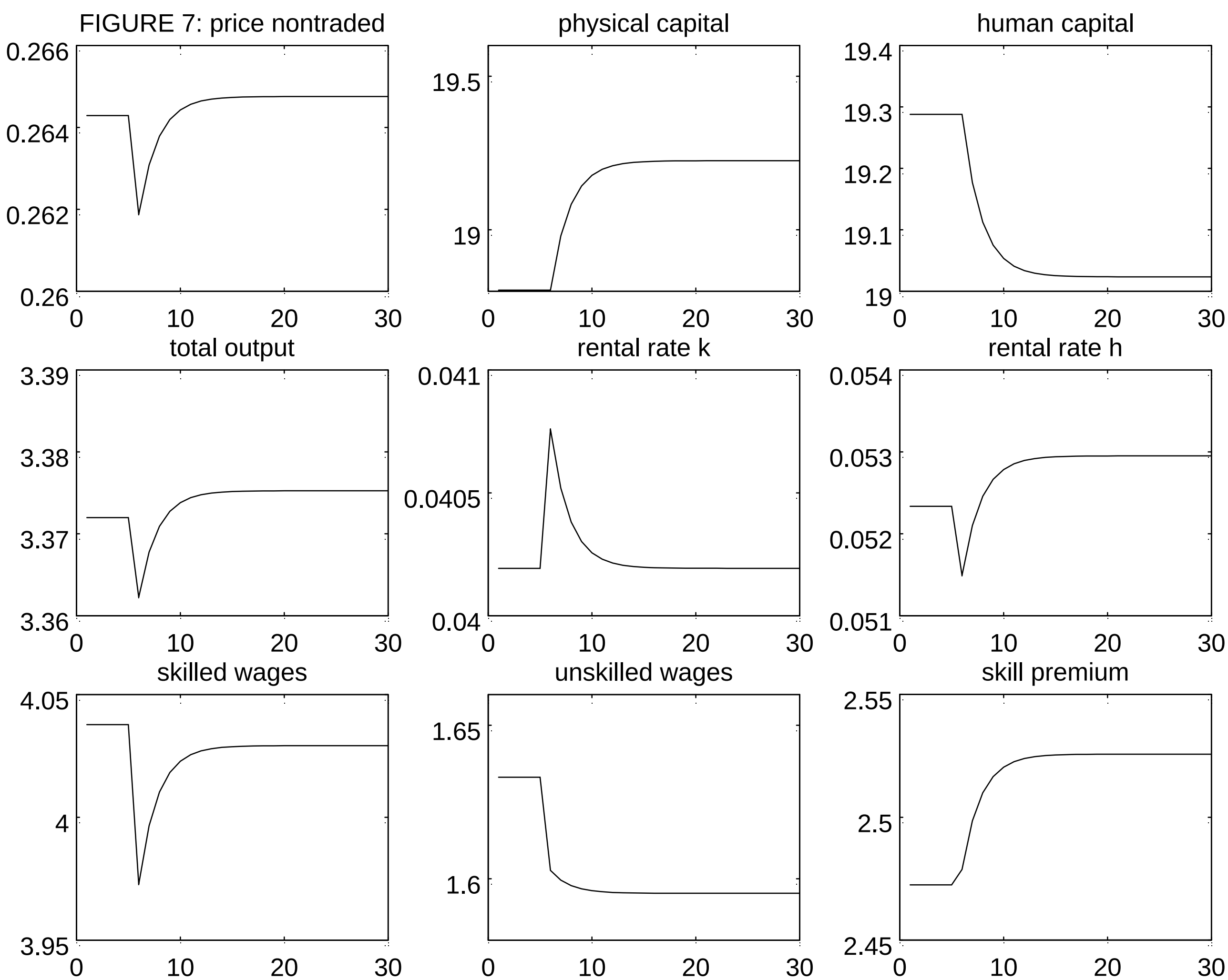


FIGURE 7: price nontraded
0.266
0.264
0.262
0.26
physical capital
19.5
19
human capital
19.4
19.3
19.2
19.1
19
total output
3.39
3.38
3.37
3.36
rental rate k
0.041
0.0405
0.04
rental rate h
0.054
0.053
0.052
0.051
skilled wages
4.05
4
3.95
unskilled wages
1.65
1.6
skill premium
2.55
2.5
2.45
0
10
20
30

