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Human Capital Externalities, Trade, and Economic Growth

by

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Human Capital, Trade, and Economic Growth[1]

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Abstract

Human capital, because of its special role in innovative activity and technological progress, has formed the bedrock of the new theories of endogenous growth. Human capital, however, not only serves as an engine of growth, but also as a productive input along with labor and physical capital. In this study, we distinguish between these two roles of human capital and find evidence of the importance of both.

We also find that the relationship between growth and the external effects of human capital vary according to trade regime. When literacy rates are relatively high, open economies grow about 0.65 to 1.75 percentage points more than closed economies.

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Human Capital, Trade, and Economic Growth

Introduction

Some popular models of endogenous growth hold that inventions are intentional and generate technological spillovers that lower the cost of future innovations.[2] Thus, human capital may serve not only as a productive input along with labor and capital but also as an engine of growth (Lucas 1988). So far, the best examples of empirical work on economic growth—such as Barro (1991), Kormendi and Meguire (1985), Levine and Renelt (1992), Mankiw, Romer, and Weil (1992), Romer (1990b)—have not attempted to distinguish between these two roles of human capital.

This paper attempts to separate the impact of human capital into its role as an input to production and its role as a determinant of technological progress and long run growth.[3] We pose the following empirical question: Once human capital is accounted for as an input to production in the neoclassical Solow growth model, can the overall stock of human capital explain any residual variation in growth? By holding constant the rate of economic growth explained by a human capital augmented neoclassical model, we can shed some light on the importance of the stock of human capital in determining long-run economic growth.

In the context of distinguishing between the different roles of human capital, we also examine the relationship between economic growth and trade regime. Numerous studies, using various measures of openness, report that relatively open economies experience substantially

[2] For example, see Romer (1990c) or Grossman and Helpman (1991). For other endogenous growth models that do not depend on externalities or spillovers, see, for example, Romer (1986) or Rebelo (1991).

[3] For a discussion of this distinction see Lucas (1988).

higher growth than closed economies.[4] This result is somewhat puzzling, given that the static gains to trade liberalization have been estimated to be rather small—an order of magnitude of about 1 percent of the level of gross domestic product (GDP).[5] The empirical analysis of this paper reconciles these findings and suggests that the stock of human capital—apart from its role as an input in production—is mostly responsible for higher growth in open economies. We find that accounting for the interaction between human capital and the trade regime gives a higher estimate of the role of human capital as a separate engine of growth.

As a starting point for the analysis, we derive a benchmark human-capital-augmented Solow model. This derivation is different from previous ones in that it follows the labor economics literature in assuming a direct relationship between rates of return on human and physical capital. We then present the estimating equation in Section II, and in Section III we discuss our data and the relationship between human capital and economic growth. In Section IV, we examine the interaction between human capital and trade regime. And finally, in Section V we conclude with some observations and implications for further work.

I. The Benchmark Solow Model with Human Capital

As a starting point for the analysis, we present a benchmark human-capital-augmented Solow growth model. Once human capital is accurately accounted for as an input to production, the residual variation in growth explained by the stock of human capital (as suggested by endogenous growth theory) can be measured.

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[4]See for example, Heitger (1987), World Bank (1987), De Long and Summers (1991), and Roubini and Sala-i-Martin (1991). Levine and Renelt (1992), however, found that the relationship between their measure of trade regime and economic growth may be sensitive to outside factors.

[5]For example, see Johnson(1960).

Although Mankiw, *et. al.* (1992) develop a human-capital-augmented Solow model, they assume that economic agents accumulate human and physical capital independently of the other factor's rate of return. However, estimates of the rate of return to schooling (human capital) tend to be similar to estimates of the rate of return to physical capital (Willis, 1986, p. 536; and McMahon, 1991, p. 283). This section presents a brief overview of the augmented Solow model when economic agents allocate their human and physical capital investments until the rates of return are equalized.

Output, Y(t), is produced by a homogeneous production function in physical capital, K(t), human capital, H(t), and labor, L(t). Per capita output can be written

(1) $y(t) = A(t)f(k(t), h(t))$,

where $y(t) = Y(t)/L(t)$, $k(t) = K(t)/L(t)$, $h(t) = H(t)/L(t)$, and A(t) is the level of technology. As usual,

(2) $L(t) = L(0)e^{nt}$

(3) $A(t) = A(0)e^{gt}$,

where n and g are the exogenous rates of growth in the labor force and technological efficiency.

Following Mankiw *et. al.*, a unit of output can be consumed, devoted to human capital accumulation, $\dot{H}$, or the creation of new capital, $\dot{K}$. The stock of human or physical capital depreciates at the rate δ at each instant. Thus,

(4) $\dot{H} + \delta H + \dot{K} + \delta K = (s_h + s_k)Y = sY$,

where $s_h = (\dot{H} + \delta H)/Y$, $s_k = (\dot{K} + \delta K)/Y$, and s is the total rate of savings. We assume s, the **human capital augmented savings rate**, is constant. The accumulation of human and physical capital are described by

(5) $dk/dt = (s - s_h)f(k,h) - (n + g + \delta)k$

(6) $dh/dt = s_h f(k, h) - (n + g + \delta)h$

(7) $f_k = f_h$.

Figure 1 shows the steady-state solution to the above system of equations.[6] The savings rate s_h must be chosen so that the dk/dt = 0 and dh/dt = 0 curves intersect on the $f_k = f_h$ curve. Stability requires that the dh/dt = 0 curve be steeper than the dk/dt = 0 curve, as illustrated by the arrows. Letting $r = f_j$ (j = k, h) denote the common rate of return, the slope of dk/dt = 0 is

(8) $$(dk/dh)_k = s_k r/(n + g + \delta - s_k r).$$

The slope of dh/dt = 0 is

(9) $$(dk/dh)_h = (n + g + \delta - s_h r)/s_h r.$$

The stability condition is then $(n + g + \delta - s_h r)(n + g + \delta - s_k r) > s_h s_k r^2$, which (using $s = s_h + s_k$) simplifies to

(10) $$n + g + \delta - sr > 0,$$

which is the same as the Solow stability condition (Solow, 1956).

