

International Trade and the Accumulation of Human Capital

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Changes in the terms of trade affect both the incentives and the ability of individuals to purchase education in a credit-constrained economy. A model is developed that shows how individual decision-making is affected in a small economy when it opens up to trade. Empirical results indicate that credit constraints are an important factor influencing school enrollment rates, particularly in low income countries. As a result, countries with low human capital stocks tend to increase their accumulation of human capital with increased trade. The response in high income countries is more muted.

1. Introduction

Heckscher-Ohlin-Samuelson (HOS) trade theory uses the concept of comparative advantage based on factor endowments as a rationale for international trade. Under free trade, it predicts equalization of factor prices across countries and, when trade is liberalized, the HOS model predicts increases in returns to the relatively abundant factor of production in each country. Straightforward dynamic adaptations of these static results permit one to conclude that, as the incentive to accumulate the relatively abundant factor in each country increases, endowments of factor supplies should diverge even further as a result of trade. When human capital is considered as a factor of production, this result implies that trade should cause countries to have diverging stocks of human capital.

This prediction is not consistent with empirical observations. In spite of increasing levels of trade, the world distribution of human capital is becoming more, rather than less, equal. In 1960, the standard deviation of the log of the average years of education across 88 countries was 0.91. By 1985, this measure of inequality had decreased to 0.61.¹ This paper reconciles this observation with the traditional theory of comparative advantage by examining how trade's effect on the distribution of income within each country may also play a role in influencing the accumulation of human capital.² Empirical evidence is presented that shows that international trade has a positive effect on the accumulation of human capital in countries in which human

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¹ Alternative measures of the dispersion of the world distribution of education yield similar results. For example, the coefficient of variation for the average years of education across these same countries decreased from 0.71 in 1960 to 0.51 in 1985 (Barro and Lee 1993).

² The importance of income distribution and credit market imperfections on the accumulation of the factors of production has been examined thoroughly in the growth literature. See, for example, Galor and Zeira (1993), who show how the initial distribution of wealth can affect human capital accumulation, and Perotti (1994), who provides empirical support for the hypothesis that credit market imperfections are a constraint on investment.

capital is a relatively scarce factor of production. In countries in which human capital is relatively abundant, the effect is much smaller or even negative.

Because the model in this paper links the accumulation of human capital to the changes in the distribution of income that occur as a result of trade, it is related to recent work that has examined the role that international trade has played in increasing the wage gap between skilled and unskilled workers in the U.S. Many culprits have been examined in recent literature including technological change, decreased power of unions, the reduced supply of college-educated entrants into the labor market, and immigration of low-skilled workers.³ Although the debate about the relative importance of each of these factors is still open, there has been some evidence amassed in favor of the idea that trade, through the Stolper-Samuelson effects on wages, has contributed to the growing income inequality in the U.S. In particular, Leamer (1996) counters the argument that the volume of trade in the U.S. is not large enough to produce the observed changes in income inequality by emphasizing that it is the wage of the marginal worker that matters. He shows that increased competition from developing countries has had an important impact on the U.S. labor market, reducing the wages of low-wage workers as much as 2% per year over the 1970 to 1990 period. Murphy and Welch (1991) show that, in the U.S., higher trade deficits in durable goods are correlated with a larger wage gap between skilled and unskilled workers, and Borjas and Ramey (1994) show that, among alternative explanations for the growing wage gap, only net imports of durable goods as a percent of GDP is cointegrated with the trend in wage inequality from the early 1960s to the late 1980s. In addition, Feenstra and Hanson (1995) find that between 15% and 33% of the increases in relative wages of nonproduction workers in the U.S. during the period 1979 to 1987 can be attributed to increasing imports. Although it is likely that the increasing disparity between skilled and unskilled wages is a result of a combination of economic factors, this work does provide evidence that international trade does affect wages of the skilled and unskilled in the manner predicted by HOS theory.

This paper is also related to recent work on international trade and long-run growth. Many of the recent studies attempting to link trade and long run growth focus on the role that international trade plays in the transfer of technology from more to less developed countries and on the increased profits offered by larger markets created by trade. (See, e.g., Grossman and Helpman 1990, 1991.) Much of the current work in this area has not focused on trade's effect on the accumulation of physical or human capital, even though the importance of a country's physical and human capital savings rates has been shown to be an important determinant of growth. In addition, a robust direct relationship between the level of trade and long-run growth rates has not been established. (See Levine and Renelt [1992] for tests of robustness and other empirical references.) The focus in the model of this paper is slightly different from that of previous work, making the point that trade may not affect all countries in the same way and offering an explanation as to why a direct relationship between trade and growth has been difficult to uncover empirically.

The importance of human capital in explaining patterns of trade was first invoked as an explanation for the Leontief paradox—the observation that the United States, a relatively capital abundant economy, exported labor intensive goods. In the early 1950s, Leontief (1956) tried to resolve this paradox by arguing that because U.S. workers were more productive than foreigners, it was legitimate to reduce the U.S. capital-to-labor ratio before assessing the comparative

³ See Burtless (1995) for a survey of this literature.

advantage of the U.S. Later authors used the theory of human capital to formalize this thinking by recognizing that U.S. exports were actually human-capital intensive and thus the U.S. was exporting the good in which it had a comparative advantage.

Findlay and Kierzkowski (1983) extend the HOS theory to incorporate the accumulation of human capital into a dynamic two-good model using skilled and unskilled labor as the factors of production. Unskilled labor becomes skilled labor through investment of physical resources and time in the educational sector. Because credit markets are perfect in their model, the amount of education purchased depends solely on the returns to skilled and unskilled labor. As a result, when trade alters the payments to skilled and unskilled labor in favor of the relatively abundant factor, incentives to purchase education become more disparate, and the country with the higher initial level of human capital accumulates more human capital, whereas the country with the low initial level of human capital accumulates less.

More recently, Davis and Reeve (1997) and Stokey (1996) have reexamined this issue in a different light. Davis and Reeve (1997) build on the Findlay and Kierzkowski framework to examine human capital accumulation in an open economy when there are differences in labor market institutions between the trading economies. They show how the introduction of a minimum wage and unemployment can explain differences in the skill premium, unemployment, and the growth rate of skill accumulation. Stokey (1996) has a different perspective, focusing on the increase in capital flows that occurs when a country integrates into the world economy. In her work, as physical capital accumulates, the incentive to accumulate human capital increases, causing increased openness to be associated with greater accumulation of human capital. Though she does not empirically test her model, it arrives at a very different conclusion from that of Findlay and Kierzkowski—all countries should have increased human capital stocks as they become more open.

This paper makes yet a third empirical prediction—human capital accumulation will increase as a result of trade in some, but perhaps not all countries. Contrary to the predictions of Findlay and Kierzkowski (1983), if trade's effect on income is strong enough, low human capital economies, exporting the unskilled-intensive good can actually see an increase in human capital accumulation.

The model in this paper is most similar in spirit to that of Findlay and Kierzkowski (1983). However, in this model, credit markets are not perfect, and the distribution of income affects a country's stock of human capital. In the economy described below, parents can increase the incomes of their children by investing in their children's education. However, because parents care about their own consumption as well as the future income of their children, there is a minimum level of income that parents must have before they begin to invest in their children's education.