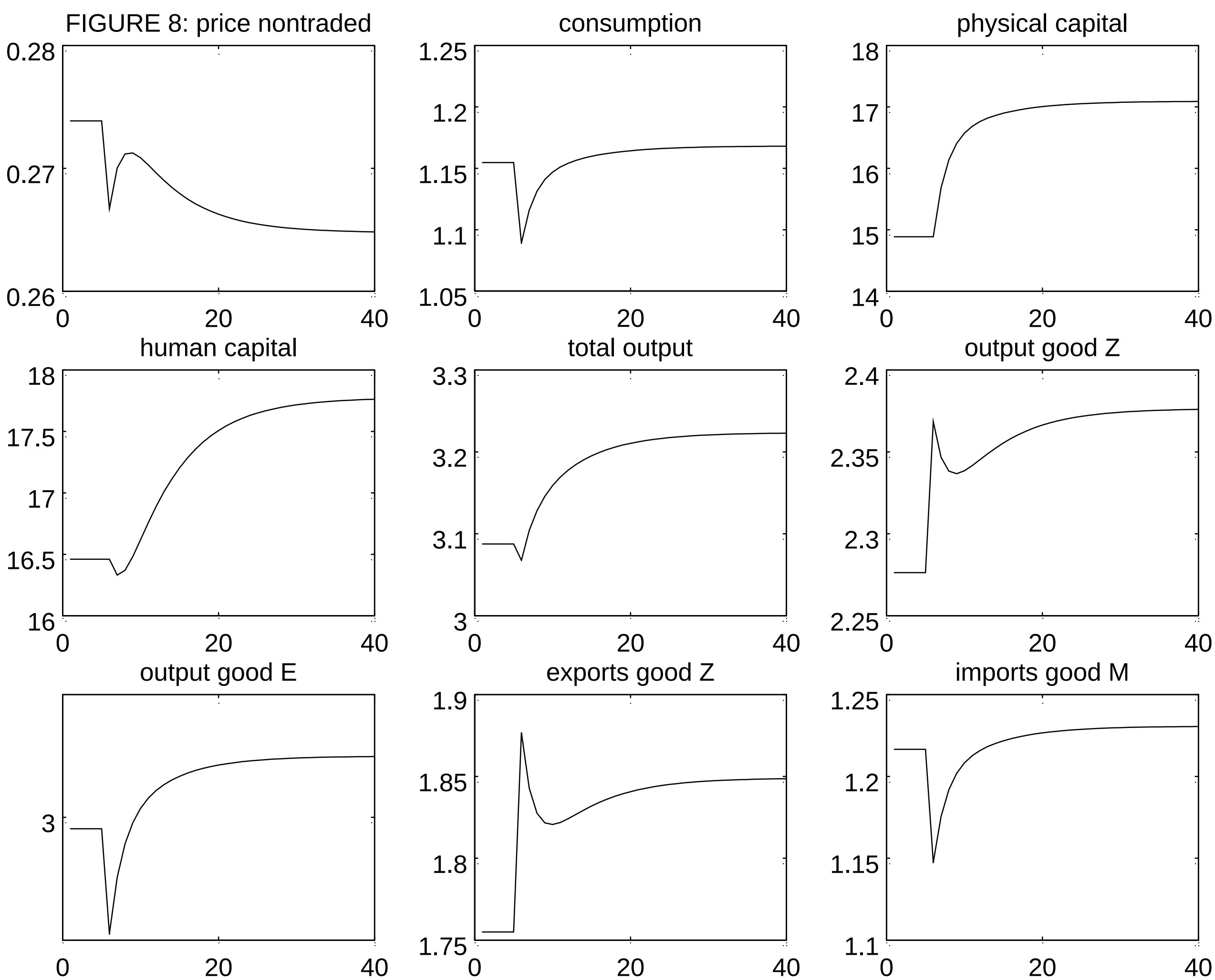


FIGURE 8: price nontraded
0.28
0.27
0.26
0
20
40
consumption
1.25
1.2
1.15
1.1
1.05
physical capital
18
17
16
15
14
human capital
18
17.5
17
16.5
16
total output
3.3
3.2
3.1
3
output good Z
2.4
2.35
2.3
2.25
output good E
3
exports good Z
1.9
1.85
1.8
1.75
imports good M
1.25
1.2
1.15
1.1