II. The Analytical Model

To examine the above model empirically, we assume that output is produced by a Cobb-Douglas production function. Thus,

(11) $$Y(t) = K(t)^{\alpha} H(t)^{\beta} (A(t)L(t))^{1-\alpha-\beta},$$

where A(t)L(t) is effective labor at time t. If k = K/AL and h = H/AL, the evolution of the economy can be described by,

(12) $$dk/dt = s_k k^{\alpha} h^{\beta} - (n + g + \delta)k$$

(13) $$dh/dt = s_h k^{\alpha} h^{\beta} - (n + g + \delta)h.$$

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[6]See Ruffin (1979) for a similar diagram describing international capital movements between two Solow economies.

As indicated by Mankiw, *et al.* (1992), it is easy to see that with constant savings rates s_k and s_h, the steady-state values are

(14) $k^* = [s_k^{1-\beta} s_h^{\beta}/(n + g + \delta)]^{1/(1-\alpha-\beta)}$

(15) $h^* = [s_k^{\alpha} s_h^{1-\alpha}/(n + g + \delta)]^{1/(1-\alpha-\beta)}$.

But we assume that the rate of total savings, $s = s_k + s_h$, is constant, with the allocation of savings between the two sectors equalizing rates of return.

If rates of return are equalized, this implies that

(16) $\beta k^* = \alpha h^*$,

and substituting in equations (14) and (15)

(17) $s_k/s_h = (\alpha/\beta)$.

Since $s = s_k + s_h$, we can see that

(18) $s_k = s\alpha/(\alpha + \beta)$

(19) $s_h = s\beta/(\alpha + \beta)$

We now derive the estimating equation. In the steady-state, the log of the level of per capita income at any time t will be

(20) $\ln [Y(t)/L(t)] = \ln A(0) + gt + [(\alpha + \beta)/(1-\alpha-\beta)]\ln [s/(n+g+\delta)]$.

We assume that if the economy is not in the steady-state, then in the vicinity of the steady-state

(21) $d \ln(y(t))/dt = \lambda[\ln(y^*) - \ln(y(0))]$,

where $\lambda = (n + g + \delta)(1-\alpha-\beta)$, y(0) is the initial per capita income, and ln(y*) is defined by (20). Solving the differential equation results in

(22) $\ln y(t) - \ln y(0) = (1 - e^{-\lambda t})\ln(y^*) - (1 - e^{-\lambda t})\ln(y(0))$.

Substituting (20) into (22) results in

(23) $\ln[y(t)/y(0)] = c + (1 - e^{-\lambda t})[(\alpha + \beta)/(1 - \alpha - \beta)]\ln[s/(n+g+\delta)] - (1 - e^{-\lambda t})\ln(y(0))$,

where $c = (1 - e^{-\lambda t})[\ln A(0) + gt]$ is the constant term.

This modified form of the equation derived by Mankiw *et al.* shows the level effects of capital accumulation, labor force growth, technological progress, and depreciation on the rate of growth between time 0 and time t. This modification represents an important insight. It shows the transition from the initial level of per capita income to the current level *as driven by the accumulation of labor, human capital, and physical capital in their role as inputs in the production function*. In brief, it shows the level effects as opposed to the growth effects of the forces of growth. Since this is a linear approximation in the vicinity of the steady-state, a regression equation based on (23) is just an empirical approximation.

Some popular models of endogenous growth theory are based on the idea that innovation is carried out to make profits on the introduction of new products. But every new product adds to the stock of human knowledge, so the costs of innovation falls as human knowledge accumulates. Thus, the rate of growth of the economy will vary directly with the rate of introduction of new products such as the automobile or the personal computer. Since new products are introduced to make a profit, it follows that the rate of growth of the economy will be higher (1) the higher the markups on new products, (2) the larger the stock of human capital, (3) the more secure the returns to future profits, and (4) the lower the rate of time preference (which raises the present value of future profits). Other models of endogenous growth are less elaborate and simply depend on constant or increasing returns to human capital.[7] We hypothesize, therefore, that if there is increased innovation or constant or increasing returns due to accumulated human capital, the stock of human capital should play a role in enhancing

[7]See, for example, Grossman and Helpman (1991) and Ruffin (1994).

economic growth in the transition between y(0) and y(t). This effect is in addition to human capital as an input and is based on the idea that growth can be driven by the stock of human capital. Equation (23) already captures the role of human capital as an input in the human capital augmented saving rate variable, s. Thus, any residual variation in the rate of economic growth may shed some light on endogenous growth theory. If the neoclassical growth model accurately reflects reality, then adding a measure of the stock of human capital to equation (23) should add nothing to the explanatory power of the equation, assuming that all the other measured variables contained errors uncorrelated with the disturbance term. However, if endogenous growth is important, then the stock of human capital may be important. Thus, the basic estimating equation is

$$(24)\ \ln[y(t)/y(0)] = c + (1-e^{-\lambda t})[(\alpha+\beta)/(1-\alpha-\beta)]\ln[s/(n+g+\delta)]-(1-e^{\lambda t})\ln(y(0))+\eta\ln H(0),$$

where η is the coefficient on the natural log of human capital.

It is difficult to explicitly derive such an equation in the context of an endogenous growth model with capital accumulation because there is no steady-state (Grossman and Helpman 1991, ch. 5). As an empirical approximation, the term $\eta\ln H(0)$ in effect eliminates that portion of the rate of growth stemming from externalities or increasing returns and allows us to estimate how a pure, hypothetical, augmented-Solow world would grow between period 0 and period t.

III. Human Capital and Economic Growth: The Results.

The benchmark model. Model 1 of Table 1 presents the estimation results of the benchmark human-capital-augmented Solow growth model. The dependent variable is the annual growth rate of real GDP per working-age person between 1960 and 1988[8], and the explanatory variables are 1) the log of real GDP per working-age person in 1960, ln(Y60); 2) the log of the sum of the growth of population, the growth of knowledge, and the rate of physical capital depreciation, $\ln(n + g + \delta)$;[9] 3) the log of the sum of physical capital and human capital savings, log(I/Y + SCHOOL). Physical capital savings is measured by the ratio of total investment to GDP and human capital savings is measured by the approximate number of pupils enrolled in secondary school divided by the working-age population.[10]

The estimation results of the benchmark model are consistent with the neoclassical model and the basic findings of Mankiw *et al.* Real GDP per working age person in 1960 is negative and highly significant, which suggests income convergence.[11] Total savings, ln(I/Y + SCHOOL), is positive and significant at the 1 percent level.[12] The sum of the growth of population, the growth of knowledge, and the rate of physical capital depreciation, ln(n + g +

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[8]The least squares estimates are used to minimize the sensitivity of the results to the end points. The primary source of this data is Summers and Heston (1991).