International trade between countries with different levels of human capital affects individuals within these two countries in two opposing ways. In the country with the higher human capital stock, the incentive to accumulate human capital increases, but parents with low skills (and low incomes) experience a reduction in their incomes. In the country with the lower human capital stock, the incentive to accumulate human capital decreases, but parents with low skills now experience an increase in their incomes. If the effect of the change in the low-skilled parents' incomes is strong enough, this model provides the result that trade increases the accumulation of human capital in the country with low human capital. The accumulation of human capital in the country with a high initial level of human capital may also increase or decrease, depending again on the strength of the income and incentive effects.

Because the model does not provide unambiguous predictions, the actual effect of trade on the accumulation of human capital then becomes a question to be answered empirically. Empirical results discussed in section 3 suggest that the effect of the change in incomes is in fact more important than the effect of the change in the returns to education, particularly in less developed countries. Increases in openness have a positive effect on enrollment ratios in countries with lower human capital stocks and a very small or negative effect on countries with higher human capital stocks. This result explains why trade has not caused increased dispersion of levels of education, as the unmodified version of HOS theory would predict.

To highlight the mechanisms by which trade affects the accumulation of human capital, section 2 of this paper lays out a stylized overlapping generations model that describes the basic elements of production and individual decision-making. Section 3 discusses empirical tests of the relationship between changes in openness to trade and school enrollment ratios, and section 4 concludes.

2. Theoretical Framework

Production

This section offers a simple model that provides an analytical framework for considering the effects of trade on human capital accumulation. Let the production of the two goods in this economy, good X and good Z, be described by a constant returns to scale production technology that uses human capital, H, and unskilled labor, L. The production technology for good Z is more human capital intensive than the technology of good X for any relative price. In addition, assume prices of both goods are within an interval that allows both goods to be produced in equilibrium. There is no population growth and the size of the population is normalized to 1.

Galor (1992) analyzes production in a similar two-sector overlapping generations economy and shows that the Stolper-Samuelson relationships apply: an increase in the relative price of the unskilled-labor-intensive good (good X) increases the wages paid to unskilled labor, increases the ratio of unskilled labor wages to skilled labor wages, and, moreover, the elasticity of the change in the unskilled wage with respect to price is greater than one. Thus, an increase in the price of the unskilled-labor-intensive good increases the real income of a unit of unskilled labor. Conversely, an increase in the price of the skilled-labor-intensive good increases the real income of a unit of skilled labor. The model below uses this result as a starting point to illustrate how the change in the price of goods that result from increased openness to trade can affect the accumulation of human capital.

Accumulation of Human Capital

Individuals of differing abilities live for two periods in overlapping generations. In the first period of life, they can invest in education, which costs \bar{e} , if their parents provide them sufficient funds for this purpose. In the adult portion of their life, individuals supply their $a_{i,t}$ units of unskilled labor or their $a_{i,t}$ units of skilled labor inelastically to the production sector, where $a_{i,t}$ represents the ability of individual i at time t . Let the distribution of ability throughout the population, $\psi(a)$, be invariant through time, have an upper and lower bound \bar{a} , $\underline{a} > 0$, and let

$E(a) = 1$.⁴ In the second period, individuals also provide financial support for their children and consume.⁵

If credit market imperfections prohibit educational loans, then individuals' wages as adults will depend on whether their parents have provided them with enough funds to obtain an education.⁶ In particular, individual i 's income in the adult portion of life will equal

$$y_{i,t+1} = \begin{cases} a_{i,t+1}w_{u,t+1} & \text{if parents have not provided } \bar{e} \\ a_{i,t+1}w_{e,t+1} & \text{if parents have provided } \bar{e} \end{cases}$$

where $w_{u,t+1}$ is the wage to the uneducated worker of average ability who provides unskilled labor in period $t + 1$ and $w_{e,t+1}$ is the wage to the educated worker of average ability who provides human capital.

Individuals gain utility from their own consumption as well as the expected income of their children. For simplicity, I assume that ability is not revealed until individuals become adults and, thus, parents make decisions based on the expected ability of their children, $E(a_{i,t+1}) \equiv 1$. In other words, parents gain utility from the expected income of their children, $E(y_{i,t+2})$.

This bequest motive differs slightly from two other commonly used bequest motives. Under the "altruistic" bequest motive, parents' utility increases with the utility of their children, whereas under the "joy of giving" bequest motive, parents' utility increases with the size of the bequest. The motive in this model closely resembles the altruistic motive because there is a monotonic relationship between the utility and income of children. The specification used here, however, has two advantages. First, parents' decisions are based on a variable that can be observed more easily, their children's income; and, second, parents' decisions are simplified because they only have to look forward one period.

The utility function for individual i born at time t takes the form

$$U = \alpha \ln(x_{t+1}) + \beta \ln(z_{t+1}) + (1 - \alpha - \beta)\ln(E[y_{t+2}]),$$

where x_{t+1} is the amount of good x consumed, z_{t+1} is the amount of good z consumed, y_{t+2} is the income of the individual's child, $\alpha, \beta \in (0,1)$, and $1 - \alpha - \beta > 0$.⁷ Normalize the price of good z to one and let p_t be the relative price of x_t . Then, given income and prices, and noting that $E(a_{i,t+1}) = 1$, individuals maximize utility subject to the following sets of constraints.

If the child is uneducated

- (i) $w_{u,t+2} = E(y_{t+2})$
- (ii) $p_{t+1}x_{t+1} + z_{t+1} \leq y_{t+1}$

and if the child is educated

⁴ I thank two anonymous referees for pointing out the importance of heterogeneity in the population in explaining the empirical results in the next section.

⁵ Restricting consumption to the second period simplifies the analysis but does not materially affect its major conclusions.

⁶ Although the model in this paper uses an explicit out-of-pocket expense for education, one could also achieve similar results in a model in which children worked in the first period and the cost of education was only the opportunity cost of foregone wages. The formulation used above, with the indivisible cost of education, is similar in spirit to the one introduced in Galor and Zeira (1993) and later used by Fernandez and Rogerson (1995) and Iyigun (in press), among others.

⁷ This specific form is chosen for analytical convenience. The results presented are robust to alternative specifications. As will become clear in the analysis that follows, the essential element of this utility function is that parents care about their own consumption as well as the income of their children.

$$(i) \quad w_{e,t+2} = E(y_{t+2})$$

$$(ii) \quad p_{t+1}x_{t+1} + z_{t+1} \leq y_{t+1} - \bar{e}.$$

These conditions generate the following values for x_t and for z_t

$$x_t = \begin{cases} \frac{\alpha y_t}{p_t(\alpha + \beta)} & \text{when } y_t \leq y_t^* \\ \frac{\alpha(y_t - \bar{e})}{p_t(\alpha + \beta)} & \text{when } y_t > y_t^* \end{cases} \quad z_t = \begin{cases} \frac{\beta y_t}{(\alpha + \beta)} & \text{when } y_t \leq y_t^* \\ \frac{\beta(y_t - \bar{e})}{(\alpha + \beta)} & \text{when } y_t > y_t^* \end{cases}$$

where

$$y_t^* = \frac{\bar{e}w_{e,t+1}^\varphi}{w_{e,t+1}^\varphi - w_{u,t+1}^\varphi}, \quad \text{where } \varphi \equiv \frac{1 - \alpha - \beta}{\alpha + \beta} \quad (1)$$

is the threshold level of parents' income beyond which parents purchase education for their children. In other words, at y^* , a parent's utility from having educated children is equal to the parent's utility from having uneducated children. Note that y^* decreases as the incentive to invest in education (the disparity between the educated and uneducated wage) increases.

