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Foreign Aid Policy and Sources of Poverty: A Quantitative Framework

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The econometric literature has been unable to establish a robust association between foreign aid and growth and poverty reduction. In this paper, we argue that aid effectiveness must be assessed using methods that go beyond cross-country regressions. We calibrate a dynamic general equilibrium model that is capable of generating large sustained income gaps between rich and poor countries. The model quantifies three sources of poverty: (1) lack of access to international capital, (2) low schooling and high fertility (a poverty trap), and (3) an antigrowth domestic fiscal policy set by an elite. We analyze policies designed to address each source of poverty and compare the aid cost of their implementation. The policies differ dramatically in the extent and timing of their growth effects, and in the aid cost of their implementation. [JEL E61, F33, F34]

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Foreign aid is an important instrument in efforts to reduce poverty and promote economic development around the world. Some countries have successfully leveraged foreign assistance and escaped poverty. Despite these successes, however, the effectiveness of foreign aid overall remains in doubt. Surveys of the empirical literature generally conclude that aid has not led to

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increased growth and may have even worsened recipients' economic performance. Recent studies continue to paint a mixed picture. For example, Radelet, Clemens, and Bhavnani (2006) report robust evidence that aid targeted to infrastructure has quick growth payoffs.[1] On the other hand, Rajan and Subramanian (2005) find that aid may have adverse long-run effects, by worsening a country's competitiveness.

One fundamental reason for the lack of consensus regarding the effectiveness of foreign aid is the economics profession's ignorance about the sources of growth (for example, Rodrik, 1999 and 2005; and Azariadis and Stachurski, 2005, p. 1) and the policies that are most likely to generate growth (Feldstein, 1998; and Pronk, 2001). Development accounting exercises have not reached a consensus on how much each of the sources of growth—physical capital, human capital, and total factor productivity (TFP)—contributes to the large disparities in income observed across rich and poor countries.[2] Research on how government policies affect the sources of growth is also inconclusive.[3]

Even if growth accounting and econometric approaches were able to establish robust correlations between growth and specific policies, causation would remain an issue. It is clear that other approaches must supplement those that are designed to estimate correlations. The limitations of purely econometric methods have led some researchers to rely on detailed studies of country-specific historical events leading up to growth miracles and disasters (Rodrik, 2003). Analytical narratives help identify potential causal connections between shifts in policy and the subsequent growth in a country, but they cannot determine the quantitative effect of specific policy changes on growth. This makes the proposed causal connections difficult to test and difficult to generalize to other countries. A promising research strategy is to supplement correlation and narrative studies with analysis based on calibrated dynamic general equilibrium models. These models have been used extensively to evaluate domestic fiscal policy (for example, Auerbach and Kotlikoff, 1987) and trade policy (for example, Deardorff and Stern, 1990). The advantages of dynamic computational general equilibrium

[1]Radelet, Clemens, and Bhavnani (2006) base their conclusions on the findings of Clemens, Radelet, and Bhavnani (2004), who argue that the lack of correlation is due to the aggregation of different types of aid into one. They find that aid designed to stimulate growth in the short run (for example, aid to build infrastructure) has a robust positive correlation with growth in regressions using 4-year panel data across countries. They also doubt whether econometric methods can identify the effects of aid designed to achieve growth over longer horizons (for example, aid for health and schooling). Isard and others (2006) summarize the empirical evidence and present the views of practitioners from academia, international financial institutions, and African countries.

[2]Restricting attention to only the most recent studies still reveals wide-ranging conclusions, from "almost all growth is due to TFP" (for example, Parente and Prescott, 2000) to "almost all growth is due to capital accumulation" (for example, Manuelli and Seshadri, 2005).

[3]See, for example, the survey of the econometric evidence by Agénor (2004, Chapter 13).

models include the ability to (1) assess longer term growth effects, (2) identify causal mechanisms, (3) link microeconomic data and estimates to the macroeconomy, (4) consider welfare effects, and (5) evaluate policy reforms that have never been attempted or have been attempted too infrequently to conduct an econometric analysis.[4]

In this paper, we investigate the effects of aid in a specific computational general equilibrium model. Our model satisfies four principles that, we believe, *any* computational model used to assess aid policy should follow.

First, before jumping to policy evaluation, the underlying model *should be able to explain (replicate) significant growth experiences*. Confidence in policy recommendations stems directly from the ability of models to explain the key facts of development. The current standard in economic theory is to build models of economic development that are capable of explaining these key facts, which include (1) the steady growth of Western countries for more than a century; (2) the economic transformation—the decline of agriculture and ascendancy of industry—and the accompanying demographic transition; (3) explosive growth in some developing countries after World War II; and (4) huge differences in worker productivity across rich and poor countries today. Because replicating all these growth experiences has proved difficult, adherence to this principle will significantly narrow the candidate models that will be used to evaluate aid policy.