[9]As in Mankiw et al., g is assumed to be 2 percent and δ is assumed to be 3 percent.

[10]The source of this data is Mankiw *et al.* (1992).

[11]Although regressing average growth rates against initial income levels suggests income convergence, it does not necessarily provide statistical evidence of convergence. See the section below for further discussion of the convergence issue.

[12]Because the proportion of the working-age population enrolled in secondary school is possibly an incomplete measure of human capital savings, we probed the robustness of benchmark model by augmenting the human capital saving variable with savings in research and development. Research and development savings (R&D) is measured by a country's average expenditure on research and development during the 1970s and 1980s divided by its gross domestic product. The raw data were obtained from the UNESCO *Statistical Yearbook*, 1989. We found that R&D savings did improve the explanatory power of the benchmark model, but not markedly, which suggests the robustness of the original findings. The cost of using the R&D savings data was a reduction in the size of the data set to only 49 observations. Consequently, we chose to use only SCHOOL as the proxy for human capital savings and sacrificed the benefit of a slightly better savings variable for a large data set.

δ), is negative as expected but insignificant at the 10 percent level.

The stock of human capital. Can the stock of human capital explain any residual variation in the benchmark growth model? We investigate this question in hopes of shedding some light on endogenous growth theory. Our first proxy for the stock of human capital is the literacy rate in the early 1960s and is obtained from the United Nations' *World Economic Survey, 1969-1970*. As model 2 shows, the stock of human capital, ln(LIT60), plays an statistically significant and economically important role in determining cross-country growth rates. Holding human-capital-augmented savings constant, we find that increasing the literacy rate from 50 percent to 75 percent in 1960 would have increased the annual rate of growth by about 0.26 percentage points per year over the next 28 years as a result of the effects of human capital. Furthermore, notice that when the literacy rate is included in the benchmark growth equation, the coefficient on total savings falls by 0.51—about one-sixth—from model 1 to model 2.[13] The fall in the size of the coefficient suggests that by not including the stock of human capital in the transitional growth equation, per capita growth due to captial as an input is overestimated.

Figure 2 plots the average yearly growth in real GDP per working-age person between 1960 and 1988 against ln(LIT60), holding constant the other explanatory variables of model 2. The figure demonstrates the positive relationship between growth and the external effects of human capital and is in accord with the endogenous growth models of Lucas (1988), Romer (1990c) and Grossman and Helpman (1991).

To study the sensitivity of the regression results with respect to the use of literacy rates, we included the log of the number of physicians per thousand inhabitants in 1960 [ln(PHYS60)] as different proxy for the stock of human capital. These data were obtained from the United Nations' *World Economic Survey, 1969-1970*.

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[13]Utilizing the White test, we could not find heteroscedasticity to be a significant problem.

Because literacy rates are potentially a more broad-based proxy for the overall stock of human capital, and because the number of physicians may proxy for government health policies rather than the stock of human capital available for innovative activities, in the analyses that follow we use literacy rates as a proxy for the stock of human capital.

IV. The Role of Human Capital in Open and Closed Trade Regimes.

How does human capital influence growth in open and closed economies? Although quite a few multicountry studies have found that closed economies grow less than outward-orientated economies (Krueger, 1978; Bhagwati, 1978; Heitger, 1987; the World Bank, 1987; De Long and Summers, 1991; Michaely, *et al.*, 1991; and Roubini and Sala-i-Martin, 1992), the way in which human capital interacts with the trade regime has received little attention.

The theory. The basic one-sector model of endogenous growth of Paul Romer (1990c) or Grossman and Helpman (1991, pp. 238-46) suggests that if externalities are international in scope, then economic integration serves to increase the rates of economic growth. Figure 3 shows the comparison of autarkic growth with full economic integration growth. With integration, a country's economic growth rate depends on the stock of world human capital; accordingly, higher stocks of human capital in a country should have only a slight marginal impact on economic growth in that country. Under autarky, however, the available human capital is simply what is present in the country; consequently, the growth rate should vary with its stock of human capital. However, growth in autarky is lower than growth in a completely integrated world economy.

In other endogenous growth models, there is a dynamic sector that exhibits learning-by-doing externalities, spillover effects, or other human-capital-type externalities and another traditional sector that does not.[14] Depending on whether free trade shifts resources to or away

[14]See, for example, Krugman (1985), Lucas (1988), Young (1991), and Stokey (1991).

from the dynamic sector, economic growth may increase or decrease. How resources are allocated under free trade depends, of course, on the structure of the model and a country's initial factor endowments.

For example, Grossman and Helpman (1991) create a two-factor, three-sector endogenous growth model in an international trade setting by including a research and development (R&D) sector, a high technology good, and a traditional good. The R&D sector contributes both to the profitability of high technology goods and adds to the stock of human capital, which, in turn, reduces the costs of research and development and further contributes to the rate of innovation. The interesting feature of the model is that trade policy may increase or decrease growth. If a country has a comparative *advantage* in high technology goods, then moving toward free trade may increase growth as resources move to the research and development sector. On the other hand, if a country has a comparative *disadvantage* in high technology goods, then a movement toward free trade will could have deleterious effects on economic growth as resources leave research and development.

While the theoretical literature provides a discussion of the role of human capital and trade, it does not provide any clear cut relationship between human capital and trade regimes. We attempt to discover the central facts and then suggest a tentative explanation.

Empirical evidence. All studies face the problem of how to measure the degree of outward or inward orientation. Surveys of business opinion, the height of effective tariff rates, black market exchange rate premia, export shares, the growth of export shares, and real exchange rate distortions have all been used (World Bank, 1991). No measure is perfect because the true rate of protection reflects a complicated combination of tariffs, quotas, exchange rate controls, and a host of administrative barriers. We present results based on trade regimes as defined by effective rates of protection, black market exchange rate premiums, and real exchange rate distortions. Subjective measures or export shares, as found in the World Bank (1991), or the growth of export shares are not used because of potential inference problems. Export shares reflect the size of a country and policies in other countries; and the growth of export shares is itself a complicated endogenous variable reflecting many factors besides trade regime.[15]

We begin with the simplest measure—the height of the average national effective tariff rates. Heitger (1987) presents an extensive analysis of both the height and dispersion of effective tariff rates on economic growth rates. He finds that growth rates decline with higher levels and dispersions of effective tariff rates. We use a zero-one dummy variable for effective tariff rates because, although they are a good general measure of trade regime, cannot distinguish subtle difference in openness. This is not a problem since we are only interested in a measure of relative openness. Moreover, a binary variable of relative openness helps to elucidate the interactive effects of trade regime and human capital on economic growth. De Long and Summers (1991) use the same zero-one dummy variable for effective rates of protection. The dummy variable is assigned zero for "open" economies—those with effective rates below 40 percent—and one for "closed" economies—those with effective rates above 40 percent. The sample includes both developing and industrialized countries.