One can see that this model gives rise to two types of families—those with incomes above y^* that have positive investment in human capital and families with incomes below y^* that have no human capital investment. Thus, in any period t , given the structure of wages in the following period, the fraction of children getting an education, λ_t , depends on the distribution of income, $g_t(y)$ in that period:

$$\lambda_t = \int_{y_t^*}^{\infty} g_t(y) dy \quad (2)$$

where $g_t(y)$ is determined by λ_{t-1} and $\psi(a)$, and $g_0(y)$ is given. Specifically,

$$g_t(y) = \lambda_{t-1} \psi\left(\frac{y}{w_{e,t}}\right) \frac{1}{w_{e,t}} + (1 - \lambda_{t-1}) \psi\left(\frac{y}{w_{u,t}}\right) \frac{1}{w_{u,t}} \equiv Y(y, \lambda_{t-1}; w_e, w_u).$$

As can be seen by combining Equations 1 and 2, the accumulation of education is influenced by the benefits of education relative to its costs. When the parent's income is relatively low, the benefits of education (the discrepancy between wages to educated and uneducated workers) must be high to generate a value of y^* that is lower than the parent's income. Thus, an increase in parents' income or an increase in the incentives to become educated (a lower y^*) could generate larger school enrollments.

In a small open economy in which both goods are produced, wages are determined in the world market. Thus, given wages, a steady-state equilibrium is one in which the percent of workers who are educated is constant through time. Specifically, let

$$\lambda(\lambda_{t-1}; w_e, w_u) \equiv \lambda_t = \int_{y_t^*}^{\infty} Y(y, \lambda_{t-1}; w_e, w_u) dy.$$

Then we can define the steady-state enrollment rate as

$$\bar{\lambda} = \lambda(\bar{\lambda}; w_u, w_e)$$

In the steady state, the aggregate enrollment rate does not change, but individual families

may experience changes in their educational status from one generation to the next. Steady states can be classified into two types—those in which families experience no educational mobility and those in which there is intergenerational class mobility.⁸

When there is no mobility, there are three possible types of steady states. Either

$$\begin{aligned}
 \text{(i)} \quad & \lambda_t = \lambda_{t-1}; \quad 0 < \lambda_{t-1} < 1 \quad \text{if } \bar{a}w_u \leq y^* \leq \underline{a}w_e \\
 \text{(ii)} \quad & \lambda_t = \lambda_{t-1} = 0 \quad \text{if } \bar{a}w_e \leq y^*, \quad \text{or} \\
 \text{(iii)} \quad & \lambda_t = \lambda_{t-1} = 1 \quad \text{if } \underline{a}w_u \geq y^*.
 \end{aligned} \tag{3}$$

In case i, the discrepancy between wages to educated and uneducated parents is so large that even the highest ability uneducated parents cannot afford to purchase education for their children, but the lowest ability educated parents can afford education. As a result, children of educated parents always get an education, whereas children of uneducated parents never do. In case ii, wages paid to even the highest ability educated parents are not high enough to allow their children to become educated and nobody purchases an education. Finally, in case iii, wages to even the lowest ability uneducated parents are high enough so that they purchase education for their children and everybody becomes educated.⁹

When there is mobility in the steady state, the number of downwardly mobile families (educated parents with uneducated children) must equal the number of upwardly mobile families (uneducated parents with educated children). Define \bar{a} to be the lowest level of ability for which uneducated parents purchase an education for their children, and define \hat{a} to be the cutoff level of ability below which educated parents do not purchase education for their children. Then, $\bar{a}w_u = \hat{a}w_e = y^*$, and a steady state with mobility exists if $a < \hat{a} < \bar{a} < \bar{a}$.

In the steady state,

$$(1 - \lambda) \int_{\bar{a}}^{\hat{a}} \psi(a) da = \lambda \int_a^{\hat{a}} \psi(a) da.$$

Solving for the steady state level of λ yields

$$\lambda = \frac{\int_{\bar{a}}^{\hat{a}} \psi(a) da}{\int_a^{\hat{a}} \psi(a) da + \int_{\bar{a}}^{\hat{a}} \psi(a) da}. \tag{4}$$

One can easily see, from Equation 4, that greater upward mobility increases the steady-state enrollment rate, whereas greater downward mobility decreases it.

Thus, given wages, a cost of education, and a distribution of ability, the economy will go to either one of the three steady states with no mobility or the steady state with some mobility.

⁸ Owen and Weil (1998) examine a similar model in which wages are endogenous (as they would be in a closed economy version of the model above) and show that multiple equilibria are possible: steady states with and without mobility will exist as long as the cost of education is not too high.

⁹ Only the cases in which $w_e > w_u$ are considered here. We can rule out $w_u \geq w_e$ as long as, in the rest of the world, there is a cost to education. We could also rule out cases ii and iii of Equation 3 if both uneducated and educated labor were necessary for production. In this case, the wages determined in the rest of the world would not be consistent with either no educated workers or no uneducated workers.

In case i of the no-mobility steady states, the initial distribution of skills, λ_0 , determines all subsequent distributions—children of uneducated parents will never get educated and children of educated parents will always get educated. However, in all other cases, initial conditions do not matter. When the cost of education is the same as in the rest of the world, the distribution of education within any one small open economy will match the distribution of education in the world economy.

Impact of Trade

Though highly stylized, the model above can be used to examine how an unexpected permanent change in the terms of trade (e.g., removal of tariffs) will affect the accumulation of human capital in a small open economy. As is customary in models of trade, I assume that, while goods flow freely between countries, the two factors of production do not cross international boundaries and there is no international lending or borrowing. Thus, trade causes a change in the relative price of goods, and through the Stolper-Samuelson relations, in the real income of skilled and unskilled labor.

The model highlights two factors that determine human capital investment—parents' income and relative wages. Both of these factors are influenced by the changing relative wages resulting from trade. For example, consider two countries, A and B. In Country A, unskilled labor is relatively abundant and in Country B, educated labor is relatively abundant, that is, $\lambda_A < \lambda_B$. Consequently, when Country A opens up to trade, it exports the unskilled-labor-intensive good and per capita income increases, but unskilled labor takes the greater share of the increase. Therefore, the increased incomes of uneducated parents could result in more children of uneducated parents getting an education. However, in Country A, relative wages to the unskilled also increase, decreasing the incentive to accumulate human capital (i.e., raising y^*), possibly preventing the children of uneducated parents from obtaining an education, even though their parents are now richer. Conversely, a relatively skilled parent in Country A will see a decrease in income and incentive for educating children.

