

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 it is never optimal to 'move up the skills chain' although a move in the opposite direction might be optimal. However, if the gains of trade sufficiently relax the budget constraint a trade pattern reversal from low-skill to high-skill export goods can be optimal.

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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 reversals. Good examples are India and China where there is plenty of evidence of the desire of their governments to help produce to ‘move up the value chain’.¹²

Intuitively, these policies cannot be globally optimal. As long as there is 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 constrained their choices, understanding where their comparative advantage lies is important. 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, 2006) examine the relationship between the distribution of endowments and the patterns of trade. In this paper, we move one step back by considering how the distribution of endowments arises as a consequence of human capital accumulation.

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 deci-

¹This 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 low-skill intensive goods are substituted by high-skill intensive ones.

sions on human capital accumulation are taken by agents according to their level of ability.³ In our model all agents are identical. 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 this work is more relevant for developing nations. For these nations the allocation of a constraint government budget is a far more important determinant of the overall distributions of education attainment, skills and, to take it one step further, income, than individual human capital accumulation decisions.⁴

Our economy comprises of two sectors, namely, 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 his sector of employment and his 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. Last, we allow the government to adjust its education policy and we derive the new patterns of trade.⁵⁶

We find that if the government's education budget is not binding trade pattern reversals are never optimal which suggests that reversals might be more common among developing economies. Depending on the terms of trade, a move up the skills chain can be optimal, however, when this is the case a reversal in the patterns of trade is also infeasible exactly because the budget does not allow any change in education policy. However, our set-up suggests that if the initial gains of trade are sufficiently high and thus

³The 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 (2006). 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..

⁴Our 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 government policies would still determine 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.

⁵In a recent paper, Egger, Egger, Falkinger and Grossmann (2005) follow a similar procedure to consider how optimal individual educational choice is affected by integration of capital markets rather than international trade.

⁶Our focus is on long-term trends and thus we have ignored any short-term adjustment costs. For some potential pitfalls of our approach, see Davidso and Matusz (2002, 2004).

relax the budget constraint then a reversal of exports from low-skill goods to high-skill goods can become optimal. This finding suggests that economies that move up the chain must be economies that grow fast. We also find that reversals in the opposite direction can also be optimal and that such reversals are not budget restrained.

2 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 $v(> 1)$ units in either sector.⁷ A 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 .⁸ 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. We impose the following restrictions on the parameters of the model:

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

Condition 2 $b < c$

The first condition implies that investment in the high level of education is efficient. The second condition implies that the government cannot

⁷Setting 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.

⁸Given that the size of the budget is exogenous the exact unit of account is immaterial. What matters is the size of the budget relative to the cost of education.

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:

$$\theta_l + \theta_m + \theta_h = 1 \quad (1)$$

and

$$b \geq \theta_m + c\theta_h \quad (2)$$

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

All agents have identical Cobb-Douglas preferences specified as:

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

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

2.1 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 line 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 workers first 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 .

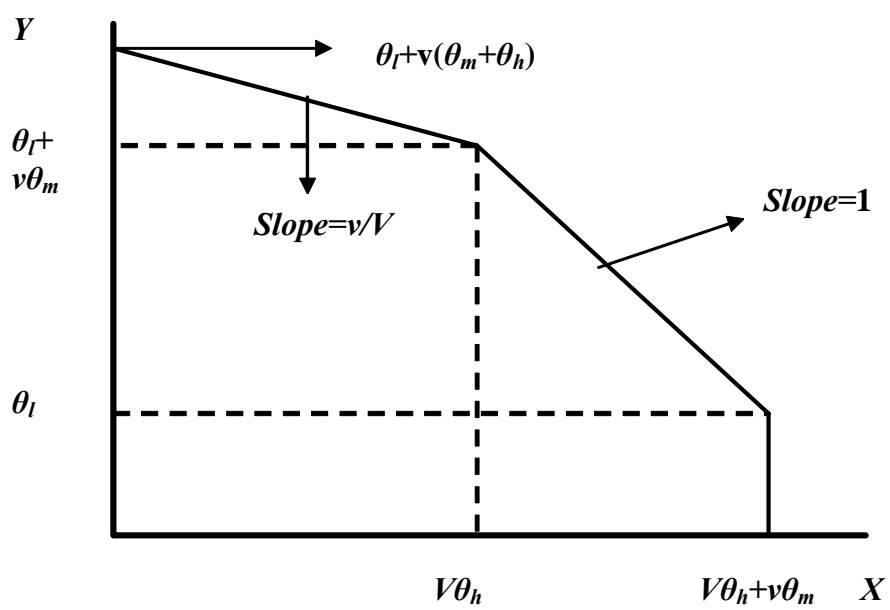


Figure 1: Production Possibilities Frontier

3 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 3 *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 with $\frac{d\theta_m}{d\theta_h} = -\frac{V}{v}$. 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:

$$X_i = \frac{I_i^A}{2p^A}, \quad Y_i = \frac{I_i^A}{2} \quad (4)$$

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:

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

and

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

Solving either of the above market clearing conditions for the equilibrium autarky price we get:

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

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

3.1 Optimal education policy

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

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

subject to (5),

$$\theta_h = 1 - \theta_l - \theta_m \quad (7)$$

and

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

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

The optimal proportion of type l workers under autarky is:

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

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:

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

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 the size of the budget, 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 decreasing as the budget increases. When the budget is sufficiently low we have $\theta_m^A = 0$. In that case

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

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 increase while the proportion of type l workers decrease. 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 than 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. In the following section we show that if $b \geq \frac{1}{2}(1+c)$ the size of the budget constraint under autarky is not binding.

4 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.

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

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

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

Differentiating with respect to θ_l we get

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

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

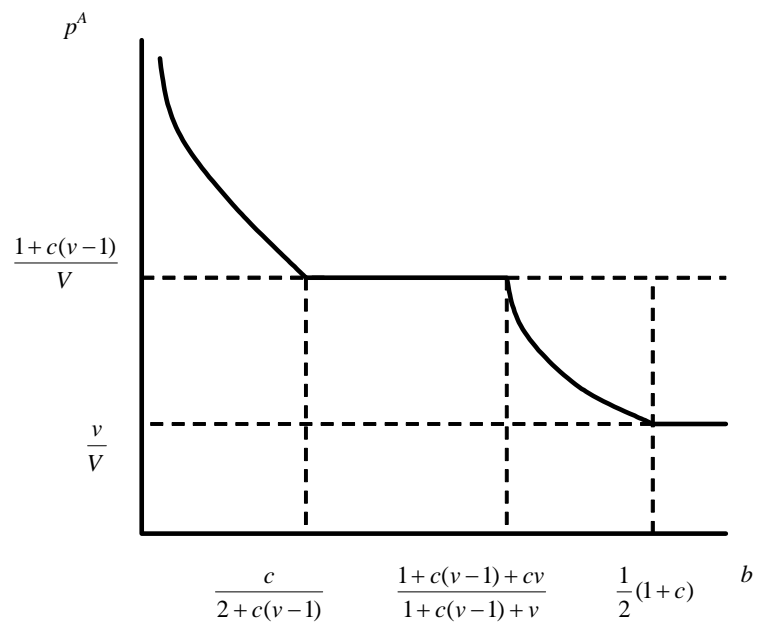


Figure 2: Autaky Price Function

for the economy to specialize as long it is allowed by the budget constraint. When the budget is sufficiently high 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. Setting it equal to 0 and solving for p^* we obtain a threshold level for the world price equal to p^{A*} . The following proposition defines the optimal production patterns under trade.

Proposition 4 (*Optimal Production Patterns*) (a) If $p^* > p^{A*}$ it is optimal that the economy will produce 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 must only produce 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 also 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 $b \leq 1$, $\theta_m = b$ 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 exported after the change.

Proposition 5 *When the economy is open the optimal production and trade patterns 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: $p^A > p^* = p^{A*}$ 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 budget constraint does not allow the government to further increase production in that sector and thus it keeps exporting the primary commodity Y . ■

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’. However, the low budget does not allow the government to pursue such a policy. By setting p^{A1} equal to p^* and solving for b we find that in order for the government to reverse the patterns of trade the budget must be higher than $\frac{c}{p^*V+1}$. Even if the government cannot achieve a reversal immediately after the economy begins to trade it might be able to do so later. This will be the case if the gains of trade sufficiently relax the budget constraint.

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. The government can increase welfare by encouraging producers to specialize in the production of the primary commodity. This is because the budget constraint does not allow the economy to take full advantage of the fact that its autarky price is lower than the world price and thus the gains of trade when it exports the high-tech product X are low. Notice that in this case the difference between the two prices is relatively small. It turns that the government can boost the gains of trade by specializing in the primary commodity.

4.1 Numerical Example

Let W^A , W^X , and W^Y denote aggregate welfare under autarky, under trade when the economy maximizes the production of the high-skill product X , and 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: $c = 2$, $v = 2$, $V = 5$. These values imply that $b_1 = .5$, $b_2 = 1.4$, $p^{A*} = .6$ and that $p^A \in (.4, 1)$. Notice that if the budget is not binding then the autarky price will be equal to .4. The various cases in table 1 below correspond to the cases analyzed in proposition 3. An asterisk denotes optimal choice.