Table 2 presents the empirical investigation into the role human capital plays in open and closed trade regimes. Because introduction of the trade orientation variable (TARIFF) reduces the size of the data set to 42 observations, a reference model of our benchmark growth equation is estimated with the 42-country data set. In comparing the benchmark model 1 of Table 2 with the corresponding model 2 of Table 1, we discover in this smaller data set that the measure of human capital, ln(LIT60), becomes statistically insignificant and the size of the point

[15]See also the comments of De Long and Summers (1991).

estimate falls substantially from 0.622 to .434. This suggests that our original results are sensitive to the countries chosen.

Model 2 of Table 2 includes an interaction term of literacy rates and the trade orientation variable [ln(LIT60) * TARIFF], as well as literacy rates [ln(LIT60)] as a variable by itself. By including both of these variables in the estimating equation, the coefficient on ln(LIT60) represents the effects of human capital in relatively open trade regimes, and the sum of the coefficients on ln(LIT60) and the interaction term, [ln(LIT60) * TARIFF], represent the effect of human capital in highly protected trade regimes.

Controlling for differences in trade regimes, we find that ln(LIT60) becomes statistically significant, and the point estimate on this variable jumps by a multiple of three to 1.260, while the interaction term itself is negative and highly significant. In a trade regime with high rates of effective protection the coefficient on the stock of human capital falls from 1.260 to .845. The results suggest that human capital plays an extremely significant and economically important role in open and closed economies, but its role is less important in closed economies.

If we assume a literacy rate of 70 percent, the point estimates on ln(LIT60) and the interaction term [ln(LIT60) * TARIFF] suggest that growth due to the external effects of human capital are approximately 1.75 percent per year higher in open versus protected economies. In other words, in countries with a sizable stock of human capital, protection is far costlier than anything envisioned by neoclassical trade theory.

Figure 4 plots the average yearly growth in real GDP per working-age person between 1960 and 1988 against ln(LIT60) for open and closed trade regimes, holding constant all the explanatory variables of model 2. That is, the figure shows the partial correlation between growth rates and our proxy for human capital, ln(LIT60), in both open and closed trade regimes. The results indicate that the relationship between growth and the stock of human capital varies significantly according to trade regime. More importantly, the figure has implications for theories that assume the international diffusion of knowledge. The figure implies that an open economy's own stock of human capital is growth enhancing. In other words, the international diffusion of knowledge is not complete. Even in open economies the stock of human capital plays an important role in determining growth.

Of course, the positive relationship between growth, human capital, and openness may be sensitive to other factors correlated with trade regime and human capital. For example, it is not at all unreasonable believe that political stability, or some other factor, could influence a country's trade regime and stock of human capital. Consequently, Model 3 of Table 2 includes many of the ancillary variables Barro (1991) found to be important in determining economic growth. These variables include the amount of government spending, as proxied by the average ratio of real government consumption (exclusive of defense and education) to real GDP (GovCon), the degree of political instability, as proxied by the number of revolutions and coups per year (REV), and the number of assassinations (ASSN). After controlling for these other factors, we continue to find that the external effects of human capital play an important role in closed and open trade regimes. With a literacy rate of 70 percent, a move from a high to a low effective tariff rate raises the annual growth rate by about 1.2 percent.

Model 4 extends the sensitivity analysis by including zero-one dummy variables for Latin America and Sub-Saharan Africa. These variables account for special factors that may influence growth is these regions. The inclusion of these variables do not alter the previous conclusions.

Because the above findings may be sensitive to measurement error in trade orientation, we examine trade orientation as defined by two other criteria—black market exchange rate premiums and real exchange rate distortions.[16] Countries with high black market exchange rate premiums are typically highly distorted and inward-oriented. The advantage of black market exchange rate premiums over effective tariff rates is that it may be a more general measure of trade orientation. Furthermore, because of data availability, we can expand our data set to 92 countries.

Table 3 shows the results using black market exchange rate premiums. (BMPMED) is a zero-one dummy variable that is equal to one for countries that have a black market exchange rate premiums greater than the median of the sample.[17] Those countries with black market premiums greater than the median of the sample are considered relatively closed trade regimes.

Model 2 of Table 3 shows the coefficient on the interaction term, BMPMED*ln(LIT60), to be negative and significant at the 5-percent level. Moreover, the size of the coefficient indicates that this in an important effect. For example, the point estimate implies that an open economy with a literacy rate of 70 percent grew 0.88 percent per year faster than a closed economy with the same literacy rate. This is about half the size of the effect estimated in Table 2, but it is still incomparably larger than the neoclassical gains. Model 3 indicates that the results of model 2 have the same sign but are weaker when controlling for government consumption expenditures and political assassinations and revolutions. Adding dummies for Latin America and Africa weakens the significance of the ln(LIT60) slightly.

Table 4 shows the results of the same experiment as conducted in Tables 3 and 2 with the measure of trade orientation as defined by the real exchange rate distortion developed by

[16]Black market premium and real exchange rate distortion data were obtained from Levine and Renelt (1992). The real exchange rate distortion data are averaged over the years 1976-1985.

[17]We also used the average of the sample, and black market premiums greater than one as different cut-off points for trade orientation. The results using these definitions did not change our original inferences.

Dollar (1992).[18] We use a zero-one dummy variable around the median of the sample (RERMED) with one indicating a relatively closed economy. The results are virtually the same as Table 3, except that the coefficient on the interaction term, RERMED*ln(LIT60), is about one-fourth smaller. The smaller coefficient indicates that for this definition of trade regime, open economies with a literacy rate of 70 to 100 percent grow about .65 percent faster than closed economies.