Second, *the fundamental sources of poverty, or the barriers to growth, should be identified*. It is not enough to identify the "proximate," or immediate, sources of poverty—such as a lack of factor accumulation or technological adoption. The most important and deepest causes of poverty, the reasons factors are not accumulated or technologies adopted, must be identified to focus policy efforts effectively. This requires uncovering the microeconomic foundations of poverty. Explicit microeconomic foundations also allow welfare effects to be computed.

Third, *the aid cost of achieving growth through alternative policies should be estimated*. Some sources of poverty are likely to be easier to eliminate than others. Pro-poor, pro-growth reforms favored by donors are likely to be resisted by interest groups in recipient countries. The political influence of these groups often leads to inefficient economic policy frameworks, choices, and outcomes. Whether because of direct reform conditions stipulated in aid policies, or because of the indirect response to the aid policy, domestic policy will change when aid is extended. Thus, to calculate the cost of successfully implementing reforms, the model must take a stance on how existing government policies are set. One can then determine how much aid is necessary to convince governments to adopt and support particular reform recommendations that they would otherwise oppose.

[4]A weakness of the computable general equilibrium approach is that it lacks the formal hypothesis testing apparatus that has been developed for statistical theory. However, as discussed below, these models can be informally tested by examining their ability to match a wide array of stylized facts.

Fourth, some insight should be provided into the reasons as to why regression analysis has been unable to estimate a robust positive correlation between aid and growth. As mentioned above, regression studies seem to indicate that aid policies have had mixed success at best in improving economic growth. The absence of correlation between aid and growth in regression studies is in itself a stylized fact that models should attempt to explain.

Below, we present a model that follows these four principles. The model starts with a standard overlapping-generations theory of physical capital accumulation and augments it with a theory of fertility, schooling, and endogenous government policy formation. Although the model is primarily put forth as a prototype of how the principles can be implemented, it also generates some interesting insights for the formation of aid policy. The model satisfies the four principles in the following ways.

First, we consider trade-offs between the quantity and quality of children. The key element in our theory, which was developed by Lord and Rangazas (2006), is that older children can either attend school or work to raise their family income. The theory successfully replicates the patterns of worker productivity, fertility, interest rates, and schooling in the United States from 1800 to 2000.

Second, we identify three fundamental sources of low worker productivity that help explain low incomes in developing countries today: (1) a closed economy, (2) a poverty trap that keeps schooling low and fertility high, and (3) a relatively large weight placed by governments on their own consumption when taxes and government investment are set.

Third, we examine five reform policies that address the three sources of poverty in low-income countries. In each case, we take into account the domestic government's willingness to adopt the policy, which shapes its policy response to the conditions attached to foreign aid. Our baseline is an unconditional aid policy that takes the form of "budget support." The second policy opens the economy to trade and international capital flows. The third is a policy that provides funds to subsidize families for some of the income they forgo when they send their older children to school, similar to Mexico's Progresa program *(Programa de Educación, Salud y Alimentación)*. Fourth, we also analyze the common attempt to increase schooling by enacting laws that extend the age of compulsory schooling or that prohibit child labor. The final policy aims to reform domestic fiscal policy so as to increase growth by lowering taxes and increasing public investment.

Fourth, we identify reasons aid policies may produce disappointing outcomes as measured by regression techniques. The failures relate to the ineffectiveness of unconditional aid, the high cost of aid required to induce certain reforms, and the conflict of interest that can develop between the ruling government and private households.

Our main findings are as follows:

- Differences in schooling, fertility, and domestic fiscal policy generate large differences in worker productivity across rich and poor countries.

The model explains 28-fold differences in closed economies and nine-fold differences in open economies.

- Unconditional "budget support" has very modest growth effects. Growth rates initially rise, but only slightly, and then fall below pre-aid levels for a long time. In the long run, there are no sustained benefits from unconditional budget support.
- Openness helps to discipline fiscal policy—tax rates are lower and the portion of the budget devoted to investment is higher when the poor country opens its economy to international capital. Opening the economy to international capital generates a double dividend: not only does the resource transfer raise growth directly, it also leads to a more pro-growth fiscal policy.
- Technological change or physical capital accumulation may not by themselves be enough to eliminate the poverty trap. To reduce fertility and increase schooling of older children requires policy interventions, such as the Progresa program or compulsory schooling legislation, that reduce the incentives of poor families to interrupt the schooling of their older children.
- Although the Progresa policy is a Pareto improvement, budgetary constraints may lead the government to opt for compulsory schooling legislation instead that makes the initial (current) generation of young households worse off.
- Traditional fiscal policy reforms have only modest growth effects and the aid cost of maintaining the reforms is very high.