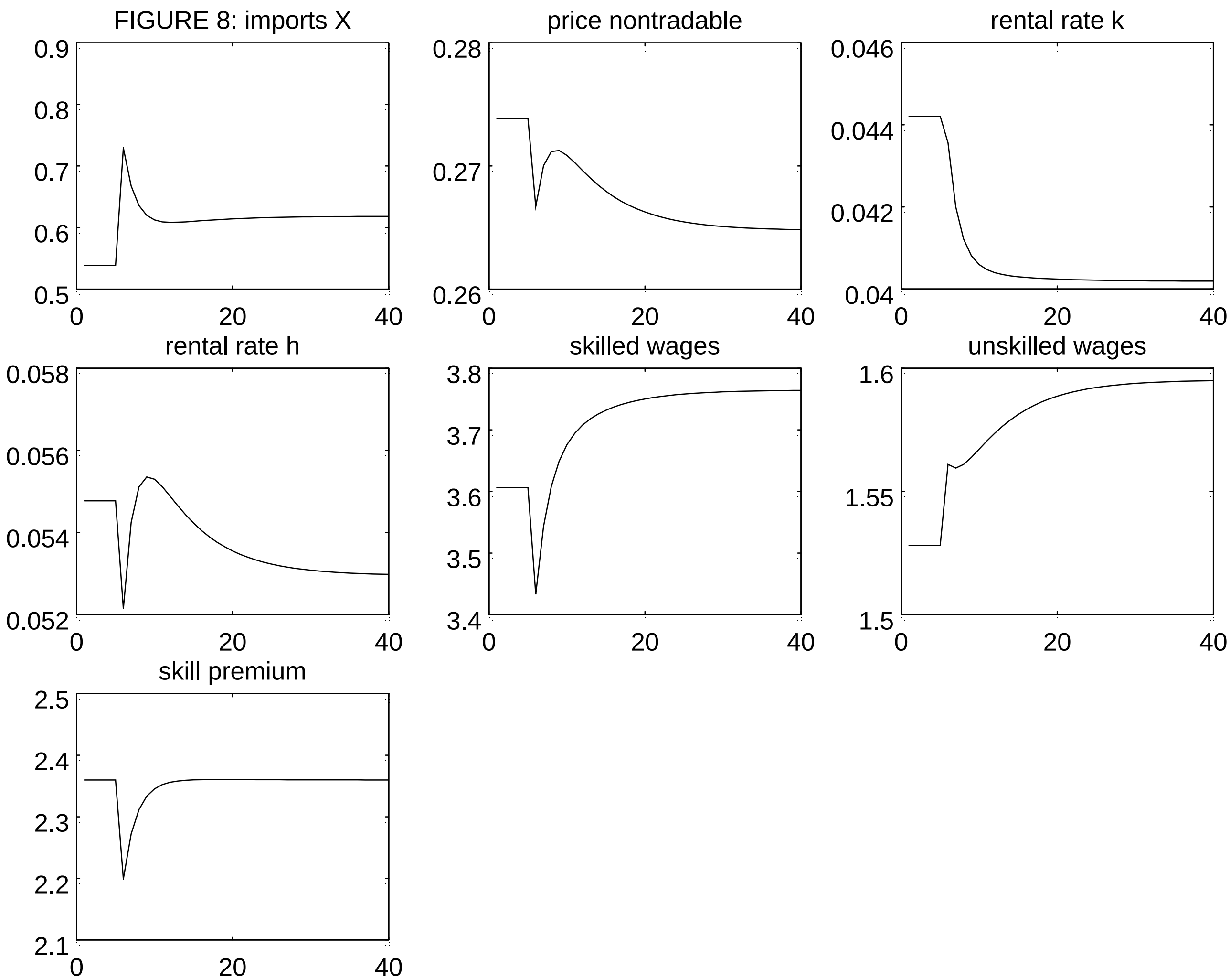


FIGURE 8: imports X
0.9
0.8
0.7
0.6
0.5
0
20
40
price nontradable
0.28
0.27
0.26
0
20
40
rental rate k
0.046
0.044
0.042
0.04
0
20
40
rental rate h
0.058
0.056
0.054
0.052
0
20
40
skilled wages
3.8
3.7
3.6
3.5
3.4
0
20
40
unskilled wages
1.6
1.55
1.5
0
20
40
skill premium
2.5
2.4
2.3
2.2
2.1
0
20
40