Figures 5 and 6 plot the average yearly growth in real GDP per working age person for open and closed trade regimes, as defined by black market premiums and real exchange rate distortions. The results are consistent with those shown in Figure 4 and indicate that the effects of human capital on growth varies slightly according to trade regime.

Discussion. The empirical results presented in this section suggest that a portion of the superior growth experience in open economies is due to the stock of human capital. This cannot be explained in a simple way by the present collection of endogenous growth models or by neoclassical trade theory. We now attempt an explanation.

Although a liberal trade regime may increase economic efficiency, perhaps a more literate society can better take advantage of the greater economic opportunities presented by liberal trade policies. Imagine two islands, one with an illiterate population and the other with a highly literate population. Which one is more likely to grow faster when it switches from autarky to free trade? We conjecture that it would be the literate island.

Neoclassical trade theory captures the gains deriving from the static opportunities that arise from trade liberalization. The empirical results above suggest that a more dynamic theory

[18]A shortcoming of Dollar's real exchange rate distortion index is that it covers only the 1976-85 period—the last 10 years of our sample period. Because this measure of trade orientation does not cover the earlier years of the sample, the observed relationship between trade regime, human capital and economic growth, may be weaker than it would be otherwise.

of trade, one that emphasizes human capital externalities and highlights the gains generated by dynamic opportunities that arise from trade liberalization.

These ideas are related to similar thoughts expressed in the literature on economic development. Theodore Schultz, one of the pioneers of human capital theory, states (Schultz 1975), "The mainspring of development consists of the 'creative and innovative responses' of the entrepreneur." Thus, high stocks of human capital increase the efficiency with which people take advantage of economic opportunities. Similarly, Jagdish Bhagwati (1984) has pointed out that the advantages of open trade is in exploiting new opportunities:

> Perhaps the chief lesson of the success story of the EP [export-promotion]-strategy of countries is not in the demonstration of the success of this strategy per se. Rather, it may be in the demonstration that economic success comes from taking risks, from recognizing and seizing opportunities. The risk-averse export pessimists saw the postwar trade opportunities pass them by; the Schumpeterian risk-takers of the Far Eastern four [Taiwan, Korea, Singapore, and Hong Kong] . . . seized the opportunities and prospered.

V. Conclusion

Human capital, because of its special role in innovative activity and technological progress, has formed the bedrock of the new theories of endogenous growth. Human capital, however, not only serves as an engine of growth, but also as a productive input along with labor and physical capital. In this study, we attempt to shed new light on these two roles of human capital and find evidence of the importance of both.

We also find that the relationship between growth and the external effects of human capital vary according to trade regime. When literacy rates are relatively high, open economies experience growth rates about 0.65 to 1.72 percentage points higher than closed economies. These results may help explain an empirical puzzle: while there are high growth rates in open trade regimes, these high rates cannot be explained by the fairly minor neoclassical gains from trade.

Further theoretical work is required to explain the interaction between the external effect of human capital and the rate of growth. Such a theory would undoubtedly be along the lines of endogenous growth theory, but would focus on the interaction between trade and the dynamic opportunities made available though open markets.

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TABLE 1

Growth and the Role of Human Capital

Dependent Variable: log difference GDP per working-age person 1960-1988

	(1)	(2)	(3)
Constant	-3.851	-2.460	0.293
	(2.938)	(2.834)	(3.637)
ln(Y60)	-0.654††	-1.005††	-1.012††
	(0.248)	(0.260)	(0.310)
ln(n + g + δ)	-0.643	-0.861	-0.702
	(1.273)	(1.216)	(1.257)
ln(I/Y + School)	2.980††	2.465††	2.618††
	(0.370)	(0.387)	(0.412)
ln(LIT60)		0.622††	
		(0.193)	
ln(PHYS60)			0.348†
			(0.185)
$\overline{R}^2$	0.44	0.49	0.46
r.m.s.e.	1.41	1.34	1.39
observations	98	98	98

NOTE: Standard errors in parentheses. ††Significant at the 5% level. †Significant at the 10% level.

Table 2

Growth: The Role of Human Capital and Trade Regimes
(Effective Rates of Protection > 40% = Closed Regime)

Dependent Variable: log difference GDP per working-age person 1960-1988

	(1)	(2)	(3)	(4)	
Constant	-1.100	8.439††	8.087	8.039††	
	(4.072)	(4.310)	(4.278)	(4.031)	
ln(Y60)	-0.860††		-1.234††	-1.382††	-1.184††
	(0.423)	(0.376)	(0.361)	(0.354)	
ln(n + g + δ)	-0.332	1.757	0.534	1.719	
	(1.776)	(1.620)	(1.546)	(1.535)	
ln(I/Y + School)	2.393††	1.281	1.505	1.509†	
	(0.977)	(0.888)	(0.918)	(0.865)	
ln(LIT60)	0.434	1.260††	0.971†	1.335††	
	(0.531)	(0.505)	(0.560)	(0.668)	
TARIFF * ln(LIT60)		-0.415††	-0.290††	-0.256††	
		(0.110)	(0.113)	(0.126)	
GovCon			-7.449††	-7.102††	
			(3.340)	(3.374)	
ASSN			-0.597	-0.506	
			(0.421)	(0.405)	
REV			-1.241††	-0.740	
			(0.713)	(0.708)	
AFRICA				0.707	
				(0.769)	
LATIN				-0.686	
				(0.458)	
$\bar{R}^2$	0.28	0.47	0.57	0.59	
r.m.s.e.	1.26	1.07	0.97	0.94	
observations	42	42	42	42	

NOTE: Standard errors in parentheses. ††Significant at the 5% level. †Significant at the 10% level.

