Macroeconomic Dynamics, **3**, 1999, 204–225. Printed in the United States of America.

A MIXED BLESSING

Natural Resources and Economic Growth

THORVALDUR GYLFASON
University of Iceland

TRYGGVI THOR HERBERTSSON
University of Iceland
and
University of Aarhus

GYLFI ZOEGA
Birkbeck College, University of London

This paper diagnoses the symptoms of the Dutch disease in a two-sector stochastic endogenous growth model. A productive, low-skill-intensive primary sector causes the currency to appreciate in real terms, thus hampering the development of a high-skill-intensive secondary sector and thereby reducing growth. Moreover, the volatility of the primary sector generates real-exchange-rate uncertainty and may thus reduce investment and learning in the secondary sector and hence also growth. Cross-sectional and panel regressions based on data for 125 countries in the period 1960–1992 confirm a statistically significant inverse relationship between the size of the primary sector and economic growth, but not between the volatility of the real exchange rate and growth.

Keywords: Economic Growth, Natural Resources, Dutch Disease, Learning-by-doing

> Since the second world war it has become quite clear that rapid economic growth is available to those countries *with adequate natural resources* [italics added] which make the effort to achieve it.—W. Arthur Lewis (1968, p. ix).

1. INTRODUCTION

Economic growth is a complex phenomenon. Nevertheless, the empirical growth literature of recent years has identified only a couple of robust determinants of the

The authors wish to thank J. Michael Orszag, Ron Smith, Fridrik M. Baldursson, and seminar participants at Birkbeck College, Queen Mary College, and the London School of Economics for useful comments and Haukur C. Benediktsson for research assistance. Address correspondence to: T. Gylfason, University of Iceland, Odda v/Sturlugotu, IS-101 Reykjavik, Iceland, SNS, Stockholm, and CEPR; e-mail gylfason@hi.is. T. Herbertsson, Institute of Economic Studies, University of Iceland, Odda v/Sturlugotu, IS-101 Reykjavik, Iceland, and University of Aarhus; e-mail tthh@hi.is. G. Zoega, Birkbeck College, University of London, 7-15 Gresse Street, London W1P 2LL; e-mail gzoega@econ.bbk.ac.uk.

© 1999 Cambridge University Press 1365-1005/99 $9.50

https://doi.org/10.1017/S1365100599011049 Published online by Cambridge University Press

rate of growth of per capita GDP across countries: initial GDP and the ratio of investment to GDP. A few more variables have been suggested by some writers: foreign trade, school enrollment, inflation, political instability, corruption, inequality, and the preponderance of the primary sector in the economy. We focus on the links between primary production and growth.

We contend that the division of GDP between primary and secondary production affects economic growth in the long run. A casual look at the evidence seems to support this view. There is, for example, a statistically significant negative correlation between the initial share of the primary sector in the labor force and the average ratio of investment to GDP (Figure 1). This suggests that excessive primary production may inhibit growth by reducing investment in physical capital. If this is the sole channel through which primary production affects growth, however, then the inclusion of investment in a cross-country growth regression should render the effect of primary production on growth statistically insignificant.

Our main hypothesis in this paper is that an abundance of natural resources and a corresponding preponderance of primary production tend to inhibit economic growth by reducing investment in *human* capital.

The role of human capital in empirical models of economic growth has been emphasized lately by Barro (1991), Mankiw et al. (1992), and Barro and Sala-i-Martin (1995). The idea goes back, at least, to Lewis (1955) and Nelson and Phelps (1966), who claim that educated workers are faster learners, because education

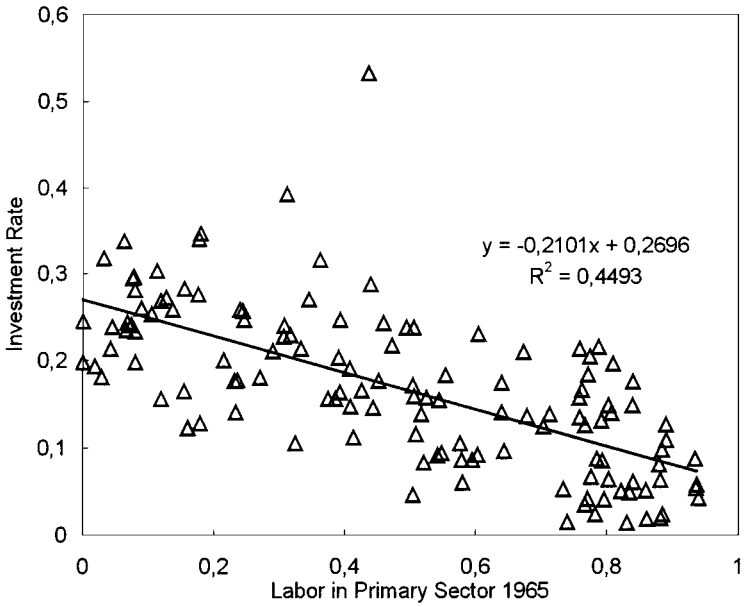


Figure 1. Relationship between average investment rate over 1960–1992 and the share of labor in the primary sector during 1965 in a cross section of countries.

https://doi.org/10.1017/S1365100599011049 Published online by Cambridge University Press

teaches people to learn; see also Romer (1986, 1990) and Lucas (1988). In the context of endogenous growth models, a faster rate of learning and knowledge spillovers free the economy from diminishing returns and thus facilitate sustained growth.

This paper is intended to shed further light on the role of human capital in models of economic growth by pointing out the possible role of sectoral differences in education in explaining cross-country differences in growth. In particular, we claim that the primary sector, which includes agriculture, fishing, and forestry, may need—and also generate—less human capital than services and manufacturing.[1] We suspect that, for this reason, countries with a comparative advantage in the production of primary output consequently may experience less economic growth. This may help explain the significance of measures of human capital in cross-country growth regressions reported by Barro (1991), Mankiw et al. (1992), and Barro and Lee (1993).

Why do countries that specialize in a stagnant primary sector fail to develop a thriving secondary sector and thus sustain growth? A plausible explanation involves the Dutch disease [see Corden (1984)]: The dominant primary industry causes the currency to appreciate in real terms, hence reducing the profitability of other exports. We extend this argument by describing how a floating-exchange-rate regime can provide insurance for the dominating primary export industry at the cost of increased exchange-rate uncertainty for all other industries.[2] These problems magnify the distortions in the intersectoral allocation of the factors of production, so that economic growth is reduced further.

The next section lays out a simple stochastic endogenous growth model with a tradable and a nontradable sector, where the former has access to two different kinds of production technology, viz., a *primary* sector and a *secondary* sector. We assume that learning-by-doing and knowledge spillovers only occur in the latter. We describe the conditions necessary for the emergence of a secondary sector, which escapes diminishing returns and generates growth, in the presence of a dominant primary sector. Section 3 tests the implications of the model based on both a cross section and a panel of countries. Section 4 concludes.