We can see what happens to the accumulation of education in Country A by using Equation 4 and examining what happens to upward and downward mobility by determining what happens to \bar{a} and \hat{a} .¹⁰ Rewriting \bar{a} , the threshold level of ability above which children of uneducated parents receive education

$$\bar{a} = \frac{y^*}{w_u} = \frac{\bar{e}w_e^\varphi}{w_u(w_e^\varphi - w_u^\varphi)}$$

and noting that

$$d\bar{a} = \frac{\partial \bar{a}}{\partial w_u} dw_u + \frac{\partial \bar{a}}{\partial w_e} dw_e \quad (5)$$

we can determine whether upward mobility increases or decreases in the less developed economy when it opens up to trade (giving a positive dw_u and a negative dw_e) by recognizing that

$$\frac{\partial \bar{a}}{\partial w_e} = -\frac{\varphi \bar{e} w_e^{2\varphi}}{(w_u(w_e^\varphi - w_u^\varphi))^2} \left(\frac{w_u}{w_e}\right)^{\varphi+1} \quad \frac{\partial \bar{a}}{\partial w_u} = -\frac{\bar{e} w_e^{2\varphi}}{(w_u(w_e^\varphi - w_u^\varphi))^2} \left(1 - (\varphi + 1) \left(\frac{w_u}{w_e}\right)^\varphi\right). \quad (6)$$

¹⁰ This is true in either the mobility or no-mobility steady states because the conditions written in Equation 3 can be rewritten in terms of ability levels: (i) $\bar{a} > \bar{a}$ and $\hat{a} < \underline{a}$, (ii) $\hat{a} > \bar{a}$, (iii) $\bar{a} < \underline{a}$.

We can see from Equation 6 that $\partial \bar{a} / \partial w_e < 0$ but is decreasing in w_u / w_e , and the sign of $\partial \bar{a} / \partial w_u$ is undetermined but is likely to be negative when w_u / w_e is small. Thus, upward mobility is likely to increase (\bar{a} decreases) in the less developed country when it opens up to trade if the discrepancy between wages to educated and uneducated workers is large. It is possible, however, that upward mobility may not increase even if \bar{a} decreases if the economy was originally in a no-mobility steady state and the decrease in \bar{a} was not large enough to push it below \bar{a} .

On the other hand, the threshold level of ability below which educated parents do not educate their children, $\hat{a} = y^* / w_e$, unambiguously increases when the less developed economy opens up to trade (y^* increases and w_e decreases). This would cause an increase in downward mobility if \hat{a} increases above \underline{a} . If it does not, then downward mobility continues to be non-existent, and the children of educated parents will always get educated.

To summarize, the effect on the steady-state enrollment rate in the less developed economy depends on the relative changes in upward and downward mobility. The steady-state enrollment rate will increase if an increase in upward mobility is larger than the decrease in downward mobility. It will decrease if either upward mobility decreases or the increase in upward mobility is small relative to the increase in downward mobility. Finally, the steady-state enrollment rate might not change if the economy was originally in a no-mobility steady state and the changes in wages and incentives are too small to affect upward and/or downward mobility.

The direction and magnitude of the change in upward mobility in the less developed economy depends on the relative importance of the income effect, which encourages investment in education by children of poor parents, and the incentive effect, which discourages investment in education. If the income effect is strong enough, Country A could actually experience an increase in human capital accumulation even though the incentive to accumulate human capital has decreased.

The analysis of the effects of trade in the more developed, human-capital-abundant economy mirrors that of the less developed economy. When Country B opens up to trade, w_e increases and w_u decreases. Given this fact and noting Equations 5 and 6 once again, we can see that the same conditions that generate increased upward mobility in the less developed economy will generate decreased upward mobility in the more developed economy. Similarly, $\hat{a} = y^* / w_e$, the threshold level of ability below which educated parents do not educate their children, unambiguously declines in the more developed economy, potentially generating less downward mobility. As in the case of the less developed economy, if the more developed economy was originally in a no-mobility steady state and the changes in incomes and incentives were small, there would be no change in the amount of upward and downward mobility and, thus, no change in the resulting steady-state enrollment rate.

Just as in the less developed economy, we cannot predict the overall effect of trade on the enrollment rate in the more developed economy. Downward mobility decreases because both the income of educated parents and the incentive to educate children increases. Upward mobility may decrease or increase depending on the net effect of the decrease in uneducated parents' incomes and the increase in incentive to educate children. If the effect of increased incentives dominates, decreased downward mobility will dominate any possible decrease in upward mobility, and the steady-state enrollment rate will increase. On the other hand, if the income effect on the uneducated is strong enough, decreased upward mobility may outweigh decreased downward mobility, and the steady-state enrollment will decrease, despite the increased incentives to become educated in the developed economy.

In short, in order to determine how human capital accumulation is affected by trade at an

economy-wide level, we need to understand what is happening to the majority of the families within the economy. But in order to determine how an individual's human capital accumulation will respond to a change in relative prices we need to know two things: (i) how was the income of the parent affected by the change in relative prices? and (ii) how did the incentives to accumulate human capital change? The answer to the second question depends on the pattern of trade, and the answer to the first question depends on the pattern of trade as well as the type of labor that the parent supplies.

The model above highlights a mechanism by which trade can affect the accumulation of human capital. Trade may not affect all economies in the same way. Low-income economies may or may not experience increases in human capital when opening to trade, depending on the importance of the relaxation of liquidity constraints. High-income economies may also experience increases or decreases in school enrollments, with decreases being more likely when a larger percentage of children of uneducated parents face liquidity constraints. Because the model does not provide unambiguous predictions, the actual effect of trade on human capital accumulation is investigated empirically in the next section.

3. Empirical Evidence

Methodology and Data

Figure 1 uses cross-country 1990 data to show the contemporaneous correlation between openness and gross enrollment ratios for both secondary and tertiary education.¹¹ The top two panels show the relationship between the level of enrollment rates and the level of openness, and the bottom two panels show the same relationships, but in growth rates. Simple regressions confirm what the eye can see in these plots—there is no simple statistically significant relationship between openness and enrollment rates.

The model above, however, suggests that a simple correlation between these two variables may not exist; a necessary aspect of international trade based on comparative advantage is that it affects the trading economies in different ways. Although the model presented is one of behavior at the individual level, it does suggest how one might approach the empirical relationship between trade and human capital accumulation with macroeconomic data.¹² Specifically, controlling for income and comparative advantage is necessary. Equation 7 does just that and offers a more complete test of the macroeconomic relationship between the changes in human capital accumulation and the changes in trade:

$$\begin{aligned} \Delta \ln(e_{i,t}) = & \beta_1 \Delta \ln(e_{i,t-1}) + \beta_2 \Delta \ln(o_{i,t-1}) + \beta_3 \Delta \ln(y_{i,t-1}) + \beta_4 \ln(h_{t-1}) + \beta_5 \ln(h_{t-1}) \Delta \ln(o_{t-1}) \\ & + \alpha_i + \lambda_t + \nu_{i,t} \end{aligned} \quad (7)$$

where $e_{i,t}$ is a school enrollment rate of country i at time t , $o_{i,t}$ is its level of openness, $y_{i,t}$ is

¹¹ Openness is (exports + imports)/GDP, from the Penn World Tables 5.6. Gross enrollment ratios are shown. Gross enrollment ratios equal the number of people enrolled in a level of schooling divided by the age group typically enrolled in that level of schooling. They can be greater than one. Data for college enrollment ratios are available for a smaller number of countries than are data for secondary school enrollment ratios. The data are discussed more thoroughly below.

¹² One might also test elements of the model with microeconomic data, but it would not be possible to discern an overall macroeconomic effect from this approach.