Table 3

Growth: The Role of Human Capital and Trade Regimes
(Black Market Premium > Median of Sample = Closed Regime)

Dependent Variable: log difference GDP per working-age person 1960-1988

	(1)	(2)	(3)	(4)	
Constant	-1.724	2.537	4.224	6.232†	
	(2.974)	(3.506)	(3.239)	(3.348)	
ln(Y60)	-1.022††		-1.148††	-1.257††	-1.167††
	(0.269)	(0.270)	(0.248)	(0.247)	
ln(n + g + δ)	-0.536	0.690	0.043	0.682	
	(1.292)	(1.384)	(1.270)	(1.271)	
ln(I/Y + School)	2.397††	2.215††	2.497††	2.323††	
	(0.400)	(0.400)	(0.398)	(0.396)	
ln(LIT60)	0.751††	0.986††	0.550††	0.465†	
	(0.226)	(0.246)	(0.247)	(0.262)	
BMPMED * ln(LIT60)		-0.207††	-0.132	-0.067	
		(0.095)	(0.090)	(0.092)	
GovCon			-10.111††	-9.772††	
			(2.405)	(2.367)	
ASSN			-0.045	-0.024	
			(0.301)	(0.080)	
REV			-1.218††	-1.231††	
			(0.594)	(0.581)	
AFRICA				-0.599	
				(0.410)	
LATIN				-0.863††	
				(0.389)	
$\overline{R}^2$	0.50	0.51	0.59	0.62	
r.m.s.e.	1.37	1.34	1.21	1.17	
observations	92	92	92	92	

NOTE: Standard errors in parentheses. ††Significant at the 5% level. †Significant at the 10% level.

Table 4

Growth: The Role of Human Capital and Trade Regimes
(Real Exchange Rate Distortion > Median of Sample = Closed Regime)

Dependent Variable: log difference GDP per working-age person 1960-1988

	(1)	(2)	(3)	(4)	
Constant	-1.883	-1.637	1.829	5.009†	
	(2.903)	(2.868)	(2.754)	(2.982)	
ln(Y60)	-0.988††		-1.092††	-1.231††	-1.147††
	(0.261)	(0.264)	(0.241)	(0.238)	
$\ln(n + g + \delta)$	-0.581	-0.764	-0.874	0.186	
	(1.254)	(1.241)	(1.132)	(1.169)	
ln(I/Y + School)	2.419††	2.510††	2.630††	2.408††	
	(0.390)	(0.388)	(0.384)	(0.383)	
ln(LIT60)	0.671††	0.669††	0.355†	0.321	
	(0.200)	(0.198)	(0.201)	(0.221)	
RERMED * ln(LIT60)		-0.154†	-0.129†	-0.083	
		(0.082)	(0.076)	(0.077)	
GovCon			-9.641††	-9.466††	
			(2.240)	(2.198)	
ASSN			-0.129	-0.012	
			(0.297)	(0.296)	
REV			-1.365††	-1.309††	
			(0.570)	(0.557)	
AFRICA				-0.612	
				(0.397)	
LATIN				-0.869††	
				(0.356)	
$\overline{R}^2$	0.50	0.51	0.60	0.63	
r.m.s.e.	1.35	1.33	1.20	1.15	
observations	97	97	97	97	

NOTE: Standard errors in parentheses. ††Significant at the 5% level. †Significant at the 10% level.

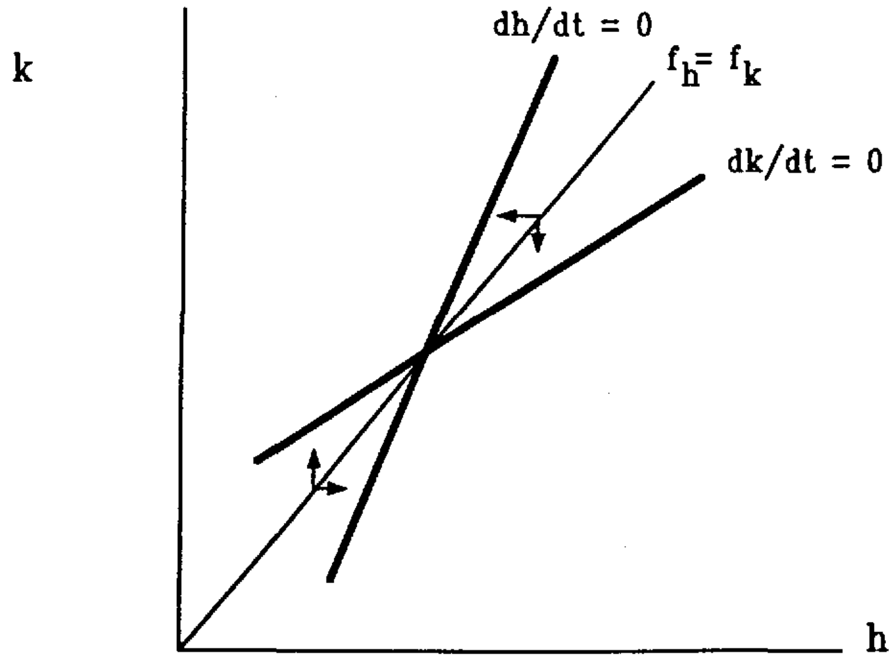
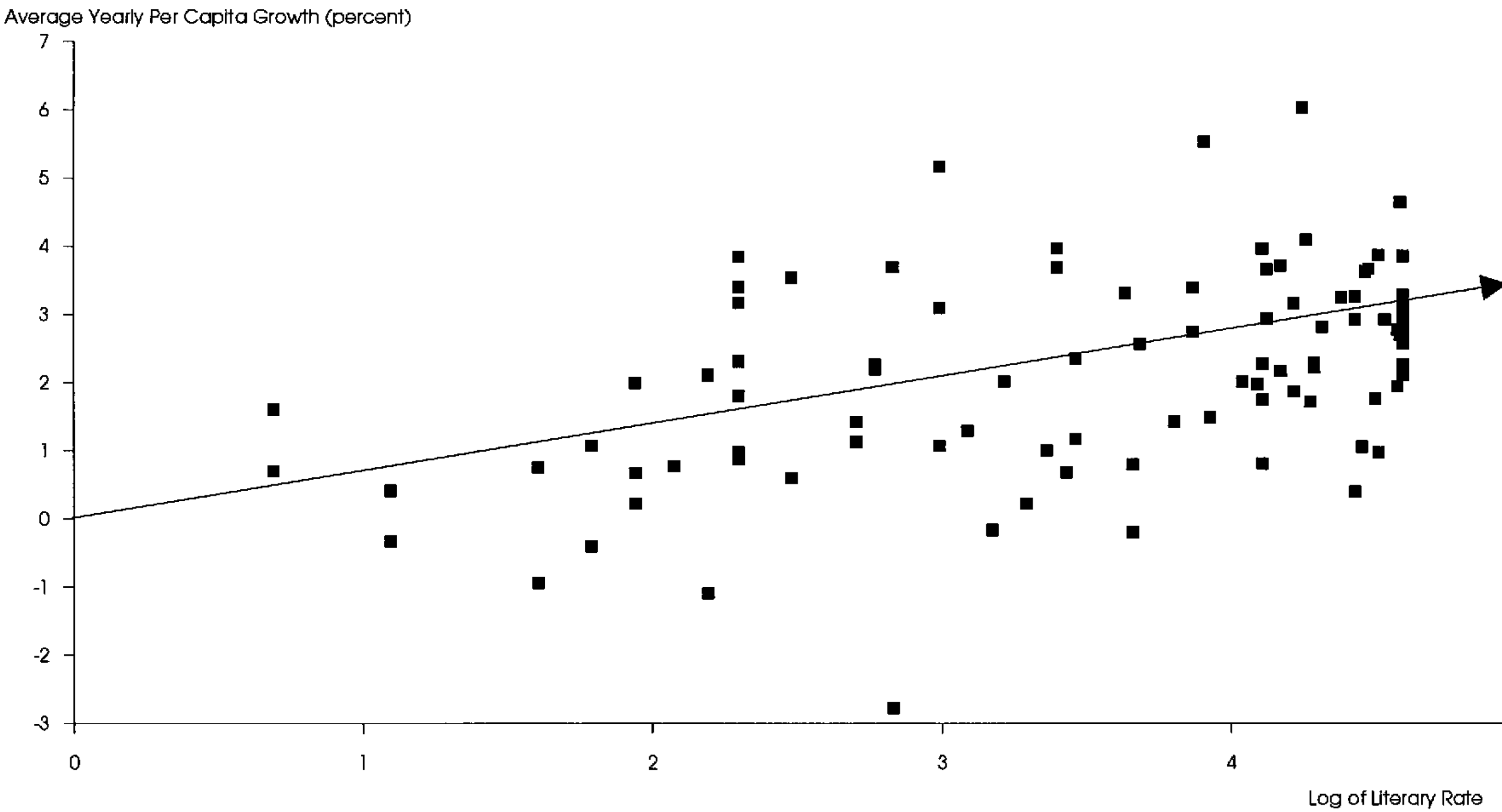