2. GROWTH WITH A SMOTHERING PRIMARY SECTOR

2.1. Primary Production and the Real Exchange Rate

The economy initially produces tradable goods, y_1^T, in a primary sector, where output depends on the relative price of tradable goods in terms of nontradables, $\lambda = p^T/p^N$, i.e., the real exchange rate:

$$y_1^T = B_1 + \beta\lambda, \qquad \beta > 0. \tag{1}$$

B_1 represents productivity in the primary sector, which is subject to productivity shocks that follow a geometric Wiener process, $dB_1 = \sigma B_1 dW$, without drift. The domestic demand for the tradable primary good also is described by a simple linear

https://doi.org/10.1017/S1365100599011049 Published online by Cambridge University Press

function of the real exchange rate,

$$c^T = A - \alpha\lambda, \qquad \alpha > 0, \tag{2}$$

where A represents autonomous demand. The real exchange rate is determined by the intertemporal budget constraint, which requires the economy to export (import) enough tradable goods to pay (consume) interest on foreign debt (assets). In the absence of trend productivity growth, this translates into equation (3), where D denotes the noninterest external surplus—measured in units of tradable goods—needed to meet interest payments on foreign debt in order to keep its stock constant. A constant level of foreign debt is assumed:

$$D = y_1^T - c^T = B_1 - A + (\alpha + \beta)\lambda. \tag{3}$$

Equations (1–3) give the real exchange rate, λ, as a function of B_1, D, A, and the effects of the real exchange rate on primary sector output supply and demand, β and α. For a given value of the noninterest surplus, taking the total differential of (3) and using Ito's lemma gives

$$d\lambda = -\left(\frac{1}{\alpha + \beta}\right)\sigma B_1 dW. \tag{4}$$

Changes in the real exchange rate are thus a function of the stochastic process followed by B_1. This is the same process as the one followed by productivity except for the first term on the right-hand side, which is negative. Thus a productivity improvement in the primary sector leads to a real appreciation of the currency: λ falls. The relationship between the real exchange rate and B_1 is commonly referred to as the Dutch disease: A productive primary sector causes the currency to appreciate in real terms (i.e., λ to fall), hence making it difficult for other potential export industries to establish themselves or for existing ones to thrive. The magnitude of the effect on the real exchange rate depends on supply-and-demand elasticities of primary output of tradables, hence β and α. If these two parameters are small, the effect on the real exchange rate is large. Thus we expect the symptoms of the Dutch disease to be particularly serious in countries with low elasticities. Moreover, real exchange rates will be more volatile in such countries: The variance term in equation (4) will be larger. We discuss the consequences of this below.

2.2. When Can a Secondary Sector Emerge?

Now, imagine that tradable output also could be produced by using an alternative technology in the secondary sector. Moreover, assume that its share of employment is initially small: $l_2 = \epsilon$. Thus we imagine that there is one type of (tradable) output and two types of production technology, primary and secondary. Both have diminishing private returns to labor. However, they differ in two ways as follows: (1) No training of labor is required in the primary sector, whereas in the secondary

https://doi.org/10.1017/S1365100599011049 Published online by Cambridge University Press

sector, hiring involves training, i.e., investment in human capital.[3] (2) There is learning-by-training in the secondary sector, involving instantaneous knowledge spillovers. This implies constant returns to scale at the social level in the secondary sector. This follows from our presumption, supported by the studies mentioned above, that workers in the secondary sector are more skilled on average and, for that reason, more open to new production processes while in training.

The production technology in the secondary, tradable sector now can be described as follows for the representative firm:

$$y_2^T = B_2 l_2^{\alpha} L_2^{1-\alpha}, \tag{5}$$

where y_2^T is output, B_2 is an exogenous measure of technology in the secondary sector, l_2 is labor in the secondary sector, and L_2 is the aggregate labor force used there. The number of firms is $n = L_2/l_2$. The inclusion of L_2 in the production function reflects the effect of learning-by-doing (training): A new worker trained in the secondary sector increases aggregate knowledge about production in the sector through instantaneous knowledge spillovers. We assume that B_2 is deterministic and fixed.

The exchange rate regime and the (initially) dominant share of primary output in exports reduce the risk of production in the primary sector. Real exchange rate movements reduce uncertainty in the primary sector, whereas they increase it in the (hypothetical) secondary sector: Starting secondary production is risky because the real exchange rate and B_2 are not correlated.

B_1 and B_2 have no trend, and so, the only potential source of technological progress is learning-by-doing in the secondary sector. Accordingly, until a secondary sector emerges, there is no growth. This means that the higher the value of B_1, the higher will be the real exchange rate (i.e., λ will be lower), and hence the more difficult it will be for a secondary sector to take off, i.e., for growth to take place. We return to this theme shortly.

Because of the training costs in the secondary sector, we treat labor in that sector as a quasi-fixed asset. The decision to hire workers in that sector is inherently an intertemporal (investment) decision. We use the methods described by Dixit and Pindyck (1994) to solve the optimization problem faced by the representative firm in this sector. We denote the cost of hiring by T per worker. Workers in the secondary sector quit with probability q. This is because of random preferences, which cause workers to switch between firms for nonwage reasons with a fixed probability per unit of time. Because firms, when hiring new workers, know only the average quit rate but not an individual's exposure to personal factors, it is this average quit rate that they take into account when making their hiring decisions.[4]

Using Ito's lemma, we get the following Bellman equation, which describes the value of the stock of trained, secondary-sector workers l_2, i.e., the value of the firm, V, when the value of future hires in the sector is ignored:

$$rV(l_2, \lambda) = \lambda B_2 l_2^{\alpha} L_2^{1-\alpha} - w l_2 - q l_2 V_{l_2} + \frac{1}{2}\left(\frac{1}{\alpha+\beta}\right)^2 \sigma^2 B_1^2 V_{\lambda\lambda} \tag{6}$$

https://doi.org/10.1017/S1365100599011049 Published online by Cambridge University Press

and r is the real rate of interest and w is the real wage measured in nontraded goods. Each firm is small enough to take the total number of workers in the industry, L_2, as given. Equation (6) is essentially an asset equation. The left-hand-side variable shows the required return. The right-hand side is the sum of a dividend and an expected capital gain. The first term on the right-hand side is current output in the secondary sector. The second term shows the wage bill. The third term is the expected loss due to quits of previously trained workers. The last term is the expected change in the value of the firm in response to future changes in the real exchange rate.

The solution to differential equation (6) contains the following particular integral, V^P:

$$V^P(l_2, \lambda) = E \int_0^\infty \left[\lambda B_2 \left(l_2 e^{-qt}\right)^\alpha L_2^{1-\alpha} - w\left(l_2 e^{-qt}\right)\right] e^{-rt}\, dt. \tag{7}$$

This is the expected, present discounted value of future profits from the l_2 workers employed at time zero, measured by the difference between future output and wage payments, taking into account the constant quit rate, q. The equation can be rewritten as follows:

$$V^P(l_2, \lambda) = \frac{\lambda B_2 l_2^\alpha L_2^{1-\alpha}}{r + \alpha q} - \frac{w l_2}{r + q}. \tag{8}$$

To find the value of the marginal secondary-sector worker,[5] we take the derivative of (8) with respect to l_2:

$$v^P(l_2, \lambda) \equiv V_{l_2}^P(l_2, \lambda) = \frac{\alpha\lambda B_2 l_2^{\alpha-1} L_2^{1-\alpha}}{r + \alpha q} - \frac{w}{r + q}. \tag{9}$$

We also need to calculate the value of the option to hire a worker in the secondary sector, i.e., the complementary function. Now, define v^G as the value of the option to hire the marginal worker, where G denotes general,

$$v^G(l_2, \lambda) \equiv V_{l_2}(l_2, \lambda), \tag{10}$$

and differentiate the homogenous part of equation (6) with respect to l_2. This gives

$$(r + q)v = \left[-q l_2 v_{l_2} + \frac{1}{2}\left(\frac{B_1}{\alpha + \beta}\right)^2 \sigma^2 v_{\lambda\lambda}\right]. \tag{11}$$