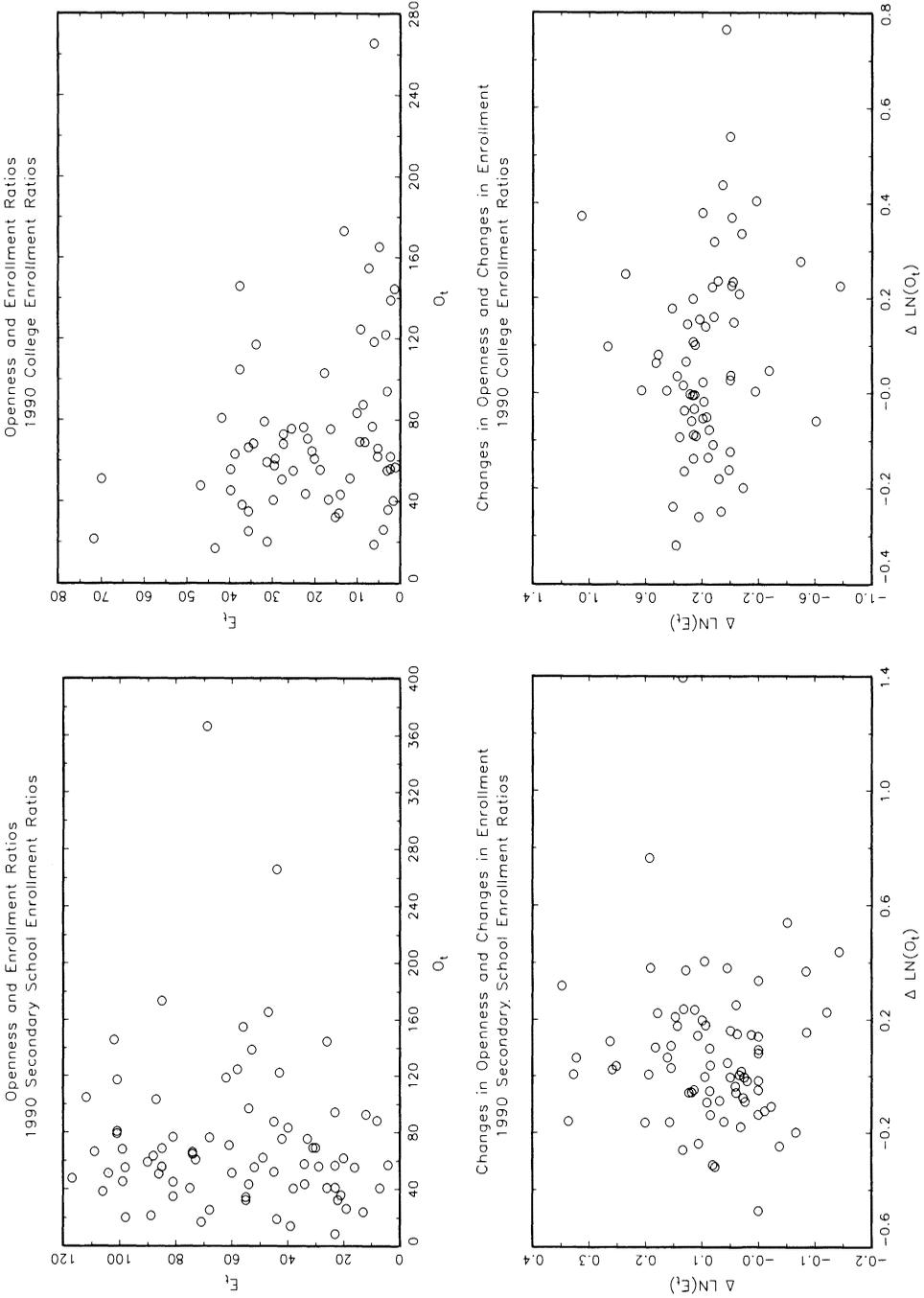


Figure 1. Contemporaneous Correlations

per capita income, and $h_{i,t}$ is the average number of years of education of the labor force. Effects of variables not included in Equation 7 are absorbed in the last three terms— α_i is a country-specific fixed effect, λ_t is a time-specific effect, and $\nu_{i,t}$ is assumed to be a mean zero normal error term. The estimated coefficients β_2 and β_5 will suggest whether openness helps or hinders school enrollment.

Because Equation 7 is only suggested by and not explicitly derived from the model of the previous section, a few comments are in order.¹³ First, average years of education (h) proxies for a source of an economy's comparative advantage. Quite literally, it is H/L , the stock of education divided by the stock of raw labor, and it is a direct measure of comparative advantage. One might also consider subtracting the world average education level from this variable as an alternative measure of comparative advantage, but because the same constant would be subtracted from each observation, this alternative procedure would produce similar results. Including the stock of educated labor as an explanatory variable also mitigates any concern that growth of enrollment rates might be systematically related to the level of development. The model also suggests that growth of per capita income may also affect changes in enrollment rates. If individuals are credit constrained, higher incomes (whether or not they are the result of trade) should result in higher enrollments, and thus the change in income growth is also included as an explanatory variable.¹⁴ The lagged difference in enrollment rates is also included as a control variable, capturing any persistence in the process of human capital accumulation. The other independent variables are also lagged one time period to implement a test of Granger causality. If these variables "cause" enrollment rates, their effects are not likely to be contemporaneous.

The panel data used to implement Equation 7 were compiled from a variety of sources.¹⁵ Openness ($[\text{exports} + \text{imports}]/\text{GDP}$) and real GDP per capita were obtained from Penn World Tables 5.6. Secondary and tertiary gross enrollment rates were obtained from UNESCO statistical yearbooks (1960–1989) and the World Bank Development Report (1993); estimates of the average years of education of the adult population (25 years of age and older) were obtained from Barro and Lee (1993). To reduce the effect of cyclical fluctuations in the data, each observation of per capita income and openness is a 3-year average. (For example, the 1970 observation is the mean of the 1969, 1970, and 1971 observations.)

School enrollment ratios are collected somewhat sporadically for some countries but are available for most countries in 5-year intervals. Therefore, in order to maximize the number of countries in the sample, time periods are separated by 5-year intervals. All countries for which all data were available were included in the estimation (a list of countries is provided in the

¹³ The change in enrollment rates derived from the model is

$$\lambda_{t+1} - \lambda_t = \int_{y_t^*}^x g_{t+1}(y) dy - \int_{y_t^*}^x g_t(y) dy,$$

which, unfortunately, is not possible to implement directly. As discussed in the text, however, it does suggest the factors, such as changes in trade and the stock of human capital, that might influence the change in enrollments through their effects on y^* .

¹⁴ Unfortunately, it is not possible to isolate the "incentive effect" from the "income effect" by including the change in per capita income. The change in per capita income does not control for the income effect of trade discussed in the model. Because different groups in the population experience different changes in income as a result of trade, determining the change in the average does not measure the net income effect for the whole economy.

¹⁵ On-line links to the Penn World Tables and the Barro and Lee data are available from the Economic Growth Resources web site (<http://hicks.nuff.ox.ac.uk/economics/growth>). Enrollment data are available in electronic form from the World Bank (<http://worldbank.org>).

