Optimal Education Policies and Comparative Advantage

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Abstract

We consider the optimal education policies of a small economy whose government has a limited budget. Initially, the economy is closed and the government chooses its education policy to maximize welfare under autarky. Then the economy trades with the rest of the world. Lastly, the government chooses a new education policy that maximizes welfare under trade. Is it ever optimal for the government to choose its new policy so that it reverses the economy's comparative advantage? We find that if the budget stays fixed when it is optimal to 'move up the skills chain' it is not feasible. In such a case a foreign loan is welfare improving. A move in the opposite direction can be optimal and when it is optimal it is also feasible.

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1 Introduction

During the second half of the past century, many, at the time, developing countries that have traditionally been inward looking, opened their economies and began to trade with the rest of the world. Initially these economies specialized in low-skill goods and most of them still do so. But some countries (e.g. countries in the East Asian region) have managed to transform their economies by shifting resources to high-skill sectors and thus reversing their patterns of trade. Their exports are now dominated by goods whose production requires the use of high-skill labor. These economies that have successfully achieved this transformation had to devote resources to education in order to equip workers with the new skills that were necessary for employment in the new sectors. This is reflected by the steadily increasing flow of young persons to higher education. The same type of policies are adapted by many governments that aim to achieve similar trade pattern reversals. Good examples are India and China where there is plenty of evidence that their governments actively pursue to help produces to 'move up the value chain'.[1][2]

Intuitively, these policies cannot be globally optimal. As long as there is a demand for low-skill intensive goods there always be some countries with a comparative advantage in their production. For developing countries with limited government budgets that constrain their choices, understanding where their comparative advantage lies is important. The following two figures show the export patterns and education attainment levels of four countries that have followed four distinct development paths over the last three decades.

Figure 1 depicts the percentage of high-tech exports in total manufacturing exports over the period 1980-2000 for Argentina, Korea, Poland and United States.[3] Not surprisingly, we find that over the whole period the exports of United States are dominated by high-tech products. In contrast,

[1] This is clear from the World Economic Forum's reports on the China Business Summit 2003 and on the India Economic Summit 2004 and from daily business magazines and newspapers in these two countries.

[2] 'Moving up the chain' has a dual meaning. In some cases it is taken to mean ascending a quality ladder where the products are still the same however their quality is increasing. In our context it implies a move along the production possibilities frontier such that high-skill intensive goods substitute for low-skill intensive goods.

[3] The data on exports were obtained from the World Trade and Production Database. For the separation of sectors into high-tech and low-tech ones we used the OECD classification of sectors according to their level of skills employed. We have experimented with different threshold levels but with no consequence for our comparisons.

Argentina's exports over the whole period are dominated by relatively low-tech products. The other two countries are examples of economies that have seen a change in their patterns of trade. For Korea we observe a steady increase in the proportion of high-tech products exports as a percentage of total exports that highlights the transformation of the economy during its high-growth period. Lastly, for Poland we observe the reverse pattern. Before the collapse of the Soviet Union and consequently COMECON (the East-European Common market) Poland's exports were dominated by relatively high-tech products with main destination the former Soviet Union. These sectors proved to be non-competitive after the collapse and Poland's patterns of trade were reversed.

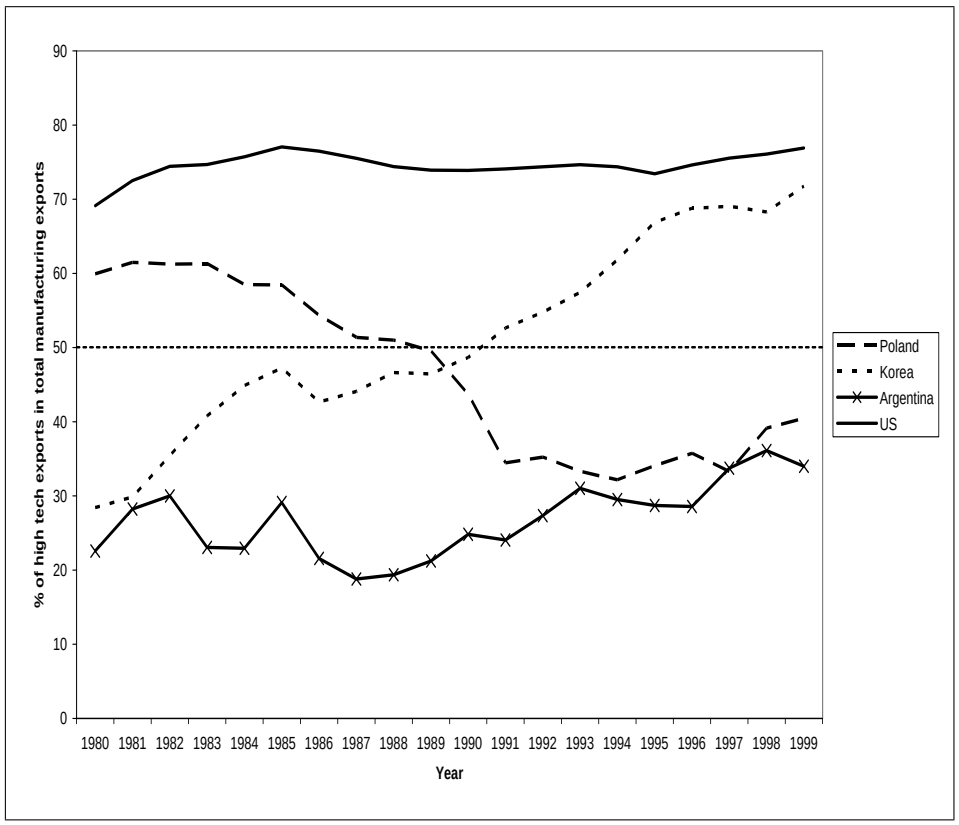

Figure 1: Patterns of Trade

Figure 2 shows the educational attainment levels for the same four coun-

tries over the same period.[4] More specifically, it shows the proportion of the population aged over 25 with post-secondary education. We observe that the countries with the highest post-secondary education attainment levels are those with exports dominated by high-tech products. In particular, we notice that while in the beginning of the 1980s Korea' s attainment level was close to that of Argentina's and Poland's by the end of the 1990s it had reached considerably higher levels.