The general solution is

$$v^G(l_2, \lambda) = C_1 \Lambda^{\gamma_1} + C_2 \Lambda^{\gamma_2}, \tag{12}$$

where $\Lambda = \alpha\lambda B_2 l_2^{\alpha-1} L_2^{1-\alpha}$, γ_1 and γ_2 are the roots of the characteristic equation, and $\gamma_1 > 1$ and $\gamma_2 < 0$.[6] The negative root is eliminated because we want the

https://doi.org/10.1017/S1365100599011049 Published online by Cambridge University Press

value of the option to go to zero as the real exchange rate approaches zero. This simplifies the general solution to

$$v^G(l_2, \lambda) = C_1 \Lambda^{\gamma_1}. \tag{13}$$

The value of the marginal employed worker in the secondary sector is then equal to v^P and the option value of hiring him is equal to v^G. The latter is part of the cost of hiring the worker. When a new worker is hired and the direct training costs, T, are incurred, the option of hiring him in the future is sacrificed. The marginal cost of hiring a new worker is, therefore, equal to the sum of T and v^G. The threshold value of the real exchange rate at which the representative firm starts hiring new workers, λ_H, is defined by the following two conditions:

Value-matching condition.

$$\frac{\alpha \lambda_H B_2 l_2^{\alpha-1} L_2^{1-\alpha}}{r + \alpha q} - \frac{w}{r+q} = T + C_1 \Lambda_H^{\gamma_1}, \qquad \Lambda_H \equiv \alpha \lambda_H B_2 l_2^{\alpha-1} L_2^{1-\alpha}. \tag{14}$$

The left-hand side of this equation is the marginal benefit from hiring a new worker. The right-hand side is the marginal cost, which is equal to the sum of the direct training cost and the indirect cost because of the sacrificed option of hiring him later.

Smooth-pasting condition.

$$\frac{\alpha B_2 l_2^{\alpha-1} L_2^{1-\alpha}}{r + \alpha q} = C_1 \gamma_1 \Lambda_H^{\gamma_1 - 1} \alpha B_2 l_2^{\alpha-1} L_2^{1-\alpha}. \tag{15}$$

This condition requires the derivative of the marginal benefit and the marginal cost with respect to the real exchange rate to be equal at the hiring threshold.

Solving equation (15) for C_1 and substituting into (14) gives

$$\lambda_H = \left(\frac{\gamma_1}{\gamma_1 - 1} \right) \left\{ \frac{(r + \alpha q)\,[w/(r+q) + T]}{\alpha B_2 l_2^{\alpha-1} L_2^{1-\alpha}} \right\}. \tag{16}$$

Combining equations (16), (1), (2), and (3) gives

$$\lambda(D, \alpha, \beta, B_1, A) \gtreqless \left(\frac{\gamma_1}{\gamma_1 - 1} \right) \left\{ \frac{(r + \alpha q)\,[w/(r+q) + T]}{\alpha B_2 l_2^{\alpha-1} L_2^{1-\alpha}} \right\}. \tag{17}$$

The implications of the model are summarized by this equation. It defines a threshold value of the real exchange rate—a *growth threshold*—such that if the exchange rate is higher, no investment takes place in the secondary sector, whereas if it is lower, there is investment in the sector. Thus, below the threshold, there is no economic growth, whereas above it, the economy grows continuously in the absence of further changes in the real exchange rate.

The first term on the right-hand side is positive and greater than one. It makes the firm wait beyond the point at which the present discounted value of future

https://doi.org/10.1017/S1365100599011049 Published online by Cambridge University Press

profits is equal to the cost of training the worker. The firm waits longer, because it seeks more information about future values of the real exchange rate: Time is of value.

We can summarize the key implications as follows:

2.2.1. Knowledge externalities and overvaluation. The knowledge externalities in the secondary sector raise the growth threshold. The private marginal product of labor is lower than the average product of labor, which is the social marginal product. The average product of labor in our representative firm is

$$\frac{y_2^T}{l_2} = B_2 (L_2/l_2)^{1-\alpha} = B_2 n^{1-\alpha} \equiv f(n), \tag{18}$$

where n is the number of firms in the secondary sector, as before. The marginal product is

$$\frac{\partial y_2^T}{\partial l_2} = f(n) - nf'(n) = B_2 n^{1-\alpha} - (1-\alpha) B_2 n^{1-\alpha}, \tag{19}$$

which is lower than the average product. Therefore, it would be optimal for investment in the secondary sector to start before the threshold of equation (17) is reached.

2.2.2. Real exchange rate and primary sector productivity. The actual value of the real exchange rate is a function of productivity in the primary sector, B_1; the effect of the real exchange rate on the supply and domestic demand for primary output, β and α; autonomous demand for primary output, A; and the noninterest external surplus required to keep the stock of foreign debt, D, constant; i.e.,

$$\lambda_{B_1} < 0, \qquad \lambda_\beta < 0, \qquad \lambda_\alpha < 0, \qquad \lambda_A > 0, \qquad \lambda_D > 0. \tag{20}$$

A more productive primary sector causes the currency to appreciate in real terms, hence moving λ further below its growth threshold. This is the Dutch disease: Growth is reduced even further. A rise in foreign indebtedness, which makes a higher noninterest external surplus necessary, causes a real depreciation of the currency, and we move up toward the threshold. Thus, increased external debt can spur economic growth by making investment in the secondary (tradable) goods sector profitable. Finally, a given positive level of D requires a higher value of λ, the more so the lower the sensitivity of tradable goods output and consumption to changes in the real exchange rate.[7]

2.2.3. Exchange rate volatility. The value of the growth threshold depends on the degree of exchange-rate uncertainty, $[B_1/(\alpha+\beta)]\sigma$, through γ_1, where σ is a measure of uncertainty about future primary-sector productivity and B_1 is the current level of productivity in that sector. Increased uncertainty reduces γ_1 and thus increases the first term on the right-hand side of (17): The threshold rises.

https://doi.org/10.1017/S1365100599011049 Published online by Cambridge University Press

Thus, the greater the size of productivity shocks in the primary sector, the higher is the growth threshold. Intuitively, firms wait longer before entering the secondary sector, because the future is less certain: They wait longer for information about future real exchange rates. Because this is due entirely to the exchange-rate regime, we conclude that a flexible exchange rate exacerbates the market failure described above: The growth threshold rises further away from its social optimum. This is a different, although less noticed, form of the Dutch disease. How much the threshold is raised depends on the elasticity of supply and demand of tradable output. Low elasticities require greater changes in the real exchange rate.

The threshold also depends on real wages, w; training costs in the secondary sector, T; the real rate of interest, r; the average quit rate in the secondary sector, q; and the level of the exogenously given productivity in the sector, B_2. High wages make it less profitable to train new workers in the secondary sector and, obviously, so do also high training costs. Similarly, both high interest rates and high quit rates make investment in the secondary sector less profitable and hence require a higher real exchange rate for investment to occur.[8] Moreover, the more productive the secondary sector, the lower the growth threshold. Finally, the more firms there are in the secondary sector, n, the higher is its marginal product and the lower is the threshold.

The question arises whether growth can continue indefinitely once the currency has depreciated enough, so that λ has reached the growth threshold. Because there are constant returns to labor at the industry level, this appears to be the case, but note that, with economic growth, demand for nontradables would increase, as would their relative price—the real exchange rate would appreciate. As the currency appreciates, growth in the secondary sector peters out. There comes a time, other things being equal, when the currency has appreciated enough in real terms to make investment in the secondary sector stop, thus stifling economic growth.