Table 1: Optimal Education Policies and Patterns of Trade

1	$b = .4$	$p^A = .8$	$\theta_l^A = .8, \theta_m^A = 0, \theta_h^A = .2$	$W^A = 1.79$
1a*	$b = .4$	$p^* = 1$	$\theta_l^X = .8, \theta_m^X = 0, \theta_h^X = .2$	$W^X = 1.8$
1a	$b = .4$	$p^* = 1$	$\theta_l^Y = .6, \theta_m^Y = .4, \theta_h^Y = 0$	$W^Y = 1.4$
1b*	$b = .4$	$p^* = .7$	$\theta_l^X = .8, \theta_m^X = 0, \theta_h^X = .2$	$W^X = 1.79$
1b	$b = .4$	$p^* = .7$	$\theta_l^Y = .6, \theta_m^Y = .4, \theta_h^Y = 0$	$W^Y = 1.67$
1c	$b = .4$	$p^* = .5$	$\theta_l^X = .8, \theta_m^X = 0, \theta_h^X = .2$	$W^X = 1.84$
1c*	$b = .4$	$p^* = .5$	$\theta_l^Y = .6, \theta_m^Y = .4, \theta_h^Y = 0$	$W^Y = 1.98$
2	$b = 1$	$p^A = .6$	$\theta_l^A = \frac{1}{3}, \theta_m^A = \frac{1}{3}, \theta_h^A = \frac{1}{3}$	$W^A = 2.58$
2a*	$b = 1$	$p^* = .8$	$\theta_l^X = .5, \theta_m^X = 0, \theta_h^X = .5$	$W^X = 2.79$
2a	$b = 1$	$p^* = .8$	$\theta_l^Y = 0, \theta_m^Y = 1, \theta_h^Y = 0$	$W^Y = 2.24$
2b	$b = 1$	$p^* = .4$	$\theta_l^X = .5, \theta_m^X = 0, \theta_h^X = .5$	$W^X = 1.58$
2b*	$b = 1$	$p^* = .4$	$\theta_l^Y = 0, \theta_m^Y = 1, \theta_h^Y = 0$	$W^Y = 3.16$
3	$b = 1.45$	$p^A = .48$	$\theta_l^A = 0, \theta_m^A = .55, \theta_h^A = .45$	$W^A = 3.15$
3a*	$b = 1.45$	$p^* = 1$	$\theta_l^X = .275, \theta_m^X = 0, \theta_h^X = .725$	$W^X = 3.9$
3a	$b = 1.45$	$p^* = 1$	$\theta_l^Y = 0, \theta_m^Y = .55, \theta_h^Y = .45$	$W^Y = 3.35$
3b	$b = 1.45$	$p^* = .55$	$\theta_l^X = .275, \theta_m^X = 0, \theta_h^X = .725$	$W^X = 3.06$
3b*	$b = 1.45$	$p^* = .55$	$\theta_l^Y = 0, \theta_m^Y = .1, \theta_h^Y = 0$	$W^Y = 3.3$
3c	$b = 1.45$	$p^* = .45$	$\theta_l^X = .275, \theta_m^X = 0, \theta_h^X = .725$	$W^X = 2.84$
3c*	$b = 1.45$	$p^* = .45$	$\theta_l^Y = 0, \theta_m^Y = 1, \theta_h^Y = 0$	$W^Y = 3.65$

4.2 Discussion

Education policies affect an economy's skill distribution, its competitiveness with the rest of the world and, as a consequence, its patterns of trade. Then a country's optimal education policy would depend on whether it is a closed economy or one that is open to trade.

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 as long as the budget remains fixed it will never be optimal to change from an economy that exports low-skill goods to one that exports high-skill goods.

However, such a conclusion is at odds with observation. There are many governments that have pursued education policies with the aim to affect their economies patterns of trade. Are these policies sub-optimal? The answer is clear negative, especially, given that many such economies have enjoyed the benefits of economic development as a result of the change in their patterns of trade.

As an economy moves from autarky to trade its real income grows. As long as government revenues rise with income the government budget will increase and offer the opportunity to the government to allocate more funds on education. Then, policies that are not feasible under autarky because of budgetary constraints can become available as the economy reaps the benefits of trade. This argument suggests that the combination of trade and economic development can account for successful policy reversals that move the economy up the skill chain. Our model also suggests that under certain circumstances reversals in the opposite direction might be optimal.

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