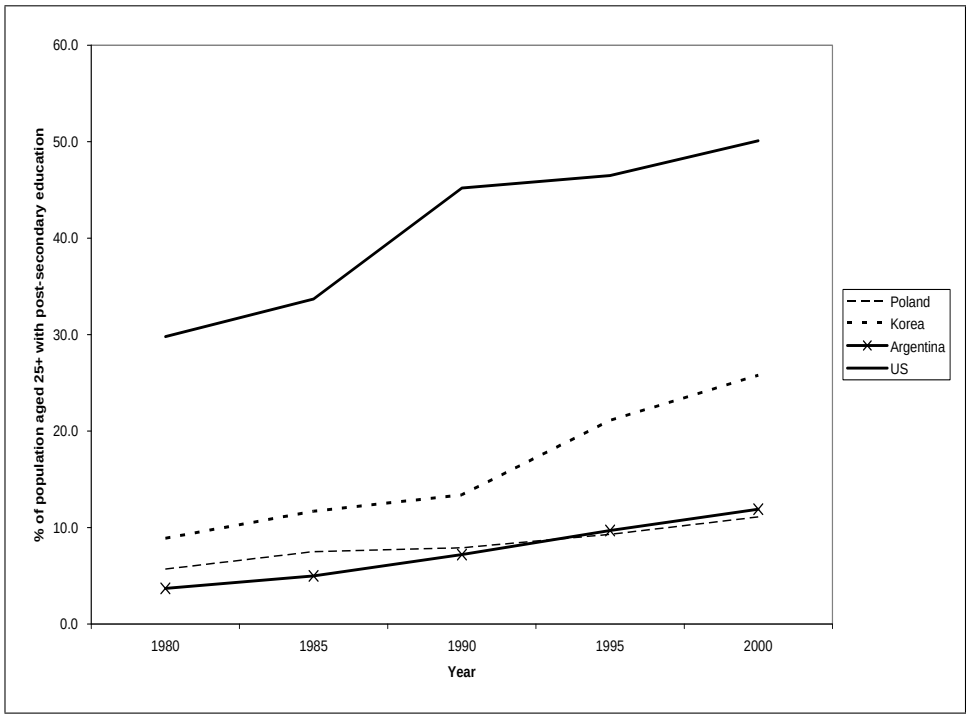

Figure 2: Educational Attainment

Our aim in this paper is to provide a theoretical understanding of the conditions under which it is optimal for governments to encourage shifts in production that will eventually lead to a reversal in their patterns of trade. A number of recent papers, (Ishikawa, 1996; Grossman and Maggi, 2002; Grossman, 2004; Bougheas and Riezman, 2007) examine the relationship between an exogenous distribution of human capital endowments and the patterns of trade. In this paper, we make the distribution of human capital

[4] The data comes from Barro and Lee (2001).

endogenous.

In our model the role of the government is crucial. It has an indirect influence on production patterns through its education policy that determines the distribution of skills in the economy. Traditionally, in trade models decisions on human capital accumulation are taken by agents according to their level of ability.[5] In our model all agents are identical and the distribution of skills in the economy is entirely determined by the government's education policy. Our choice for modeling human capital accumulation is motivated by the fact that we think this is more relevant for developing nations. For these nations the means available for individual investment in human capital are quite limited for the majority of the population. Hence, the allocation of a limited government budget is a far more important determinant of the overall distribution of educational opportunity (and human capital) than individual decisions. Hence, we focus on government policy as the main determinant of the distribution of human capital.[6]

Our economy consists of two sectors, a low-skill sector that produces a primary commodity and a high-tech sector that employs high-skill workers. The productivity of each worker depends on both her sector of employment and her level of education. Both product and labor markets are competitive. Initially, we consider the closed economy case and derive the optimal education policy that maximizes aggregate welfare under autarky. Next, we allow the economy to trade keeping the skill distribution in the economy the same. Finally, we allow the government to adjust its education policy and we derive the new patterns of trade.[7][8]

We find that depending on the terms of trade, a move up the skills chain

[5] The relationship between human capital accumulation and trade was first considered by Findlay and Kierzkowski (1983) within the H-O framework. For some more recent work, see Cartiglia (1997), Ranjan (2001) and Long, Riezman and Soubeyran (2007). What limits human capital accumulation in these papers is private wealth constraints. In contrast, Deardoff (1997) and Janeba (2000) examine the effects of public policy on human capital accumulation and the distribution of income but not on trade patterns..

[6] Our model implies that the distribution of wealth in the economy entirely depends on government policy and not on personal characteristics. It is only to keep things simple that we have not introduced any heterogeneity among agents by specifying a distribution of ability. Had we done so governemrnt policies would still detrmine the distribution of education attainment but in that case efficiency would require that the level of education attainment for each agent depends on his level of ability.

[7] In a recent paper, Egger, Egger, Falkinger and Grossmann (2005) follow a similar procedure to consider how individual educational choice is affected by the integration of capital markets.

[8] Our focus is on long-term trends and thus we have ignored any short-term adjustment costs. For some potential pitfalls of our approach, see Davidson and Matusz (2002, 2004).

can be optimal. However, when this is the case the budget does not allow any change in education policy. We then consider the case in which a foreign loan is available and find that the country can benefit from a foreign loan as the welfare gains resulted from relaxing the government budget constraint exceed the welfare losses due to the lump-sum taxation imposed in order to repay the loan.[9] We also find that reversals in the opposite direction, moving down the skills chain, can also be optimal and that such reversals are not budget restrained.