We have not dicussed the consumers' intertemporal optimization problem [see Merton (1975) for a solution to this problem using stochastic calculus]. However, a few comments are in order: Before any investment in the secondary sector takes place, the real rate of interest is equal to the world interest rate as domestic consumers can invest their savings abroad. Moreover, we assume that the world real rate of interest is equal to the pure rate of time preference. For this reason, there is initially no saving in the economy, consumption is flat, and the stock of foreign debt (assets) is fixed.

When the real exchange rate crosses the growth threshold defined by equation (17), the net supply of domestic output falls as firms in the secondary sector start using workers to train newcomers: There is domestic investment for the first time. Because this is investment in human capital, we assume that foreigners do not lend capital to finance it. Consequently, this increases investment, stimulates output demand, and drives the domestic real rate of interest above the world rate. Therefore, consumption drops initially and then grows in the new steady state along with output in the secondary sector, at a higher rate than before.

https://doi.org/10.1017/S1365100599011049 Published online by Cambridge University Press

3. EMPIRICAL EVIDENCE

The empirical implications of our model now can be summarized as follows, where g denotes the rate of economic growth:

$$g = f(\overset{-}{B_1}, \overset{+}{D}, \overset{-}{\sigma}, \overset{-}{T}, \overset{-}{q}, \overset{+}{n}). \tag{21}$$

The rate of growth of output is a declining function of the level of productivity in the primary sector, B_1, because a larger primary sector causes a real appreciation of the currency and thus reduces the profitability of investment in the secondary sector. Increased uncertainty about future primary-sector productivity, σ, raises the threshold and reduces growth, and so also do (1) an increase in the cost of training workers in the secondary sector, T; (2) an increase in the quit rate, q; and (3) a fall in the number of firms in the secondary sector, n, *ceteris paribus*. The last effect is a scale effect: There is more knowledge in a larger economy. A rise in the required noninterest external surplus, D, reduces the real exchange rate and stimulates growth.

We focus on the first three variables in equation (21) by testing the relationship between economic growth and the size and volatility of the primary sector, the latter through the volatility of the real exchange rate, and also the level of foreign debt. The key implication of the model is that an expansion of the primary sector, as, for example, brought about by an improvement in primary production technology, will reduce the rate of growth by reducing learning in the secondary sector, and hence also human capital accumulation. This effect may explain, at least in part, the apparent statistical significance of human capital variables such as school enrollment rates in the growth studies mentioned above. Investment in human capital through training in the secondary sector tends to help strengthen formal education, and a good education system, in turn, may be conducive to the creation of a (human-capital-generating) secondary sector. Figures 2 to 4 support our hypothesis by displaying a strong and statistically significant inverse correlation between the initial share of the primary sector in the labor force and the initial enrolment rate in primary schools (Figure 2), secondary schools (Figure 3), and tertiary schools (Figure 4).

These correlations suggest that primary production may be a useful proxy for human capital in cross-country growth regressions. If so, the relationship between growth and school enrollment rates may be spurious, simply reflecting the effect of an omitted variable—the size of the primary sector. To find out, we include school enrollment rates and measures of primary production, measured both by the share of primary production in the labor force and the share of primary exports in total exports, side by side among other explanatory variables in a growth regression to see which contributes the most to the explanation of differences in growth rates across countries.

https://doi.org/10.1017/S1365100599011049 Published online by Cambridge University Press

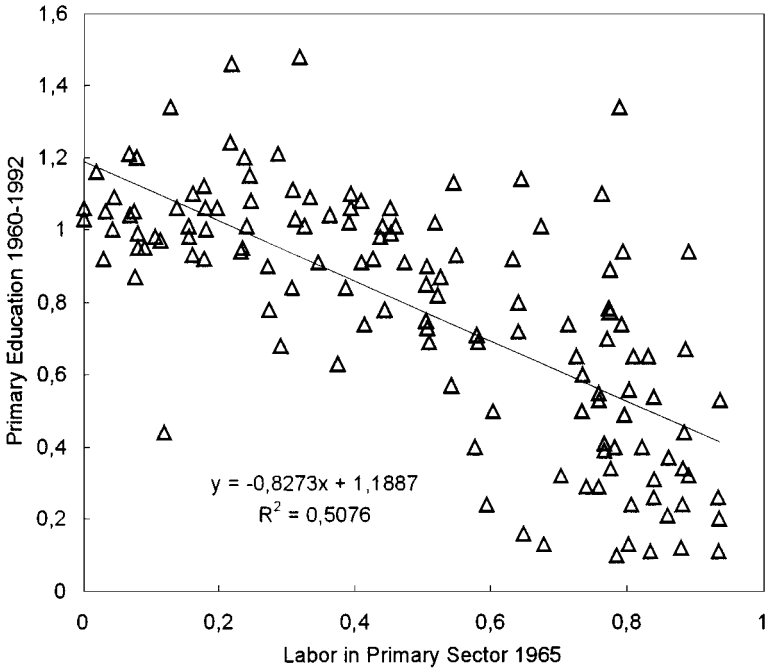


FIGURE 2. Relationship between the average primary school enrollment 1960–1992 and the share of labor in the primary sector during 1965 in a cross section of countries.

3.1. Data

We use cross-sectional data constructed from the Penn World Tables and the World Data Bank. The sample period is 1960–1992. In the first regression (Table 1), which corresponds to a β-convergence regression, we use data for 125 countries. As we move toward a more general model specification, the number of countries decreases until, in the fifth regression, we are left with 65 countries. This method enables us to use as much as possible of the information available for each model, but it leaves us with parameters that are not directly comparable across models. For a detailed description of the data, see the Appendix.

3.2. Cross-Sectional Estimation

We start with the standard cross-sectional regression model. The regressors are initial GDP (1960), investment/GDP ratio, initial share of primary production in the labor force (1970), external debt in proportion to GDP, real-exchange-rate volatility, initial primary and secondary school enrolment rates (1965), and a dummy for Africa.

The first regression is the standard convergence regression. In regression 2, we add the two standard proxies for human capital, the initial primary- and secondary-

https://doi.org/10.1017/S1365100599011049 Published online by Cambridge University Press

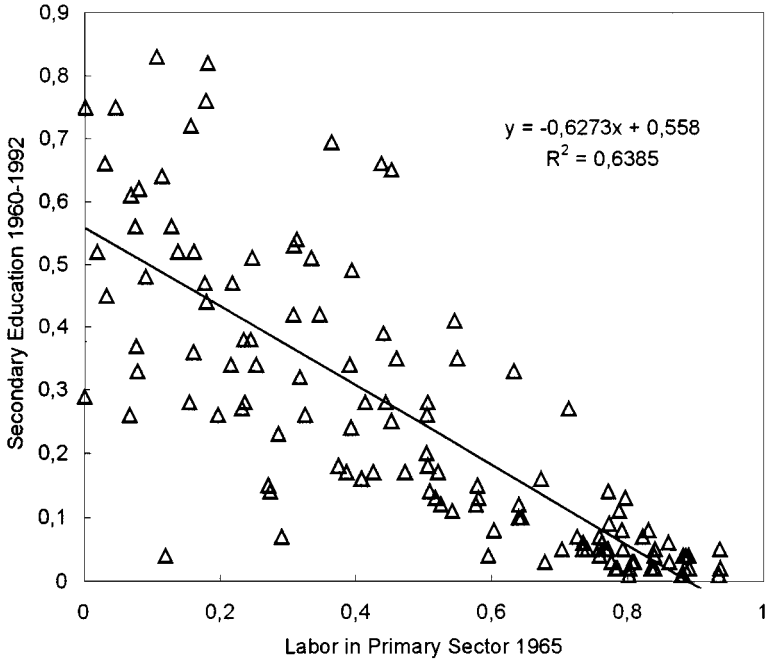


FIGURE 3. Relationship between the average secondary school enrollment 1960–1992 and the share of labor in the primary sector during 1965 in a cross section of countries.