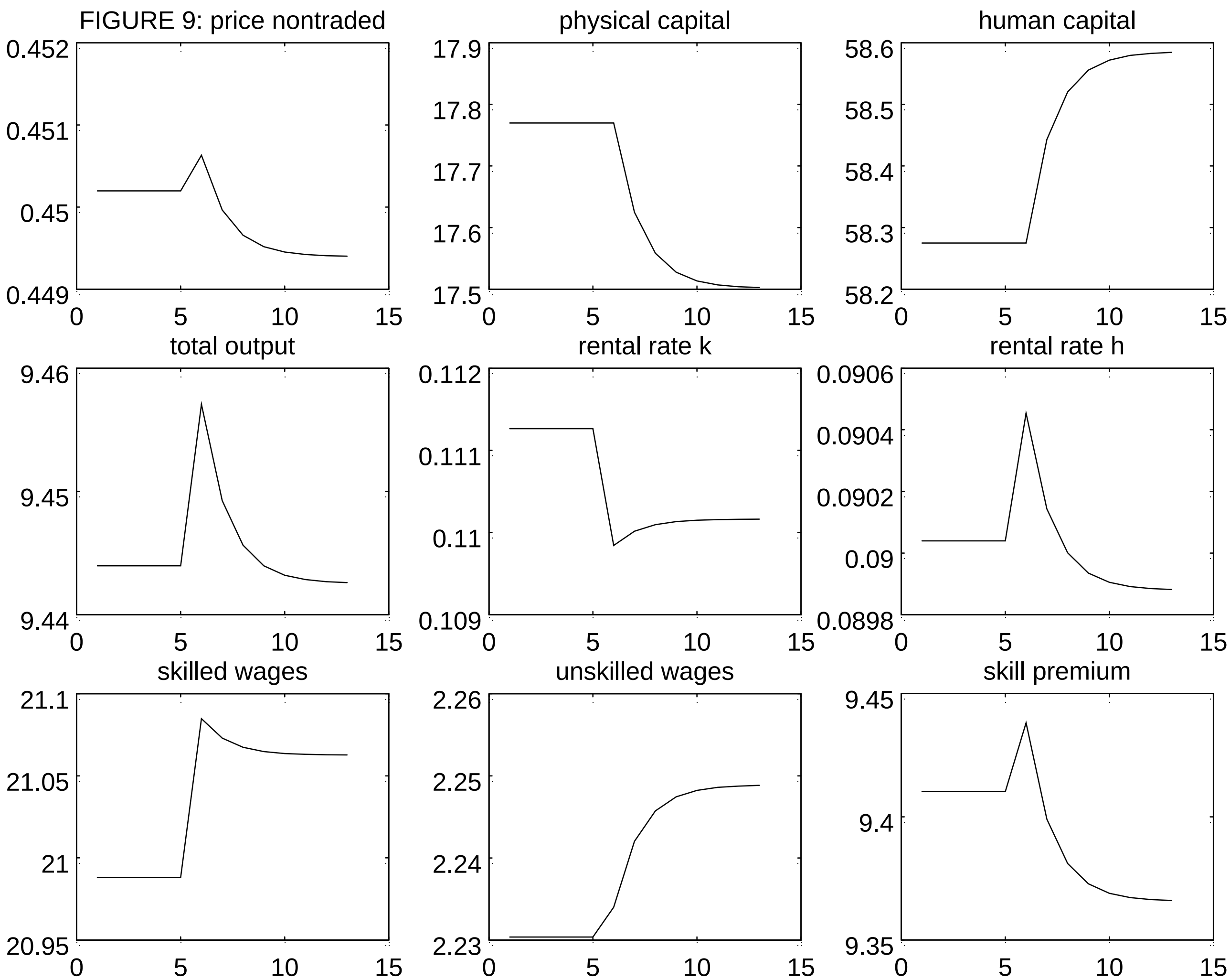


FIGURE 9: price nontraded
0.452
0.451
0.45
0.449
0
5
10
15
physical capital
17.9
17.8
17.7
17.6
17.5
0
5
10
15
human capital
58.6
58.5
58.4
58.3
58.2
0
5
10
15
total output
9.46
9.45
9.44
0
5
10
15
rental rate k
0.112
0.111
0.11
0.109
0
5
10
15
rental rate h
0.0906
0.0904
0.0902
0.09
0.0898
0
5
10
15
skilled wages
21.1
21.05
21
20.95
0
5
10
15
unskilled wages
2.26
2.25
2.24
2.23
0
5
10
15
skill premium
9.45
9.4
9.35
0
5
10
15