Table 1. Data Summary

	Mean	SD	GDP	Correlation Matrix			
				College Enrollment	Secondary Enrollment	Openness	Average Education
GDP	4788	4023	1.00	0.81	0.84	0.03	0.84
College Enrollment	12.66	12.38		1.00	0.78	-0.14	0.77
Secondary Enrollment	48.22	29.02			1.00	0.11	0.87
Openness	62.70	36.53				1.00	0.10
Average Years of Education	4.78	2.73					1.00

appendix). When secondary school enrollment ratios are used, the dimension of the panel is 75 countries and 7 time periods (1960, 1965, 1970, 1975, 1980, 1985, and 1990), for a total of 525 observations. Using tertiary enrollment ratios reduces the number of countries to 64 (448 observations). Table 1 provides some summary descriptive statistics for the data.

Equation 7 is a dynamic fixed effects model. Nickell (1981) shows that estimating such a model with panel data using a least squares dummy variable (LSDV) approach results in biased coefficients. Since then, several solutions have been proposed, including an instrumental variables estimator by Anderson and Hsiao (1982) in which the fixed effect is removed by taking a first difference and then using a twice lagged value of the dependent variable as an instrument for the lagged value of the dependent variable. More recently, Kiviet (1995) shows that the Anderson-Hsiao estimator is quite inefficient and proposes a more efficient estimator that essentially subtracts an estimated bias from the original LSDV estimate. Judson and Owen (1997) examine the properties of the Anderson-Hsiao instrumental variables estimator, Kiviet's corrected LSDV estimator, and a few GMM estimators using Monte Carlo analysis, and they confirm Kiviet's (and others) conclusion that the Anderson-Hsiao estimator is inefficient when the time dimension of the panel is less than 10. In addition, they show that when the time dimension of the panel is relatively small, Kiviet's corrected LSDV is the most efficient estimator. In light of these results and because the panel used here is relatively short, the estimation technique used below is the corrected LSDV estimator proposed by Kiviet.¹⁶ Results from the uncorrected LSDV and Anderson-Hsiao instrumental variables procedures are presented for comparison.

Results

Table 2 presents results from estimation of Equation 7 for secondary enrollment ratios using three different estimation techniques. Focusing on the first column, results from the corrected LSDV estimation show that growth of openness is positively related to growth in enrollment rates, but that effect tapers off in more educated economies and becomes negative for highly educated economies. Using the coefficients estimated in the first column, one can calculate that the level of education, h , for which the effect of openness on school enrollment ratios becomes negative, is 5.3 years. Over the entire estimation period, a little more than two thirds of the sample is below this point. Thus, for the majority of countries, increased trade has

¹⁶ The appendix provides some details on estimation of the coefficients of the corrected LSDV estimator. Standard errors are calculated using a bootstrap method. See Kiviet (1995) or Judson and Owen (1997) for further discussion of these techniques. GAUSS programs for estimating the corrected LSDV are available from the author on request.

Table 2. Secondary School Enrollment Rates (model: $\Delta \ln[e_t] = x_{it}\beta + \alpha_t + \lambda_t + \epsilon_{it}$)

X_{it}	LSDV Correction		LSDV		Anderson-Hsiao IV	
$\Delta \ln(e_{t-1})$	0.201* (0.057)	0.200* (0.050)	-0.073 (0.051)	-0.078 (0.051)	0.087 (0.089)	0.092 (0.091)
$\Delta \ln(o_{t-1})$	0.271* (0.066)	—	0.262* (0.076)	—	0.226* (0.079)	—
$\Delta \ln(y_{t-1})$	0.005 (0.093)	0.008 (0.096)	0.035 (0.102)	0.033 (0.103)	-0.022 (0.111)	-0.016 (0.111)
$\Delta \ln(o_{t-1})^*$	-0.162* (0.062)	—	-0.146* (0.071)	—	-0.202* (0.078)	—
$\ln(h_{t-1})$	-0.018 (0.063)	-0.010 (0.069)	-0.004 (0.069)	0.001 (0.069)	0.165 (0.117)	0.163 (0.119)
Δo_{t-1}^*	—	-0.004* (0.001)	—	-0.004* (0.001)	—	-0.003* (0.001)
Δo_{t-1}	—	0.006* (0.001)	—	0.006* (0.002)	—	0.004* (0.002)

e_t = gross enrollment rate; o_t = (exports + imports)/GDP; y_t = per capita income; h_t = average years of education of the labor force; LSDV = least squares dummy variable; IV = instrumental variable. Standard errors are in parentheses. Significance at the 5% level is denoted by *.

had a positive effect on secondary school education. In the model of the previous section, this result would be obtained if the increase in incomes to uneducated parents was relatively important and generated increased upward mobility.

Intuition for the second implication of these estimates, that trade has had a negative effect on enrollment ratios for a little less than one third of the sample, can also be gained from the model. Upward mobility decreases in the human-capital-abundant economies if the decrease in uneducated parents' incomes as a result of trade is large relative to the change in the incentives to get their children educated.

This second result, however, must be stated more cautiously. Although it is true that the point estimates of the coefficients lead to this conclusion, it is not robust to using coefficients that are one standard deviation higher than the point estimates. Adding one standard deviation to the coefficient of the interaction of the growth of openness and the level of education of the labor force yields an estimate of the turning point at 15 years. No country in the sample has a labor force that educated. Thus, it might be more reasonable to interpret these results as indicating that the positive effect of trade on human capital accumulation is small or nonexistent for the high-income, human-capital-abundant economies. This interpretation is consistent with the findings in some of the earnings inequality literature cited in the introduction that the trade-induced change in relative wages in industrialized countries such as the U.S. may be small. Thus, the change in the incentives to accumulate human capital in the high-income economies may be trivial.

The magnitudes of the coefficients in the first column of Table 2 indicate that increased trade has a moderate but economically significant impact on secondary enrollment rates. In a low-income country (one with average years of education one standard deviation below the average), an increase in trade equal to one standard deviation of the increases in trade in the sample would generate a growth of enrollment that was about 3.5 percentage points higher over the 5-year period. Conversely, a high-income country (one with average years of education one standard deviation above the average) that experiences an increase in trade equal to one standard deviation of the increases in trade in the sample would have growth in enrollment rates over the 5-year period that were about 1 percentage point lower.

The results in column one also indicate that growth of secondary enrollment rates are positively related to their growth in the previous period. The relationship between lagged growth of per capita income and subsequent increases in enrollment rates is not statistically significant. One possible explanation for this is that the relationship between income and human capital accumulation is not adequately explained by changes in average income. Ideally, one would like to also include a variable that controls for change in income at the tails of the distribution, but panel data of this sort are not available for most of the countries in the sample.¹⁷

Figure 2 shows the partial correlation between the growth of enrollment rates and the two variables involving the growth in openness. The left panel shows the negative relationship between growth of enrollment ratios and the interaction term (growth of openness multiplied by the level of education of the labor force), whereas the right panel shows the partial correlation between growth of enrollment rates and growth of openness. Both plots identify an outlier that, when removed, leaves the sign and significance of each of the coefficients intact.

Additional estimates using different methods and slightly different specifications are pre-

¹⁷ Deininger and Squire (1996) do provide panel data on income inequality measures, but it is not possible to construct from this data set a sample of any reasonable size using observations every 5 years.