Figure 1: The Solow Model with Human Capital

Figure 2

Partial Correlation Between average yearly per Capita Growth (1960-1988) and Literacy Rates
(from regression (2) Table 1)



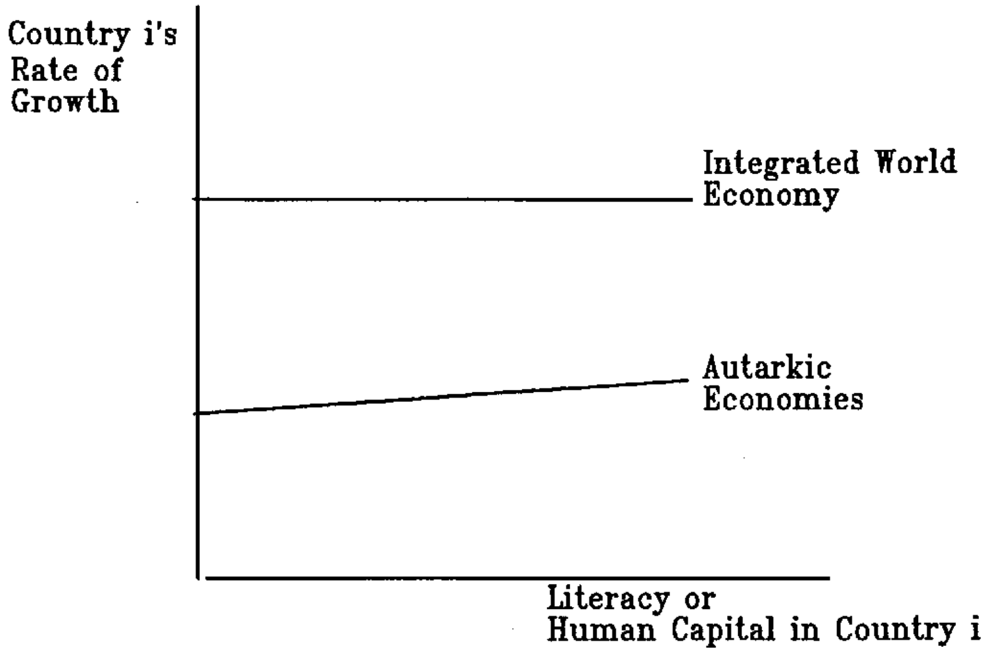


Figure 3: Endogenous Growth with Full Integration

Figure 4

Partial Correlation Between Average Yearly per Capita Growth (1960-1988) and Literacy Rates
(from regression (2) Table 2)