school enrollment rates; in regressions 3a–5a, we add, one at a time, the variables implied by our model, i.e., the initial share of the primary sector in the labor force, the ratio of external debt to GDP, and an index of real-exchange-rate volatility. In regressions 3b–5b, we use the ratio of primary exports to total exports of goods and services instead of the share of the primary sector in the labor force. In regressions 6a–8a, we add the same three variables, now excluding the schooling variables from the regressions. And finally, in regressions 6b–8b, we include the ratio of primary exports to total exports, now excluding the school enrollment variables. In Table 1, we report our findings on the relationship between growth and the explanatory variables, the standard errors of estimation (SE), the adjusted coefficient of determination ($\overline{R}^2$), and the degrees of freedom (DF).[9]

Table 2 shows the correlations between the orthogonal components of the regressors and the per-capita growth rate with and without the school enrollment variables.[10]

The partial correlation between per-capita growth and investment and external indebtedness is significant at the 1% level in both equations. The hypothesis of zero correlation cannot be rejected for primary and secondary education and the exchange-rate volatility index at reasonable levels. The same hypothesis is marginally rejected for primary labor at the 5% level in the first equation, but

https://doi.org/10.1017/S1365100599011049 Published online by Cambridge University Press

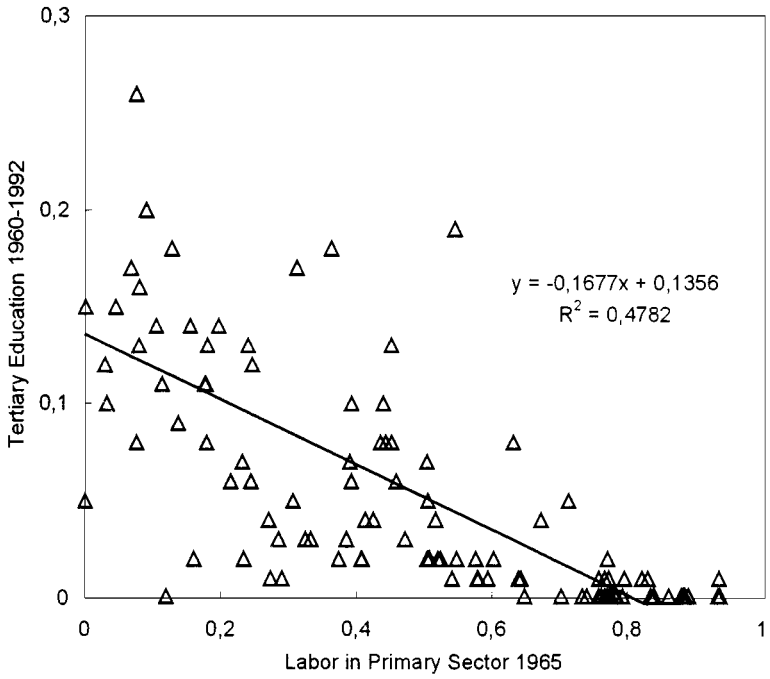


FIGURE 4. Relationship between the average tertiary school enrollment 1960–1992 and the share of labor in the primary sector during 1965 in a cross section of countries.

cannot be rejected in the second. A similar pattern is observed when the share of the primary sector in the labor force, excluding extraction industries, is replaced by the share of primary exports in total exports, and the estimates become more precise. The gain of precision is understandable in view of the fact that the correlation between the share of primary exports in total exports and primary- and secondary-school enrollment rates are smaller (-0.23 and -0.52, respectively) than the correlations between the share of the primary sector in the labor force and primary- and secondary-school enrollment (-0.41 and -0.74, respectively). These correlations in turn may be viewed as an indication that extraction industries (mining, etc.) generally use somewhat better-educated labor on average than agriculture and fisheries. The remainder of this section describes the results obtained in further detail.

3.2.1. Initial GDP. The coefficients on this variable represent β-convergence rates. The parameter reflects the speed at which poor countries converge to rich ones in terms of GDP. The coefficient is significantly different from zero in all of the regressions, but small, implying a convergence speed of 0.8% to 1.6% per year. This result is, however, in line with the findings of Nerlove (1996) and Gylfason and Herbertsson (1996) for large panels of countries.

https://doi.org/10.1017/S1365100599011049 Published online by Cambridge University Press

https://doi.org/10.1017/S1365100599011049 Published online by Cambridge University Press

Table 1. Cross-sectional results, 1960–1992

	Regression[a]													
Regressor	(1)	(2)	(3a)	(4a)	(5a)	(3b)	(4b)	(5b)	(6a)	(7a)	(8a)	(6b)	(7b)	(8b)
Initial GDP	−0.008	−0.010	−0.014	−0.016	−0.016	−0.009	−0.011	−0.011	−0.013	−0.016	−0.016	−0.009	−0.012	−0.012
	(−4.28)	(−4.54)	(−5.44)	(−4.09)	(−4.03)	(−3.58)	(−2.58)	(−2.53)	(−5.62)	(−4.34)	(−4.31)	(−4.04)	(−4.08)	(−3.98)
Investment	0.152	0.120	0.110	0.146	0.145	0.122	0.149	0.149	0.121	0.149	0.149	0.137	0.155	0.155
	(8.41)	(5.11)	(4.47)	(4.39)	(4.29)	(4.24)	(3.86)	(3.80)	(6.08)	(5.16)	(5.11)	(5.47)	(4.94)	(4.88)
Primary education 1965	—	0.015	0.011	0.006[b]	0.007[b]	0.014	0.012[b]	0.012[b]	—	—	—	—	—	—
		(3.11)	(2.03)	(0.72)	(0.74)	(2.25)	(1.13)	(1.11)						
Secondary education 1965	—	0.010[b]	0.002[b]	0.005[b]	0.005[b]	−0.006[b]	−0.010[b]	−0.010[b]	—	—	—	—	—	—
		(1.08)	(0.24)	(0.36)	(0.36)	(−0.50)	(−0.60)	(−0.60)						
Labor in primary sector 1965	—	—	−0.024	−0.019[b]	−0.019[b]	—	—	—	−0.030	−0.023	−0.023	—	—	—
			(−2.54)	(−1.48)	(−1.46)				(−3.49)	(−1.91)	(−1.89)			
Export of primary products 1970	—	—	—	—	—	−0.020	−0.021	−0.021	—	—	—	−0.019	−0.020	−0.020
						(−3.44)	(−2.58)	(−2.54)				(−3.32)	(−2.60)	(−2.57)
External debt	—	—	—	−0.019	−0.018	—	−0.026	−0.026	—	−0.019	−0.019	—	−0.030	−0.030
				(−2.87)	(−2.70)		(−2.69)	(−2.58)		(−3.29)	(−3.14)		(−3.28)	(−3.18)
Exchange rate volatility	—	—	—	—	0.003[b]	—	—	0.000[b]	—	—	0.004[b]	—	—	−0.001[b]
					(0.30)			(0.00)			(0.38)			(−0.11)
Constant	0.054	0.063	0.105	0.124	0.125	0.073	0.087	0.087	0.113	0.127	0.127	0.077	0.101	0.101
	(4.13)	(4.47)	(4.72)	(3.67)	(3.66)	(3.83)	(2.84)	(2.80)	(5.33)	(4.09)	(4.08)	(4.49)	(4.40)	(4.35)
Africa dummy	−0.010	−0.007	−0.005	−0.003[b]	−0.003[b]	−0.008	−0.001[b]	−0.001[b]	−0.007	−0.004[b]	−0.004[b]	−0.010	−0.002[b]	−0.002[b]
	(−3.14)	(−2.40)	(−1.69)	(−0.55)	(−0.57)	(−2.07)	(−0.21)	(−0.21)	(−2.12)	(−0.89)	(−0.90)	(−2.56)	(−0.34)	(−0.32)
SE	0.013	0.012	0.012	0.013	0.013	0.012	0.012	0.012	0.012	0.013	0.013	0.012	0.012	0.012
$\bar{R}^2$	0.46	0.49	0.51	0.49	0.48	0.52	0.56	0.54	0.50	0.53	0.48	0.68	0.56	0.55
DF	121	109	107	57	56	79	41	40	113	61	60	82	44	43