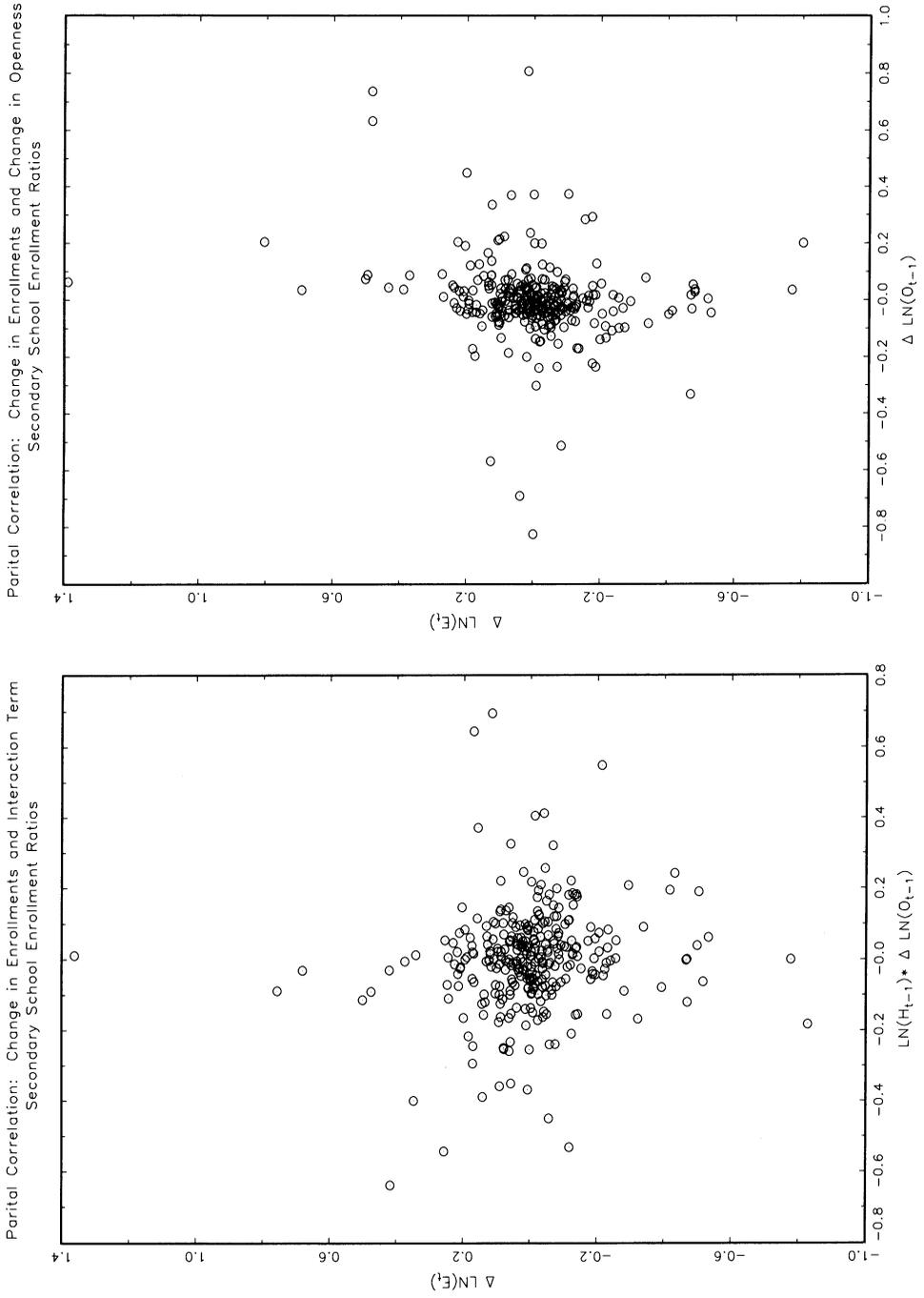


Figure 2. Partial Correlations

Table 3. College Enrollment Rates (model: $\Delta \ln[e_t] = X_{i,t}\beta + \alpha_i + \lambda_t + \epsilon_{i,t}$)

$X_{i,t}$	LSDV Correction		LSDV		Anderson-Hsiao IV	
$\Delta \ln(e_{t-1})$	-0.043 (0.058)	-0.039* (0.013)	-0.192* (0.055)	-0.188* (0.054)	0.045 (0.065)	0.046 (0.065)
$\Delta \ln(o_{t-1})$	1.06* (0.429)	—	1.02 (0.643)	—	0.522 (0.600)	—
$\Delta \ln(y_{t-1})$	0.246 (0.374)	0.085 (0.343)	0.365 (0.585)	0.208 (0.581)	-0.160 (0.540)	-0.201 (0.540)
$\Delta \ln(o_{t-1})^*$ $\ln(h_{t-1})$	-0.129 (0.318)	—	-0.093 (0.503)	—	-0.094 (0.468)	—
$\ln(h_{t-1})$	-0.311 (0.313)	-0.233 (0.285)	-0.335 (0.399)	-0.258 (0.396)	-0.005 (0.565)	0.026 (0.564)
Δo_{t-1}^* $\ln(h_{t-1})$	—	-0.014* (0.006)	—	-0.013 (0.009)	—	-0.008 (0.009)
Δo_{t-1}	—	0.037* (0.008)	—	0.035* (0.013)	—	0.019 (0.013)

e_t = gross enrollment rate; o_t = (exports + imports)/GDP; y_t = per capita income; h_t = average years of education of the labor force; LSDV = least squares dummy variable; IV = instrumental variable. Standard errors are in parentheses. Significance at the 5% level is denoted by *.

sented in columns two through six of Table 2. The second column uses the difference in openness before taking the log, the third and fourth columns report the initial LSDV estimates, and the last two columns provide new estimates using the Anderson-Hsiao instrumental variables estimator. Both the Anderson-Hsiao and the corrected LSDV method give similar results, although this table illustrates two key differences between the two procedures: the standard errors for the Anderson-Hsiao estimator are generally larger than for the corrected LSDV estimator, and a comparison of the coefficients from the two procedures with the initial LSDV estimator leads one to suspect that the Anderson-Hsiao estimation overcorrects for the LSDV bias. (Kiviet [1995] shows that it is only the coefficient on the lagged dependent variable that suffers from an LSDV bias of any magnitude.)

Table 3 provides similar estimates for college enrollment ratios. These results are consistent with the results using secondary school enrollment ratios, but they are weaker. Only the LSDV correction yields significant results for any of the change in openness variables. In the first column, the growth rate of openness is positively associated with the growth rate of college enrollment rates, and the interaction term, though negative, is insignificant. The second column uses the difference in openness rather than its growth rate and reports a significant finding for both the change in openness and the change in openness interacted with the level of education, similar to the one found for secondary school enrollment ratios. The values of the coefficients in column two of Table 3 imply that the turning point level of education for which changes in openness have a negative effect on growth rates of enrollment ratios is about 14 years. No countries in the sample have average education levels that high, suggesting, as above, that trade has a positive impact on human capital accumulation but that impact is more pronounced in less developed economies.

The fact that no countries in the sample have education levels high enough to detect a negative impact of trade on changes in college enrollment rates may also help explain why the interaction term is not significant in the first column. A final point about the results in Table 3

is that the magnitude of the coefficient on openness in the college enrollment estimations is larger than that of the secondary enrollment estimations. It is possible that the income and incentive effects trade creates for college enrollment across all countries in the sample is greater than the income and incentive effects it creates for secondary school enrollment. In fact, a calculation similar to the one performed above for secondary school enrollment rates indicates that college enrollment rates would grow about 18 percentage points faster in high-income countries and 22 percentage points faster in low-income countries in response to a one standard deviation increase in trade growth.