In the following section we take a preliminary look at the data, in section 3 we build our theoretical model, in section 4 we derive the results for the autarky case and in section 5 we open the economy to international trade and in the last section we offer some final comments.

2 A Preliminary Look at the Data

In the following five tables we present data on educational attainment and sectoral exports for a sample of 24 countries for the years 1980, 1990 and 2000.[10] For educational attainment we show the proportion of the population aged above 25 with secondary education and the corresponding proportion for those with tertiary education. The export data indicate the percentage of exports that are high tech goods. We have used two thresholds to separate high-tech from low-tech sectors. The Broad definition of high-tech goods sectors uses a lower threshold and hence delivers uniformly higher numbers than the Narrow definition.

Table 1a includes countries which, like the United States, have been exporting a large proportion of high-tech products throughout the sample period.[11] These countries also show very high educational attainment levels

[9] The theoretical literature on dynamic comparative advantage suggests that if the initial gains of trade are sufficiently high and thus relax the factors constraining growth (in our case the limited budget constraint) then a reversal of exports from low-skill goods to high-skill goods might become optimal. This suggests that economies that move up the chain must be economies that grow fast.In this paper we focus on distributional aspects of government policy and, for analytical tractability, we abstract from dynamic considerations. For theoretical work on dynamic comparative advantage see Bond, Trask and Wang (2003), Redding (1999) and Ventura (1997).

[10] The sources of the data are the same as those used for figures 1 and 2. The sample comprises of countries for which all data were available. The only exceptions are Bulgaria and Romania for which export data for 1980 are not available but were included given that their particular group is small.

[11] It is convenient to use the broad definition in our ananlysis where a proportion above fifty percent is interpreted as the country having a comparative advantage in high-tech

and furthermore, these levels are increasing strongly over time.

[Please insert Table 1a about here]

Table 1b includes countries like Argentina that have primarily been exporting low-tech goods. Table 1b countries educational attainment levels have been low relative to the countries in Table 1a throughout the period. Comparing the ratio of high-tech exports to total exports (using the Broad definition) for the two groups we observe a striking difference. All the ratios are less than 50% for the second group while nearly all ratios are above 50% for the first one.[12] We also notice that overall the first group has higher educational attainment levels although the differences here are less striking. Comparing tables 1a and 1b there appears to be some correlation between educational attainment and being an exporter of high tech goods.

[Please insert Table 1b about here]

Table 1c comprises of a group of South-East Asian economies that have achieved a remarkable transformation of their economies over the last three decades. They have moved up the chain. It is clear from Table 1c that one factor that played a crucial role for their success was an emphasis on human capital accumulation as indicated by their educational attainment rates. Looking at their patterns of trade trends we observe (using the Broad definition) that in the early 1980s most of these countries (the only exception here is Singapore) exported primarily low tech goods. By 2000 this turned around and essentially for all of these countries exports of high tech goods comprised more than 50% of all exports. It is also worth noting that all these countries, through their period of transformation, have achieved a very high rate of economic growth. As we will see later, this might play an important role in explaining how they moved up the chain of comparative advantage and became exporters of high tech goods.

[Please insert Table 1c about here]

Table 1d presents data from Eastern European countries for which a fast process of trade liberalization, as a result of the collapse of the Soviet Union, and thus COMECON, rendered many old industrialized sectors non-competitive and induced them to search for new exporting opportunities. The change in political geography, for example, the establishment of

goods.

[12] The only exception is Italy with 1980 and 1990 ratios of 48.8% and 49.3%, respectively.

many new nations throughout the period of interest, restricts considerably our sample size. Nevertheless, one of the implications of the collapse of the Eastern alliance is a move down the chain of comparative advantage. This is clear for Romania and Poland and probably for Bulgaria as indicated by the narrow definition. Hungary, whose exporting sectors have been predominantly low-skilled, is the only notable exception.

[Please insert Table 1d about here]

Finally, in Table 1e we show the corresponding data for China and India the two countries that aspire to move up the chain. Our model suggests that given the educational achievements such aspirations may be difficult to achieve.

[Please insert Table 1e about here]

We next develop a model of the optimal choice of education policy when the budget is fixed.

3 The Model

Consider a two-sector small open economy inhabited by a continuum of agents of unit measure. Sector X produces a high-tech product while sector Y produces a primary commodity. In both sectors labor is the only input in production, however, the productivity of each worker depends on his level of education and his sector of employment. To keep things simple we assume that there are three levels of education, namely low, medium, and high. Workers with a low level of education (type l) can only find employment in sector Y where they produce 1 unit while workers with a medium level of education (type m) can produce $v(>2)$ units in either sector.[13] The high level of education (type h) is useful only to workers employed in the high-tech sector where each produces $V(>v)$ units.

The distribution of educational attainment in the economy is completely determined and financed by the government. Agents are initially identical but education separates them into three skill groups that correspond to the three levels of education. We assume that the low level of education is provided to all agents and that the fixed education budget of the government is sufficiently high to cover its cost. The remaining budget is equal to b. We

[13] Setting the productivity the same in the two sectors keeps the number of parameters low and, below, it will become clear that it is without any loss of generality.

assume that the size of the education budget is exogenously determined. We normalize to unity the cost of providing an agent with the medium level of education and denote by c the cost of providing an agent with the high level of education.[14] We impose the following restrictions on the parameters of the model:

Condition 1 $\frac{V}{c} > v > 2$

Condition 2 $b < c$

The first condition implies that investment in the high level of education is efficient.[15] The second condition implies that the government cannot provide all agents with the high level of education, however, it does not necessarily imply that the government is financially constrained. As long as both goods are consumed in equilibrium then it is inefficient to provide agents employed in the Y sector with the high level of education. A sufficient condition for a financially constrained government is that $b = 1$ as either some agents employed in the X sector will be type m or some agents employed in the Y sector will be type l.