[a] t-Values appear within parentheses below the coefficients. [b] Not significant at the 5% level in a one-tail test. The cutoff point for the h_0 is 2.33 at the 1% level, 1.64 in a 5% test, and 1.28 in a 10% test.

https://doi.org/10.1017/S1365100599011049 Published online by Cambridge University Press

TABLE 2. Partial correlation between per-capita growth and regressors[a]

	Investment rate	Primary education	Secondary education	Labor share in primary sector	Share of primary exports	External debt	Exchange-rate volatility
With schooling	0.50	0.10[b]	0.05[b]	−0.19[b]	−0.36	−0.34	0.04[b]
$h_0 : r = 0$	(4.58)	(0.80)	(0.40)	(−1.54)	(−2.67)	(−2.87)	(0.33)
Without schooling	0.55	—	—	−0.24	−0.36	−0.37	0.05[b]
$h_0 : r = 0$	(5.31)	—	—	(−1.99)	(−2.67)	(−3.21)	(0.40)

[a]The t-values appear within parentheses below the correlation coefficients. [b]Not significant at the 5% level in a one-tail test. The cutoff point for the h_0 is 2.33 at the 1% level, 1.64 in a 5% test, and 1.28 in a 10% test.

3.2.2. Investment. The parameter on investment as a proportion of GDP is significant at the 1% level in all of the regressions. An increase in investment/GDP from 20% to 30% from one country to another would, according to regressions 1 to 8b, increase the growth rate per head by 1.1% to 1.5% a year, *ceteris paribus*. These findings rhyme well with those of Levine and Renelt (1992) and Sachs and Warner (1995).

3.2.3. Initial school enrollment. The primary enrollment rate is significant at the 1% level in regression 2, and is marginally significant at the same level when the labor share in primary production is added to the regression; see regression 3a. The parameter becomes insignificant, however, when foreign debt and exchange-rate volatility are added to the regression. This seems to support our hypothesis, at least in part, that the orthogonal component of the primary labor share and education crowds out the effects of school enrollment on growth. The secondary enrollment rate is insignificantly different from zero in all of the regressions.

3.2.4. Labor in primary sector. This variable appears with the right sign everywhere. The hypothesis of zero coefficients is rejected at the 5% level in all regressions except 4a and 5a. According to Table 2, a partial correlation between the share of labor in primary production and economic growth is marginally rejected when the effect of school enrollment is included. This relationship is not rejected, however, when schooling is left out. This gives us a reason to believe that these two effects should not be included in a regression model simultaneously. Further, in view of the strong correlation between schooling and primary labor shown in Figures 2 to 4, multicollinearity is likely a problem.

The effect of the primary sector on growth is quite strong. If the share of the primary sector in the labor force increases from 5% to 30% from one country to another, per-capita output growth drops by about 0.5% per annum, *ceteris paribus*. Sachs and Warner (1995) report a sizable effect of an increase in the share of primary exports in GDP on growth in a sample of 98 countries. Gylfason and Herbertsson (1996) and Gylfason (1999) also report similar results, based on different data sets: An increase in the share of primary exports to GDP from 5% to 30% reduces per-capita growth by 0.5% to 1% or more.

3.2.5. Export of primary products. The primary-sector labor share does not include labor in extraction industries because the requisite data are not available. However, we also ran the regressions using the share of primary exports in total exports instead of the primary-sector labor share. Regressions 3b–5b, now including extraction industries, show that the parameters on this variable are significant and stable. When the school enrollment variables are excluded from the regressions (6b–8b), the parameters remain significant. Finally, the hypothesis of equal coefficients in oil-producing and non-oil-producing economies cannot be rejected at the 1% level of confidence in a Wald test.

https://doi.org/10.1017/S1365100599011049 Published online by Cambridge University Press

3.2.6. External debt. The parameter on foreign debt is significantly negative throughout. The partial correlation between economic growth and debt is correspondingly significant and large; see Table 2. Our model in Section 2 predicts a positive effect of external steady-state debt on growth, because more debt entails a lower real exchange rate. However, our model does not explicitly include a phenomenon that is undoubtedly important in practice: The economies most burdened with debt may not be in long-run equilibrium. They typically have overvalued currencies accompanied by continuous debt accumulation. In this case, the intuition of our model would predict slower growth. This possibility seems to warrant further scrutiny in future work.

Another possible explanation for the inverse relationship between debt and growth could be that high levels of external debt are a symptom of economic mismanagement or political instability, as emphasized by Barro and Sala-i-Martin (1995). To investigate this possibility, we added to our regression a dummy variable derived from the data used by Alesina et al. (1996) to represent coups. If a coup took place in a given country during the sample period, the dummy takes the value one, and zero otherwise. The parameter on this variable is significantly negative when debt is not included in the regression (a coup then reduces average growth by 0.5% per year), but when debt is included, the coup dummy becomes insignificant. This result may be viewed perhaps as an indication that external debt accumulation mirrors economic mismanagement rather than political instability.

This impression becomes stronger when another measure of economic mismanagement, $\pi/(1+\pi)$, where π is the annual rate of inflation, is added to our regression [see Gylfason and Herbertsson (1996)]. The parameter on the inflation variable is significantly negative whether or not the coup dummy is included: An increase in inflation from 5% to 50% reduces average growth by about 1% per year, and the coup dummy becomes insignificant. When our external debt variable and inflation variable appear side by side in the regression, the inflation variable becomes marginally insignificant.

3.2.7. Exchange-rate volatility. This variable is statistically insignificant everywhere. We also ran regressions (not reported) using both the variance of the labor share in primary production and of GDP. Both variables entered the regressions with the wrong sign but were not statistically different from zero. This suggests that the Dutch disease may manifest itself through the level of the real exchange rate rather than through its variability.

3.2.8. Africa. The Africa dummy is significant in regressions 1 and 2, where the labor share is not included. In 8 of the remaining 12 regressions, the primary labor share undermines the African connection. We also ran the regressions without the Africa dummy, but the results obtained in regressions 3a to 8b remained virtually unchanged.

https://doi.org/10.1017/S1365100599011049 Published online by Cambridge University Press

3.3. Panel Estimation

To investigate the dynamic properties of the data, we employ the random-effects panel model.[11] The data span the same period as before (1960–1992) and now comprise a maximum of seven 5-year averages and a minimum of one for each variable. Because the subperiods are only 5 years, we do not test for the effects of exchange-rate volatility, because the estimated variance of that variable can hardly be expected to be consistent with only five observations.