These results argue for a generally positive relationship between human capital accumulation and international trade, particularly in less developed economies. The model above aids in the interpretation of these results by highlighting a channel through which trade can raise the incomes of the unskilled in less developed economies, allowing the children of unskilled workers to become more educated. In the more developed economies, increased trade has a smaller or even negative impact on enrollment ratios. This smaller effect may be due to smaller income and/or incentive effects in the high-income countries. Nonetheless, the model and empirical results do reconcile the observation that the worldwide distribution of human capital is converging with the presence of international trade based on comparative advantage.

4. Conclusion

This paper has shown how trade can affect the accumulation of human capital by identifying how trade affects the decisions of individuals within an economy. Trade changes the incentives to accumulate human capital and also the ability of individuals to purchase education by altering the distribution of income. Empirical results have shown that the effect of trade on the accumulation of human capital depends on the stock of human capital in the economy. Contrary to a straightforward application of the HOS theory, trade increases the accumulation of human capital in countries where human capital is the relatively scarce factor of production. Its effect in economies where human capital is relatively abundant is more muted. This result reconciles the converging distribution of human capital across countries with traditional trade theory and increases our understanding of the impact of trade.

These results indicate that the reduced incentive to become educated in a low-income country may be trivial in comparison to the increased incomes enjoyed by low-skill workers. In addition, the change in incentives and income in the human-capital-abundant economies that result from trade are a less important determinant of human capital accumulation.

Because a country's human capital stock is an important determinant of long-run growth, the impact of trade on its accumulation establishes another link between growth and trade. The findings in this paper suggest that the redistribution of income in less developed economies that can occur as a result of trade may be an important factor influencing human capital accumulation.

Appendix

A.1 Average Years of Education of Labor Force

	1960	1985		1960	1985
Algeria	0.85	2.39	Malta	5.11	6.90
Argentina	4.99	6.68	Mauritius	2.44	4.59
Australia	8.93	10.24	Mexico	2.41	4.42
Austria	3.67	6.64	Mozambique	0.40	1.08
Bangladesh	0.79	1.97	Myanmar	1.01	2.02
Barbados	5.50	7.48	Netherlands	5.37	8.57
Belgium	7.36	9.15	New Zealand	9.61	12.04
Bolivia	3.09	4.28	Nicaragua	2.07	3.78
Botswana	1.27	3.70	Niger	0.85	0.54
Brazil	2.64	3.49	Norway	5.63	10.38
Canada	8.07	10.37	Pakistan	0.63	1.92
Chile	5.00	6.45	Panama	4.26	6.30
Colombia	2.68	4.53	Papua New Guinea	1.35	1.65
Costa Rica	3.47	5.33	Paraguay	3.35	4.70
Denmark	9.38	10.33	Peru	3.00	5.79
El Salvador	1.70	3.57	Philippines	3.78	6.48
Fiji	4.94	6.76	Portugal	1.94	3.83
Finland	7.45	9.49	Senegal	1.55	2.39
France	4.06	6.52	Singapore	2.99	4.55
Ghana	0.69	3.22	Spain	3.43	5.58
Greece	4.42	6.73	Sri Lanka	3.43	5.37
Guatemala	1.16	2.59	Swaziland	1.66	3.77
Guyana	4.51	5.11	Sweden	7.58	9.45
Haiti	0.69	1.62	Syria	0.99	3.99
Honduras	1.69	3.56	Thailand	3.45	5.08
Hong Kong	5.19	7.51	Togo	0.21	2.13
Iceland	5.68	7.89	Trinidad and Tobago	4.60	6.50
India	1.43	3.05	Tunisia	0.45	2.48
Indonesia	1.11	3.75	Turkey	1.95	3.29
Ireland	6.45	8.01	Uganda	1.15	1.92
Israel	6.84	9.41	Uruguay	4.28	6.45
Italy	4.56	6.28	U.K.	7.74	8.65
Jamaica	2.46	4.16	U.S.A.	8.67	11.79
Japan	6.71	8.46	Venezuela	2.53	5.37
Kenya	1.16	3.09	Zaire	0.62	2.24
Korea	3.23	7.85	Zambia	1.64	4.35
Malawi	1.61	2.58	Zimbabwe	1.67	2.63
Malaysia	2.34	5.36			

Data source: Barro and Lee (1993).

A.2. LSDV Correction

Kiviet (1995) derives the bias of the LSDV estimator:

$$\begin{aligned} E(\hat{\delta} - \delta) = & -\sigma_{\varepsilon}^2(\bar{D})^{-1} \left(\frac{N}{T-1} (i'_{T-1} C i_{T-1}) [2q - \bar{W}' A \bar{W} (\bar{D})^{-1} q] + \text{tr}\{\bar{W}' (I_N \otimes A_{T-1} C A_{T-1}) \bar{W} (\bar{D})^{-1}\} q \right. \\ & + \bar{W}' (I_N \otimes A_{T-1} C A_{T-1}) \bar{W} (\bar{D})^{-1} q \\ & \left. + \sigma_{\varepsilon}^2 N q' (\bar{D})^{-1} q \times \left[-\frac{N}{T-1} (i'_{T-1} C i_{T-1}) \text{tr}\{C' A_{T-1} C\} + 2\text{tr}\{C' A_{T-1} C A_{T-1} C\} \right] q \right) + O(N^{-1} T^{-3/2}) \end{aligned}$$

where

$$\begin{aligned} \bar{D} & \equiv \bar{W}' A \bar{W} + \sigma_{\varepsilon}^2 \text{Ntr}(C' A_{T-1} C) q q' \\ A_{T-1} & \equiv I_{T-1} - \frac{1}{T-1} i_{T-1} i'_{T-1} \\ A & \equiv I_N \otimes A_{T-1} \\ AW & \equiv E(AW) \\ q & \equiv [1 \ 0 \ \dots \ 0]', \quad K \times 1 \end{aligned}$$

i_{T-1} is a $(T-1) \times 1$ vector of ones, and W is an $N(T-1) \times K$ matrix of independent variables constructed as follows. Define $y_i^{(-1)}$ and X_i as the independent variables for the i th individual. Then,

$$y_i^{(-1)} = \begin{bmatrix} y_{i,1} \\ \vdots \\ y_{i,T-1} \end{bmatrix} \quad \text{and} \quad X_i = \begin{bmatrix} x_{i2} \\ \vdots \\ x_{iT} \end{bmatrix}$$

and $y^{(-1)}$ and X are $N(T-1) \times 1$ and $N(T-1) \times (K-1)$ matrices such that

$$y^{(-1)} = \begin{bmatrix} y_1^{(-1)} \\ \vdots \\ y_N^{(-1)} \end{bmatrix} \quad \text{and} \quad X = \begin{bmatrix} X_1 \\ \vdots \\ X_N \end{bmatrix}$$

then $W = [y^{(-1)} X]$. \bar{W} is the expected value of W . In order to calculate the LSDV correction, one first needs to obtain a preliminary estimate of the coefficients in order to estimate σ_{ε}^2 and \bar{W} . Any consistent estimator can be used; the Anderson-Hsiao estimator is used for the estimations in the text.

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