Let θ_i $(i = l, m, h)$ denote the proportion of type i agents. The government's choice of θ_i's must satisfy the following two constraints:

$$\theta_l + \theta_m + \theta_h = 1 \tag{1}$$

and

$$b \geqslant \theta_m + c\theta_h \tag{2}$$

where the second constraint states that government spending on education cannot exceed the budget.

All agents have identical Cobb-Douglas preferences specified as:

$$U_i = (X_i Y_i)^{\frac{1}{2}} \qquad i = l, m, h \tag{3}$$

where X_i and Y_i denote a type i's worker consumption of the high-tech product and primary commodity, respectively.

[14] Given that the size of the budget is exogenous what matters is the size of the budget relative to the cost of education.

[15] Notive that if $v < 2$ it is never optimal to employ agents with medium level of education at the primary sector.

3.1 The Production Possibilities Frontier

The government's choice of education policy determines the economy's production possibilities which is shown graphically in Figure 1. The reason that the frontier is vertical at the point where it intersects the horizontal axis is that type l workers can only produce the primary commodity. The maximum amount of X that can be produced is attained when all type m and type h workers are employed in that sector. Given the education distribution in order to produce more than θ_l units of Y (remember that a type l worker can produce 1 unit of Y), efficiency requires that the first workers to change employment are type m workers and, thus the middle section of the frontier has a slope equal to 1. As the production of Y is further increased the slope takes the value $\frac{v}{V}$ because type h workers can each produce either V units of X or v units of Y.

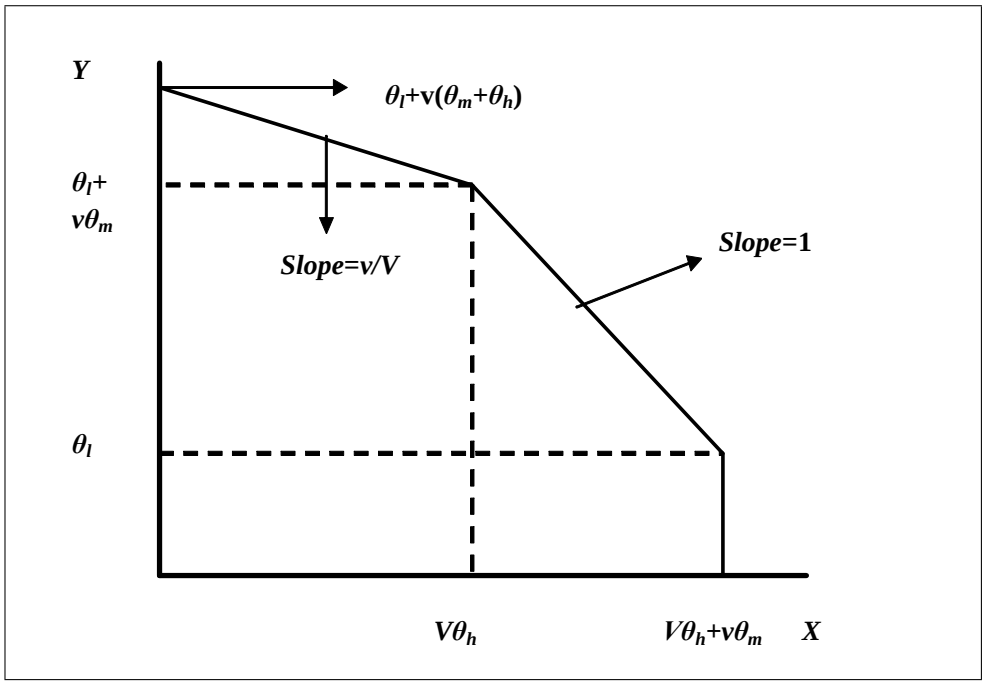

Figure 3: Production Possibilities Frontier

4 Autarky

We derive the equilibrium under autarky in two stages. Under the assumption that all markets are competitive, we begin by deriving the equilibrium price and the corresponding production and consumption allocations for an arbitrary education policy. Then, we derive the education policy that maximizes aggregate welfare. The following preliminary result significantly simplifies the equilibrium analysis.

Proposition 1 *If the government is financially constrained, efficiency requires that type l and type m workers are employed in the Y sector and type h workers are employed in the X sector.*

Proof. Suppose not. Then one of the following must be true:

a) Aggregate production of the X sector is less than $V\theta_h$. But this implies that some type h workers are employed in the Y sector. Further, a binding government constraint means that $\theta_l > 0$. Then the government could have enhanced welfare by reducing θ_h and increasing θ_m as this change in policy would result in a higher output of the primary commodity without any reduction in the production of the high-tech product. We have a contradiction.

b) Aggregate production of the X sector is more than $V\theta_h$. But this implies that some type m workers are employed in the X sector. Consider a small increase in the proportion of type h workers. Then the budget constraint implies that the proportion of type m workers has to be reduced with $\frac{d\theta_m}{d\theta_h} = -c$. Now suppose that after this change you keep the production in sector X constant. Given that all type h workers are employed in sector X then the proportion of type m workers employed in this sector will be reduced and $\frac{d\theta_m}{d\theta_h} = -\frac{V}{v}$. But since $\frac{V}{v} > c$ the reduction in the proportion of type m workers in sector X is higher than the reduction in the overall proportion of type m workers in the economy and therefore after the above change the government can increase production in sector Y without decreasing production in sector X. We have a contradiction. ■

The above result implies that given the government's education policy production in sector X will be equal to $V\theta_h$ while production in sector Y will be equal to $\theta_l + v\theta_m$.