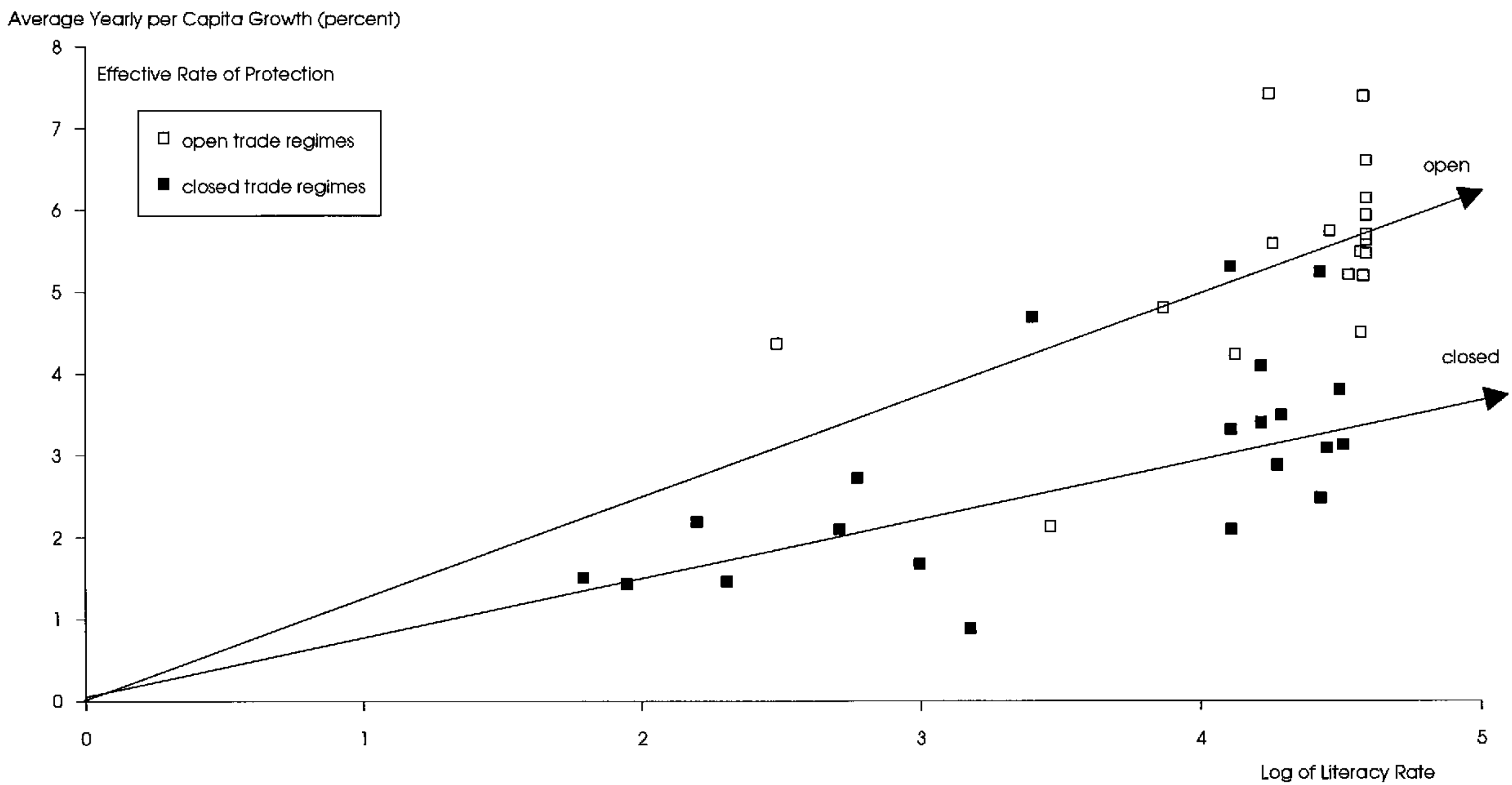


Figure 5

Partial Correlation Between Average Yearly per Capita Growth (1960-1988) and Literacy Rates
(from regression (2) Table 3)

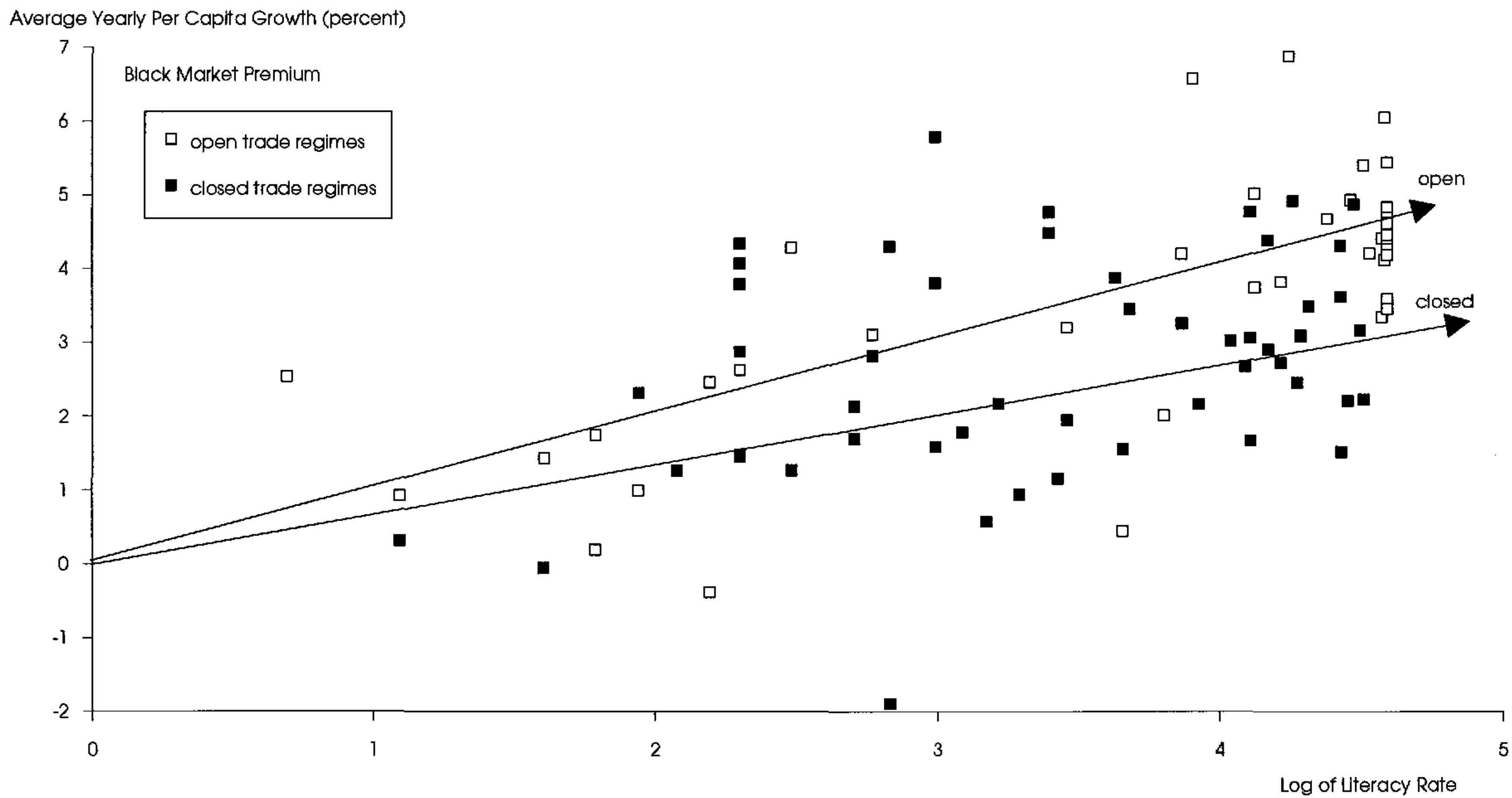


Figure 6

Partial Correlation Between Average Yearly per Capita Growth (1960-1988) and Literacy Rates
(from regression (2) Table 4)