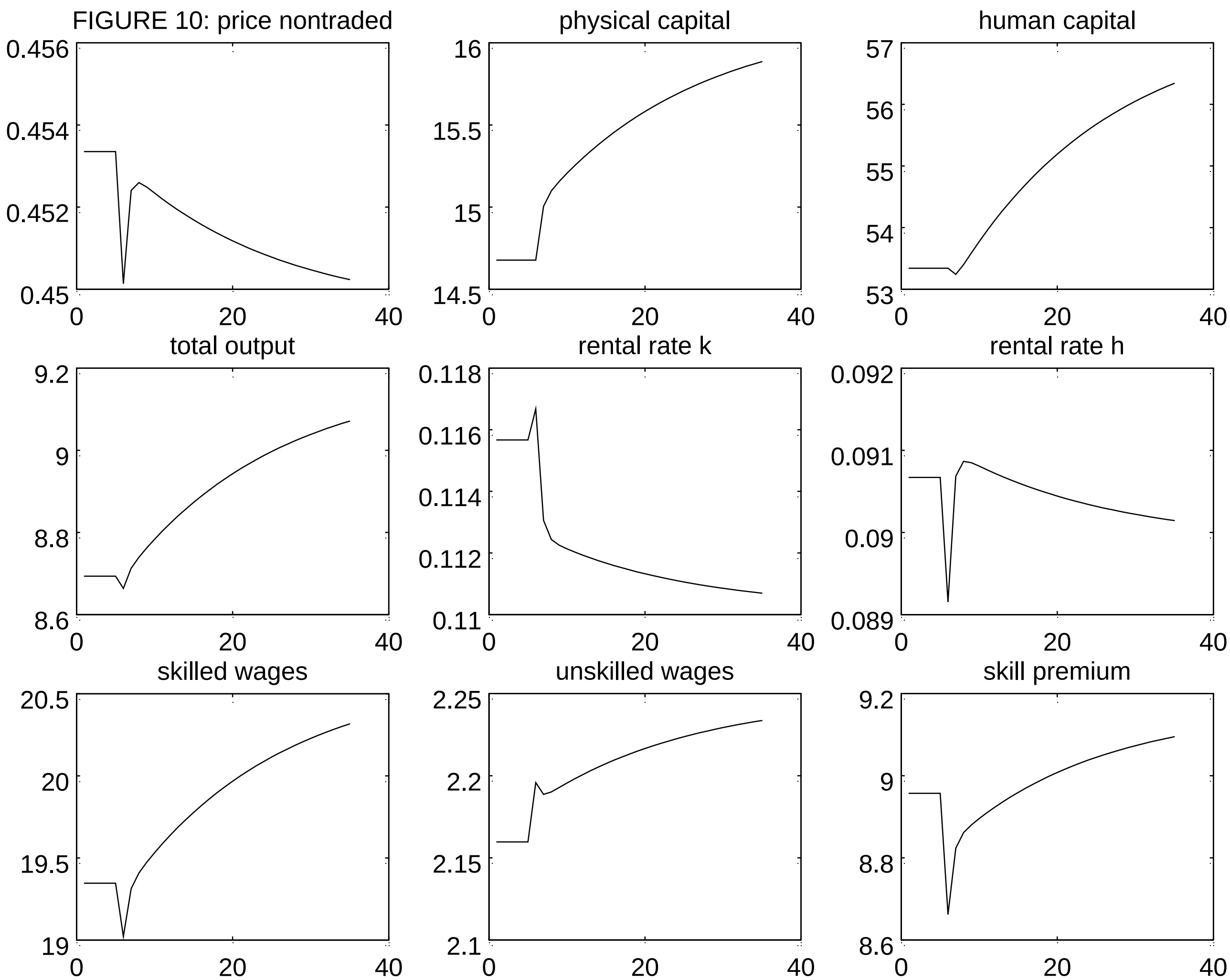


FIGURE 10: price nontraded
0.456
0.454
0.452
0.45
0
20
40
physical capital
16
15.5
15
14.5
human capital
57
56
55
54
53
total output
9.2
9
8.8
8.6
rental rate k
0.118
0.116
0.114
0.112
0.11
rental rate h
0.092
0.091
0.09
0.089
skilled wages
20.5
20
19.5
19
unskilled wages
2.25
2.2
2.15
2.1
skill premium
9.2
9
8.8
8.6