In Table 3 we report our panel regressions.[12]

Regressions 1–3a yield similar coefficients on initial GDP as the cross-sectional regressions. When external debt is added (regressions 4a and 6a), the magnitude of the convergence parameter increases substantially, from approximately 1% to almost 6% in regression 4a and to almost 4% in regression 6a. The parameters on the export share are less significant than before. Because the share of primary exports in total exports is less closely correlated with education than is the labor share of the primary sector excluding extraction industries, it is natural that the primary export share makes a smaller contribution than the primary-sector labor share to the growth equations. However, regressions 4a and 6a should be taken with a grain of salt, because the number of observations is small compared with the other regressions.

The parameters on investment are approximately the same in the cross-sectional and panel regressions.

The parameters on primary education seem more robust in the panel in the sense that the primary-education variable survives the introduction of primary labor into the panel regression. Secondary education shows up with the wrong sign everywhere. Moreover, the labor share of the primary sector now survives the introduction of the external debt ratio into the regression, and renders the Africa dummy insignificant everywhere. The parameters on the labor share in primary production in our preferred panel regressions, 3a and 5a, are about the same as in the cross-sectional analysis (Table 1). The share of primary exports in total exports has a smaller and less significant effect on growth than the primary labor share, presumably because the former is a less satisfactory proxy for human capital than the latter. This leads us to conclude that our main results are quite robust: The size of the primary sector matters for growth.

4. CONCLUSION

We have found a statistically significant relationship between the size of the primary sector and the average rate of growth of output across countries. This effect appears to diminish the importance of the relationship between education variables and growth: The effects of schooling generally drop in size and significance when primary employment or primary exports are added to the regressions.

We can draw two possible inferences from the empirical relationship between growth, the size of the primary sector, and school enrollment. First, it is possible

https://doi.org/10.1017/S1365100599011049 Published online by Cambridge University Press

https://doi.org/10.1017/S1365100599011049 Published online by Cambridge University Press

TABLE 3. Panel results, five-year intervals, 1960–1992[a]

	Regression									
Regressor	(1)	(2)	(3a)	(4a)	(3b)	(4b)	(5a)	(6a)	(5b)	(6b)
Initial GDP	−0.007	−0.009	−0.013	−0.058	−0.009	−0.023	−0.010	−0.038	−0.009	−0.017
	(−4.66)	(−4.27)	(−3.33)	(−5.29)	(−3.35)	(−3.59)	(−2.98)	(−4.05)	(−3.79)	(−3.71)
Investment	0.164	0.164	0.128	0.212	0.169	0.18	0.133	0.266	0.188	0.24
	(10.0)	(7.84)	(4.89)	(3.55)	(5.53)	(3.37)	(5.65)	(4.83)	(7.01)	(5.44)
Primary education	—	0.012	0.035	0.041	0.021	0.038	—	—	—	—
		(1.69)	(4.24)	(2.20)	(1.97)	(1.69)				
Secondary education	—	−0.017[b]	−0.044[b]	−0.008[b]	−0.025[b]	0.003[b]	—	—	—	—
		(−2.44)	(−4.38)	(−0.43)	(−2.77)	(−0.20)				
Labor in primary sector	—	—	−0.022[b]	−0.099	—	—	−0.021	−0.065	—	—
			(−1.47)	(−2.58)			(−1.73)	(−2.20)		
Export of primary products	—	—	—	—	−0.015	−0.007[b]	—	—	−0.009[b]	−0.013[b]
					(−1.79)	(−0.50)			(−1.24)	(−1.02)
External debt	—	—	—	−0.051	—	−0.045	—	−0.077	—	−0.030
				(−1.65)		(−2.84)		(−2.72)		(−2.54)
Constant	0.046	0.054	0.111	0.476	0.06	0.157	0.095	0.311	0.06	0.130
	(4.31)	(3.76)	(3.01)	(4.93)	(2.85)	(3.08)	(3.04)	(3.81)	(3.13)	(3.39)
Africa dummy	−0.002[b]	−0.001[b]	−0.005[b]	0.000[b]	−0.003[b]	−0.002[b]	0.004[b]	0.004[b]	0.001[b]	0.000[b]
	(−0.87)	(−0.34)	(−1.45)	(0.06)	(−0.76)	(−0.34)	(−0.98)	(0.53)	(0.33)	(0.02)
SE	0.032	0.030	0.025	0.017	0.030	0.024	0.031	0.025	0.030	0.249
$\bar{R}^2$	0.11	0.11	0.17	0.37	0.12	0.21	0.11	0.26	0.10	0.19
DF	856	535	268	54	311	100	353	81	429	158

[a]The *t*-values appear within parentheses below the coefficients. [b]Not significant at the 5% level in a one-tail test. The cutoff point for the h_0 is 2.33 at the 1% level, 1.64 in a 5% test, and 1.28 in a 10% test.

that a large primary sector based, e.g., on an abundant natural resource inhibits the creation of a (human-capital generating) secondary sector through its effect on the real exchange rate, thereby reducing the need for formal education as measured by the school enrollment rates. Second, it is also conceivable that a bad system of education inhibits the secondary sector by raising training costs. The continued dominance of the primary sector then further suppresses the secondary sector through the Dutch disease. These two possibilities are not mutually exclusive.

Of course, the statistical relationship between growth and primary employment and exports could result from a mechanism not involving human capital. In particular, it is possible that a productive primary sector could affect wages in the secondary sector by offering high wages to its own workers. Efficiency wage theories would predict that wages be a positive function of industry productivity—as well as its expected rate of growth. Other industries, however, paying lower wages than the primary sector and hence possibly facing high quit rates as workers leave for the lucrative primary sector, may be induced to offer similarly high wages to combat quits. This may deter hiring, learning, and growth.

NOTES

1. British and German data indicate that the proportion of workers with little or no education is higher in agriculture, fisheries, and forestry than in most other sectors. The proportion of primary-sector workers with no vocational degrees is 76% in Britain and 52% in West Germany [Prais (1995)]. In Germany, this is by far the highest proportion of less-advantaged workers. A distant second is hotels and catering, with a proportion of 42%. In Britain, a few sectors match our primary sector: distributive trades (78%); hotels and catering (77%); insurance, banking, and finance (76%); the manufacturing industries of food, drink, and tobacco (74%); and textiles, leather, and footwear (81%).

2. A similar argument would apply to other systems of insurance, such as agricultural price support schemes.

3. We make this assumption only to simplify the model; its relaxation would not affect any of our results.

4. We take L_2 to be independent of the quit rate. Thus we assume that quitting does not reduce aggregate knowledge in the industry because either the workers quit to start their own firms within the industry or they pass on their know-how to remaining workers before leaving for other industries.

5. We do not consider the option value of firing the worker at a later date.

6. By using equations (1–3), the characteristic equation is: $\frac{1}{2}\sigma^2\gamma(\gamma-1)-q(\alpha-1)\gamma-(r+q)=0$, given suitable parameter restrictions.

7. This implication is reversed if D is negative, i.e., if there are foreign assets.

8. The real rate of interest and the quit rate also affect the threshold indirectly through γ_1. This effect goes in the opposite direction: Firms invest sooner at higher interest and quit rates because they discount possible future losses at a higher rate; i.e., they are more willing to take risk.