Using the primary commodity Y as the numeraire let p^A denote the autarky price. Further let I_i^A denote the income of a type i worker. Maximization of (3) subject to the budget constraint yields the demand functions:

$$X_i = \frac{I_i^A}{2p^A}, \qquad Y_i = \frac{I_i^A}{2} \tag{4}$$

where proposition 1 implies that $I_l^A = 1$, $I_m^A = v$, and $I_h^A = p^A V$. Equilibrium under autarky requires that the following market clearing conditions for sectors X and Y respectively, are satisfied:

$$V\theta_h = \frac{1}{2}\left[\frac{1}{p^A}\left(\theta_l + v\theta_m\right) + V\theta_h\right]$$

and

$$\theta_l + v\theta_m = \frac{1}{2}\left[\theta_l + v\theta_m + p^A V\theta_h\right]$$

where in both conditions the left-hand side equals the supply of that good and the right-hand side equals the corresponding demand. Solving either of the above market clearing conditions for the equilibrium autarky price we get:

$$p^A = \frac{\theta_l + v\theta_m}{V\theta_h} \tag{5}$$

It also follows from proposition 1 that $1 > p^A > v/V$.

4.1 Optimal education policy

The optimal education policy corresponds to the solution of the following program:

$$\begin{aligned}&\max_{\theta_l} \frac{1}{2}\{\left(\theta_l + v\theta_m\right)\left(\frac{1}{p^A}\right)^{\frac{1}{2}} + V\theta_h\left(p^A\right)^{\frac{1}{2}}\} \\ &= \frac{1}{2}(p^A)^{-\frac{1}{2}}\left[\theta_l + v\theta_m + V\theta_h p^A\right]\end{aligned} \tag{6}$$

subject to (5),

$$\theta_h = 1 - \theta_l - \theta_m \tag{7}$$

and

$$\theta_m = \frac{c(1-\theta_l) - b}{c-1} \tag{8}$$

where the last two constraints follow from (1) and (2).

The optimal proportion of type l workers under autarky is:

$$\theta_l^A = \frac{1 - b - c + bc - bv + 2cv - bcv}{2(1 - c + cv)} \tag{9}$$

By substituting the above solution in (7) and (8) we find the optimal solutions for θ_h and θ_m, respectively, and then by substituting these solutions in (5) we can solve for the optimal price under autarky:

$$p^{A*} = \frac{1 + c(v-1)}{V} \tag{10}$$

Notice that the autarky price does not depend on the size of the budget. This is because we have focused our attention to the case of an interior solution for the education policy; i.e. when $\theta_l > 0, \theta_m > 0$ and $\theta_h > 0$. In this case, because preferences are homothetic, the size of the budget does not affect the ratio of the production levels of the two goods and hence the equilibrium price. For intermediate values of budget size, as the latter changes the proportions of the three types of agents adjusts so that the above ratio stays constant.

By substituting (9) in (8) and differentiating with respect to b we find that θ_m is increasing as the budget increases. When the budget is sufficiently low we have $\theta_m^A = 0$. In that case

$$\theta_l^A = \frac{c-b}{c}, \quad \theta_m^A = 0, \quad and \quad \theta_h^A = \frac{b}{c}$$

Using (5) we find that the equilibrium autarky price for this case, is given by

$$p^{A1} = \frac{c-b}{bV} > \frac{1 + c(v-1)}{V} = p^{A*}$$

where notice that v does not appear in the above solution because there are not any type m workers. Also notice that the relative price decreases as the budget increases. This is because the budget restrains output in the high-tech sector X. As the budget size increases the proportion of type h workers increases while the proportion of type l workers decreases. Equating p^{A1} with p^{A*} we find a threshold level for the budget, given by

$$b_1 = \frac{c}{2 + c(v-1)}$$

such that when $b < b_1$, $\theta_m^A = 0$.

There is another threshold level for the budget, b_2, such that when the budget is higher that this threshold $\theta_l^A = 0$. In that case (5) implies that the corresponding autarky price is given by:

$$p^{A2} = \frac{v(c-b)}{V(b-1)} < p^{A*}$$

Equating p^{A2} with p^{A*} we find that

$$b_2 = \frac{1 + c(v-1) + cv}{1 + c(v-1) + v}$$

Figure 2 shows the autarky price as a function of the budget. Notice that if $b \geqslant \frac{1}{2}(1+c)$ the size of the budget constraint under autarky is not binding.

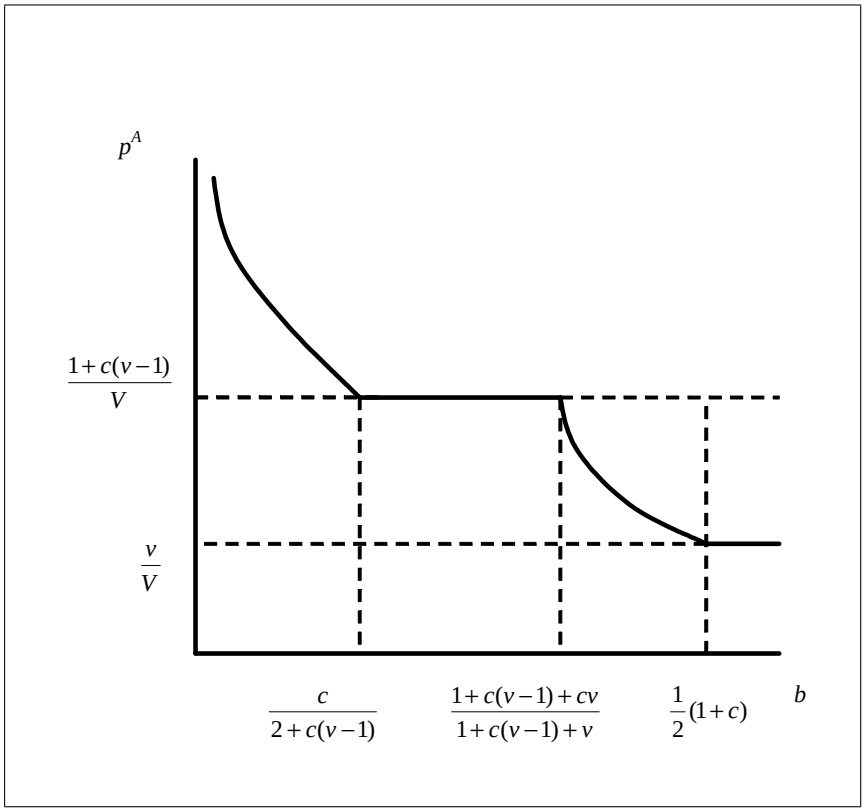

Figure 4: Autaky Price Function

5 Trade

Suppose that the small economy trades with the rest of the world at the world price p^* and that the government does not adjust its education policy.