9. To test for the robustness of our results, we also tried the Huber (1973) robust estimator, and thus in effect imposed a normal distribution on the residuals. The results (not reported here) remained virtually the same as in Table 1. Therefore, by virtue of the central limit theorem, we are not concerned with the sensitivity of our results to outliers. We also ran the regressions using a consistent covariance matrix allowing for heteroskedasticity. The standard errors thus obtained did not deviate substantially from the ones reported, from which we infer the absence of heteroskedasticity.

10. Partial correlations provide a direct measure of the strength of the relationship between the dependent and the independent variables. The partial correlation coefficients are estimated from the

https://doi.org/10.1017/S1365100599011049 Published online by Cambridge University Press

sample data as follows: (1) Fit an OLS regression with growth as dependent variable and independent variables $X_2, X_3, \ldots, X_K$; (2) fit an OLS regression with X_1 as dependent variable and independent variables $X_2, X_3, \ldots, X_K$; (3) compute the sample correlation between the residuals from the regressions in steps 1 and 2. The purpose of steps 1 and 2 is to remove the effects of $X_2, X_3, \ldots, X_K$ on growth and on X_1 before computing the sample correlation.

11. Using the Hausman specification test, we find that the random-effects estimator is BLUE. However, the estimation results using the fixed-effects estimator are quantitatively the same except for a more rapid rate of convergence.

12. As in the cross-sectional regressions, we also ran the regressions using a robust estimator. The results reported remained virtually unchanged, so that we need not be concerned with potential nonnormality due to outliers.

REFERENCES

Alesina, A., S. Özler, N. Roubini & P. Swagler (1996) Political stability and economic growth. *Journal of Economic Growth* 1, 189–211.

Barro, R.J. (1991) Economic growth in a cross section of countries. *Quarterly Journal of Economics* 106, 407–443.

Barro, R.J. & J.W. Lee (1993) International comparisons of educational attainment. *Journal of Monetary Economics* 32, 363–394.

Barro, R. & X. Sala-i-Martin (1995) *Economic Growth*. New York: McGraw-Hill.

Corden, W. M. (1984) Booming sector and Dutch disease economics: Survey and consolidation. *Oxford Economic Papers* 36, 359–380.

Dixit, A.K. & R.S. Pindyck (1994) *Investment under Uncertainty*. Princeton, NJ: Princeton University Press.

Gylfason, T. & T.T. Herbertsson (1996) Does Inflation Matter for Growth? CEPR discussion paper 1503.

Gylfason, T. (1999) Exports, Inflation, and Growth. *World Development* 27, 1033–1059.

Huber, P.J. (1973) Robust regression: Asymptotics, conjectures and Monte Carlo. *Annals of Statistics* 1, 799–821.

Levine, R. & D. Renelt (1992) A sensitivity analysis of cross-country growth regressions. *American Economic Review* 82, 942–963.

Lewis, W.A. (1955) *The Theory of Economic Growth*. London: George Allen and Unwin.

Lewis, W.A. (1968) *Some Aspects of Economic Development*. Accra and Tema: Ghana Publishing Corp.

Lucas, R.E. (1988) On the mechanics of economic development. *Journal of Monetary Economics* 22, 3–42.

Mankiw, N.G., D. Romer & D.N. Weil (1992) A contribution to the empirics of economic growth. *Quarterly Journal of Economics* 107, 407–437.

Merton, R. (1975) An asymptotic theory of growth under uncertainty. *Review of Economic Studies* 42, 375–393.

Nelson, R. & E.S. Phelps (1966) Investment in humans, technological diffusion, and economic growth. *American Economic Review* 56, 69–75.

Nerlove, M. (1996) Growth Rate Convergence, Fact or Artifact? An Essay in Panel Data Econometrics. Manuscript, University of Maryland.

Prais, S.J. (1995) *Productivity, Education and Training: An International Perspective* Occasional paper XLVIII. National Institute of Economic and Social Research.

Romer, P.M. (1986) Increasing returns and long-run growth. *Journal of Political Economy* 94, 1002–1037.

Romer, P.M. (1990) Endogenous technological change. *Journal of Political Economy* 98, 5, S71–S102.

Sachs, J.D. & A.M. Warner (1995) Natural Resource Abundance and Economic Growth. NBER Working paper 5398.

https://doi.org/10.1017/S1365100599011049 Published online by Cambridge University Press

APPENDIX: DESCRIPTION OF DATA

Growth of GDP. The RGDPCH (real GDP per capita at 1985 international prices, chain index) is taken from the Penn World Tables. This is an average, given by the formula $\frac{1}{T}\sum_{t=1}^{T}[\log(GDP_t) - \log(GDP_{t-1})]$, where T is the number of observations. T is at least 25 in the cross-sectional analysis, but 5 in the panel analysis.

Initial GDP. Here we use RGDPCH from the Penn World Tables as defined above. GDP_0 is the observation in the initial year.

Investment. This is an average for the period 1960–1992 of the ratio of real gross domestic investment, private and public, to GDP (from Penn World Tables). At least 25 observations are in each average in the cross-sectional analysis. In the panel analysis, this is a five-year average.

Initial school enrolment. Here we use World Bank data. Because no data are available for school enrollment before 1965, that year was used as the initial year in the cross-sectional analysis. In the panel analysis, corresponding initial values for each subperiod were used. The primary enrollment rate is measured by gross enrollment of students at the primary level as a percentage of school-age children as defined by each country and reported to UNESCO. The secondary enrollment rate is the gross enrollment of students at the secondary level as a percentage of school-age children as defined by each country and reported to UNESCO. Late entry of more mature students as well as repetition and bunching in the final grade can influence these ratios.

Labor in primary sector. This is the labor force in farming, forestry, hunting, and fishing as a percentage of total labor force in the cross-sectional analysis in the year 1965 (from World Data Bank).

Export of primary products. This is the combined export of fuel and nonfuel primary products, as a percentage of total exports of goods and services in 1970. All data are from the World Bank. Exports of fuels comprise commodities in SITC Revision 1, Section 3 (Mineral Fuels and Lubricants and Related Materials). Exports of nonfuel primary products comprise commodities in SITC Revision 1, Sections 0, 1, 2, 4, and Division 68 (food and live animals, beverages and tobacco, inedible crude materials, oils, fats, waxes, and nonferrous metals). The export figures are in current U.S. dollars. The figures are dollar values converted from domestic currencies using single-year official exchange rates. For a few countries, where the official exchange rate does not reflect the rate effectively applied to actual foreign-exchange transactions, an alternative conversion factor is used. In the panel analysis the years 1970, 1975, 1980, 1985, and 1990 were used for each five-year period.

External debt. This is an average for the period 1960–1992 of foreign debt in domestic currency divided by GDP at market prices in the cross-sectional analysis. Foreign debt consists of the outstanding stock or recognized direct liabilities of the government to the rest of the world. Often there were very few observations for each country. GDP measures are from the World Data Bank. At least three observations were included in each five-year average in the panel analysis.

Exchange-rate volatility. This is defined as the variance of the logarithm of exchange rate divided by the GDP deflator for the period 1960–1992. The exchange rate, which is relative to the U.S. dollar, is reported in the Penn World Tables. The GDP deflator is taken from the World Bank Data. At least 16 observations are used for each average in the cross-sectional analysis.

https://doi.org/10.1017/S1365100599011049 Published online by Cambridge University Press