Then it is clear that if $p^A > p^*$ the economy will export the primary commodity and if $p^A < p^*$ it will export the high-tech product. However, the government can further enhance welfare by adjusting its education policy after the change in the trade regime.

By substituting the world price for the autarky price in (6) we obtain the government's problem under trade.

$$\max_{\theta_l} \frac{1}{2}(p^*)^{-\frac{1}{2}}(\theta_l + v\theta_m + V\theta_h p^*)$$

which using (7) and (8) can be written as:

$$\max_{\theta_l} \frac{1}{2}(p^*)^{-\frac{1}{2}} \left(\theta_l + v\frac{c(1-\theta_l)-b}{c-1} + \left(1 - \theta_l - \frac{c(1-\theta_l)-b}{c-1}\right) Vp^*\right)$$

Differentiating with respect to θ_l we get

$$\frac{1}{2}(p^*)^{-\frac{1}{2}} \left(1 - v\frac{c}{c-1} - Vp^* + Vp^*\frac{c}{c-1}\right) \tag{11}$$

Notice that the above expression is independent of θ_l which implies that we obtain corner solutions. The intuition is that under free trade it is optimal for the economy to specialize as long it is allowed by the budget constraint. When the budget is sufficiently high so that the corresponding constraint is not binding we also allow the government to redistribute any budgetary surplus.

The optimal education policy under trade depends on the sign of the expression in (11) that is in brackets. The expression is equal to 0 when the world price p^* is equal to p^{A*}. The following proposition defines the optimal production patterns under trade.

Proposition 2 *(Optimal Production Patterns) (a) If $p^* > p^{A*}$ it is optimal that the economy produces as much as possible of the high-tech product, X (the budget will not allow complete specialization). (b) If $p^* < p^{A*}$ it is optimal that the economy specializes in the production of the primary commodity, Y.*

Proof. (a) In this case (11) is greater than 0 which implies that θ_l must be set as high as possible. This is because, given the budget constraint, the only way that the economy can increase the production of X is by increasing θ_h that can only be accomplished by increasing θ_l while decreasing θ_m. At the optimum we have $\theta_l = \frac{c-b}{b}, \theta_m = 0$, and $\theta_h = \frac{b}{c}$. (b) In this case (11)

is less than 0 and optimality requires to set θ_l as low as possible so that θ_m is at the maximum possible level. If $b \leqslant 1$, $\theta_m = b$ and if $b > 1, \theta_m = 1$ (budget surplus). ■

Notice that the above optimal production decisions do not depend on the price under autarky. This is in contrast to traditional trade models where the optimal production decisions and hence the patterns of trade depend on the difference between the autarky price and the world price. The reason is that in traditional models the production possibilities frontier is fixed. In the present model, when the government changes the education mix it also changes the production possibilities frontier. We will see shortly that this is crucial for understanding patterns of trade reversals. The following proposition defines the patterns of trade before and after the change in education policy for all possible autarky prices. Let X^- or Y^-denote the good that was exported before the change in education policy and X^+ or Y^+ denote the good that is exported after the change.

Proposition 3 *Optimal trade patterns before and after the change in education policy are as follows:*

Case 1: $b < b_1$

1a: If $p^* > p^A$ *then* X^- *and* X^+

1b: If $p^A > p^* > p^{A*}$ *then* Y^- *and* Y^+

1c: If $p^A > p^{A*} > p^*$ *then* Y^- *and* Y^+

Case 2: $b_1 < b < b_2$

2a: If $p^* > p^A = p^{A*}$ *then* X^- *and* X^+

2b: $p^A = p^{A*} > p^* =$ *then* Y^- *and* Y^+

Case 3: $b_2 < b$

3a: If $p^* > p^{A*} > p^A$ *then* X^- *and* X^+

3b: If $p^{A*} > p^* > p^A$ *then* X^- *and* Y^+

3c: If $p^{A*} > p^A > p^*$ *then* Y^- *and* Y^+

Proof. Consider the patterns of trade before the change in education policy. Then it is clear that when $p^* > p^A$ was optimal for the economy to export the high-tech product X while when $p^* < p^A$ was optimal to export the primary commodity Y. Next, consider the patterns of trade after the change in education policy. With only exception case 1b, they depend on the patterns of specialization derived in proposition 2. In case 1b the education policy is determined by proposition 1 and welfare is maximized when the economy specializes in the high-tech product X. However, the binding budget constraint does not allow the government to further increase

production in that sector and thus it keeps exporting the primary commodity Y. ■

The proposition identifies four type of economies. Sub-cases (1a), (2a) and (3a) identify economies for which it is always optimal to export the high-tech product while sub-cases (1c), (2b) and (3c) identify economies for which it is always optimal to export the primary commodity. In contrast, sub-cases (1b) and (3b) identify economies for which a change in the patterns of trade is optimal.

Moving up the chain: Notice that case 1b is the only instance where it would be optimal for the government to adjust its education policy in order to reverse the patterns of trade so that the economy 'moves up the chain'. What prevents the government from pursuing such a policy is the binding budget constraint. We show below that if the government is able to borrow from abroad it would be beneficial to do so. The following proposition demonstrates that the welfare gains resulting from a change in the patterns of trade will be higher than the welfare loss incurred from a lump-sum tax imposed to finance the loan.

Proposition 4 *Suppose that $p^A > p^* > p^{A*}$. Then it is optimal to finance increased educational expenditures and move up the chain of comparative advantage.*

Proof. We know that in this case it is optimal for the economy to maximize the production of the high-tech product; thus $\theta_l^A = \frac{c-b}{c}, \quad \theta_m^A = 0, \quad and \quad \theta_h^A = \frac{b}{c}$. Define welfare without borrowing as W_n and welfare with increased educational expenditures financed by foreign borrowing as W_b.Using (6) we find that

$$W_n = \frac{1}{2}(p^*)^{-\frac{1}{2}} \left[\frac{c-b}{c} + V\frac{b}{c}p^* \right]$$

The new welfare level after an increase in the budget by Δb that is financed by a lump-sum tax, is equal to

$$W_b = \frac{1}{2}(p^*)^{-\frac{1}{2}} \left[\frac{c-b-\Delta b}{c}(1-\Delta b) + \frac{b+\Delta b}{c}(Vp^* - \Delta b) \right]$$

where the increase in the budget allows for a greater proportion of agents receiving the high level of education. Subtracting the former expression from

the latter we get

$$\begin{aligned} W_b - W_n &= \frac{1}{2}(p^*)^{-\frac{1}{2}}\left[\frac{-\Delta b}{c} - \frac{c-b-\Delta b}{c}\Delta b + \frac{\Delta b}{c}Vp^* - \frac{b+\Delta b}{c}\Delta b\right] \\ &= \frac{1}{2}(p^*)^{-\frac{1}{2}}\left[Vp^* - 1 - c\right] \end{aligned}$$

Given that $p^* > p^{A*}$ the expression above is more than

$$\frac{1}{2}(p^*)^{-\frac{1}{2}}\left[V\frac{1+c(v-1)}{V} - 1 - c\right]$$

which is positive given that $v > 2$. ■

Moving down the chain: Proposition 3 identifies one instance, that is case 3b, where a reversal in the patterns of trade is optimal and feasible without any outside intervention. The government can increase welfare by encouraging producers to specialize in the production of the primary commodity. This is because the world price of the high tech good is relatively low and thus welfare is higher when the economy specializes in the production of the primary commodity. In contrast, when the economy exports the high-tech product the gains from trade are low because of the relatively small differential between the autarky price and the world price.

5.1 Numerical Example

Let W^A, W^X, and W^Y denote aggregate welfare under autarky, aggregate welfare under trade when the economy maximizes the production of the high-skill product X, and aggregate welfare under trade when the economy maximizes the production of the low-skill primary commodity Y. In addition, θ_i^j denote the proportion of type $i(= l, m, h)$ agents given that the economy maximizes production in sector $j(= X, Y)$. We set the following parameter values: $c = 2$, $v = 2.2$, $V = 5$. These values imply that $b_1 = .455$, $b_2 = 1.393$, $p^{A*} = .68$ and that $p^A \in (.44, 1)$. Notice that if the budget is not binding then the autarky price will be equal to .4. The various cases in table 2 below correspond to the cases analyzed in proposition 3. An asterisk denotes optimal choice.

[Please insert Table 2 about here]

6 Conclusion

In the beginning of this paper we asked the following question. Is it ever optimal for a government of a small developing economy that moves from

autarky to trade, and with an initial skill distribution that was optimal under autarky, to change its education policy so that its patterns of trade are reversed? The above analysis suggests that not only is it sometimes optimal to increase educational spending in order to move up the chain, i.e., change from an economy that exports low-skill goods to one that exports high-skill goods, but sometimes it is optimal to move down the chain and switch from exporting high tech goods to exporting low tech goods.

Moving up the chain might require outside help so our results have also some interesting policy implications for the provision of aid. Any economy with a binding budget constraint can benefit from aid in the form of loans or grants to increase educational spending. However, the size of the benefits can differ significantly. For those countries in which it is optimal to move up the chain, relaxing the budget constraint would allow them to switch their patterns of trade and in that case the welfare gains would be very high. In fact, they will be sufficient to cover the cost of financing the loan.

In future work we would like to endogenize the government budget and determine the optimal government policy in the context of a dynamic model.

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Table 1a: High-tech Exports

Country	Year	Sec. Ed.	Tert. Ed.	Broad	Narrow
France	1980	43.0	8.5	56.8	23.7
	1990	48.3	11.4	59.4	28.3
	2000	55.7	18.4	65.7	35.1
Italy	1980	33.3	4.1	48.8	16.7
	1990	40.5	9.0	49.3	18.7
	2000	46.7	14.7	51.6	20.4
Japan	1980	54.3	14.4	72.9	47.1
	1990	65.7	21.2	84.0	49.6
	2000	71.9	24.0	85.1	49.4
Mexico	1980	17.2	5.4	54.3	35.7
	1990	32.6	9.2	67.7	38.1
	2000	40.3	11.3	73.8	53.5
UK	1980	44.7	11.8	65.5	23.2
	1990	52.4	13.9	67.9	27.0
	2000	58.2	19.1	73.1	33.5
US	1980	92.7	29.8	72.5	30.0
	1990	89.6	45.2	73.9	34.4
	2000	89.7	50.1	76.9	40.0

Table 1b: Low-tech Exports

Country	Year	Sec. Ed.	Tert. Ed.	Broad	Narrow
Argentina	1980	26.5	6.1	28.2	3.4
	1990	37.3	12.0	24.8	3.6
	2000	44.6	19.7	34.0	13.4
Chile	1980	34.1	7.2	5.8	1.1
	1990	46.2	12.3	7.2	1.2
	2000	51.8	15.8	12.2	3.1
Colombia	1980	21.3	4.3	19.5	4.6
	1990	26.0	6.9	28.7	1.7
	2000	31.3	9.9	41.1	5.1
Ecuador	1980	23.6	7.6	34.7	2.6
	1990	30.4	17.4	32.8	1.0
	2000	37.0	18.7	22.2	3.5
Guatemala	1980	9.6	2.2	20.4	1.3
	1990	11.1	4.4	14.5	1.0
	2000	15.3	5.8	31.6	2.6
South Africa	1980	28.5	1.4	24.4	4.7
	1990	26.9	3.8	27.7	9.0
	2000	57.9	10.4	37.1	14.2

Table 1c: Moving Up the Chain

Country	Year	Sec. Ed.	Tert. Ed.	Broad	Narrow
Hong Kong	1980	37.6	7.1	37.6	17.1
	1990	53.9	10.6	40.8	19.2
	2000	62.7	15.3	49.0	25.1
Korea	1980	45.8	8.9	29.8	21.5
	1990	67.3	13.4	48.6	32.8
	2000	75.3	25.8	71.8	43.3
Malaysia	1980	21.3	1.4	29.8	23.6
	1990	29.9	2.8	56.6	44.1
	2000	50.5	7.5	75.6	43.5
Singapore	1980	18.0	3.4	71.5	24.8
	1990	36.0	4.7	80.7	28.4
	2000	59.1	10.6	89.4	37.1
Taiwan	1980	32.6	9.3	36.0	21.1
	1990	49.9	12.2	48.7	23.3
	2000	60.2	19.1	55.8	26.6
Thailand	1980	9.7	2.9	11.4	7.3
	1990	15.8	7.8	30.5	15.3
	2000	20.6	11.3	55.8	26.6

Table 1d: Moving Down the Chain

Country	Year	Sec. Ed.	Tert. Ed.	Broad	Narrow
Bulgaria	1980	28.8	6.7		
	1990	40.0	8.9	33.0	6.8
	2000	54.6	16.6	40.5	6.1
Hungary	1980	30.6	7.0	4.1	0.5
	1990	39.1	10.1	4.2	0.2
	2000	46.7	12.0	18.4	2.7
Poland	1980	39.6	5.7	61.5	22.7
	1990	55.7	7.9	43.7	14.8
	2000	60.6	11.1	40.5	26.0
Romania	1980	44.2	5.2		
	1990	70.1	6.9	55.9	15.9
	2000	72.9	8.9	28.1	12.1

Table 1e: China and India

Country	Year	Sec. Ed.	Tert. Ed.	Broad	Narrow
China	1980	22.7	1.0		
	1990	36.4	2.0	33.1	15.7
	2000	38.4	2.7	41.2	21.0
India	1980	16.2	2.5	16.4	6.5
	1990	18.2	4.1	21.2	4.7
	2000	22.2	4.8	20.6	5.4

Table 2: Optimal Education Policies and Patterns of Trade

1	$b = .4$	$p^A = .8$	$\theta_l^A = .8$, $\theta_m^A = 0$, $\theta_h^A = .2$	$W^A = 0.89$
1a*	$b = .4$	$p^* = 1$	$\theta_l^X = .8$, $\theta_m^X = 0$, $\theta_h^X = .2$	$W^X = 0.9$
1a	$b = .4$	$p^* = 1$	$\theta_l^Y = .6$, $\theta_m^Y = .4$, $\theta_h^Y = 0$	$W^Y = 0.74$
1b*	$b = .4$	$p^* = .7$	$\theta_l^X = .8$, $\theta_m^X = 0$, $\theta_h^X = .2$	$W^X = 0.90$
1b	$b = .4$	$p^* = .7$	$\theta_l^Y = .6$, $\theta_m^Y = .4$, $\theta_h^Y = 0$	$W^Y = 0.88$
1c	$b = .4$	$p^* = .5$	$\theta_l^X = .8$, $\theta_m^X = 0$, $\theta_h^X = .2$	$W^X = 0.92$
1c*	$b = .4$	$p^* = .5$	$\theta_l^Y = .6$, $\theta_m^Y = .4$, $\theta_h^Y = 0$	$W^Y = 1.05$
2	$b = 1$	$p^A = .68$	$\theta_l^A = .32$, $\theta_m^A = .36$, $\theta_h^A = .32$	$W^A = 1.33$
2a*	$b = 1$	$p^* = .8$	$\theta_l^X = .5$, $\theta_m^X = 0$, $\theta_h^X = .5$	$W^X = 1.40$
2a	$b = 1$	$p^* = .8$	$\theta_l^Y = 0$, $\theta_m^Y = 1$, $\theta_h^Y = 0$	$W^Y = 1.23$
2b	$b = 1$	$p^* = .4$	$\theta_l^X = .5$, $\theta_m^X = 0$, $\theta_h^X = .5$	$W^X = 1.18$
2b*	$b = 1$	$p^* = .4$	$\theta_l^Y = 0$, $\theta_m^Y = 1$, $\theta_h^Y = 0$	$W^Y = 1.74$
3	$b = 1.45$	$p^A = .54$	$\theta_l^A = 0$, $\theta_m^A = .55$, $\theta_h^A = .45$	$W^A = 1.66$
3a*	$b = 1.45$	$p^* = 1$	$\theta_l^X = .275$, $\theta_m^X = 0$, $\theta_h^X = .725$	$W^X = 1.95$
3a	$b = 1.45$	$p^* = 1$	$\theta_l^Y = 0$, $\theta_m^Y = .55$, $\theta_h^Y = .45$	$W^Y = 1.73$
3b	$b = 1.45$	$p^* = .60$	$\theta_l^X = .275$, $\theta_m^X = 0$, $\theta_h^X = .725$	$W^X = 1.58$
3b*	$b = 1.45$	$p^* = .60$	$\theta_l^Y = 0$, $\theta_m^Y = 1$, $\theta_h^Y = 0$	$W^Y = 1.71$
3c	$b = 1.45$	$p^* = .45$	$\theta_l^X = .275$, $\theta_m^X = 0$, $\theta_h^X = .725$	$W^X = 1.42$
3c*	$b = 1.45$	$p^* = .45$	$\theta_l^Y = 0$, $\theta_m^Y = 1$, $\theta_h^Y = 0$	$W^Y = 1.97$

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