I. Related Literature

Several recent studies use calibrated dynamic general equilibrium models to examine aid-related issues. These works differ from ours across three dimensions. First, there are differences in focus. Our goal is to link the analysis of aid to the academic study of economic development in general and to the policies that may eliminate poverty traps or speed transitional growth. In our study, aid is secondary to the task of identifying effective pro-growth policies. Other studies have instead focused more directly on aid, with an emphasis on its sectoral and distributional effects (Adam and Bevan, 2004, Agénor, Bayraktar, and Aynaoui, 2005); the volatility of aid (Arellano and others, 2005); and the comparison of tied and untied aid (Chatterjee, Sakoulis, and Turnovsky, 2003; and Chatterjee and Turnovsky, 2004 and 2005). In this sense, the different studies are complementary.

Second, there are significant differences in the models used that are driven largely by the differences in focus. Our objective requires the model to contain a mechanism of the basic determinants of long-term growth, such as savings, education, and fertility. A model of physical capital accumulation alone, as in Arellano and others (2005) and the papers by Chatterjee and his co-authors, does not suffice because of the well-known fact that physical capital differences do not explain large productivity differences across time and space (for example, King and Rebelo, 1993; and Parente and Prescott, 2000). In addition, we need to identify the barriers to growth: poverty traps and antigrowth policies. In our initial attempt at these tasks, we abstract from the sectoral and distributional issues that are the primary focus of Adam and Bevan (2004) and Agénor, Bayraktar, and Aynaoui (2005). In turn they must compromise by having exogenous sources of growth and exogenous domestic fiscal policy.

Finally, there are differences in methodology or modeling principles. In our view, models of aid effectiveness should (1) identify why the aid recipients are poor to begin with and (2) demonstrate that the proposed sources of poverty are quantitatively important. Following these principles will serve to discipline the analysis by narrowing the range of aid models to those that are the most empirically relevant. It will also help to narrow the types of policies that can effectively address the specific sources of poverty that have been identified.

Although existing models of aid contain many important insights, it is hard to gauge their empirical importance because the four principles are not being followed. As an example, in Adam and Bevan (2004) the sources of poverty are (1) low saving rates and skill levels in the household sector, (2) a lack of public infrastructure, and (3) an inefficiently low share of the workforce employed in the export sector, where a learning-by-doing externality resides. These are potentially interesting sources of poverty, but the reasons poor countries differ from rich countries in these respects are not explained within the model (saving rates, skill levels, public capital, and rural-to-urban migration are all exogenous variables). Furthermore, there is no demonstration that these sources of poverty lead to large worker productivity differences between rich and poor countries under their calibration.

II. The Model

We first describe the behavior of the private sector in the poor country and then turn to the government.

Households

In our model, households live for three periods, each of which lasts 20 years. The three periods correspond to one period of childhood and two periods of adulthood. Households make saving, fertility, and schooling decisions. They value their consumption over the two periods of adulthood (c_t^y, c_{t+1}^o) and the adult earnings ($w_{t+1}h_{t+1}$) of all their children (n_{t+1}). Earnings are the product of the after-tax market rental rate for skills (w_{t+1}) and the embodied skills, or human capital (h_{t+1}), of the worker. Preferences are given by

$$U_t = \ln c_t^y + \beta \ln c_{t+1}^o + \psi \ln(n_{t+1} w h_{t+1}),$$

where $0<\beta<1$ and $\psi>0$ are preference parameters.[5] This preference specification is a simple way of capturing the idea that parents value both the quantity and the quality of their children. It has been used extensively in the literature on fertility and growth (for example, Galor and Weil, 2000; Greenwood and Seshadri, 2005; Hazan and Berdugo, 2002; Moav, 2005; and Lord and Rangazas, 2006).

Adults inelastically supply one unit of labor when young, and zero units when old. Children have an endowment of $T<1$ units of time that they can use to attend school (s_t) or work ($T-s_t$). Children have less than one unit of time to spend productively because early in childhood they are too young to either attend school or to work, and in the middle years they do not have the mental or physical endurance to attend school or to work as long as an adult.

Although children may work as they become older, they are also expensive to care for and feed. To raise each child requires a loss of adult consumption equal to a fixed fraction τ of the adult's first-period wages.

The government decrees that younger children receive some education during their early years. So children invest at least $\bar{s}$ units of time into learning during the first portion of their childhood.[6] This gives older children $\gamma\bar{h}_t=\gamma\bar{s}^\theta$ units of human capital that can be used in production during the later years of childhood, where $0<\theta<1$ is a parameter that gauges the effect of schooling on human capital accumulation and $0<\gamma<1$ reflects the fact that children lack relative physical strength or experience in applying knowledge to production compared with adults. Adult human capital of the same person in the next period is $h_{t+1}=s_t^\theta$. Thus, a person is more productive in adulthood than in childhood because of greater strength and experience ($1>\gamma$) and additional schooling ($s_t\geq\bar{s}$).

The household maximizes utility subject to the lifetime budget constraint,

$$c_t^y+\frac{c_{t+1}^o}{1+r_{t+1}}+n_{t+1}\tau w_t h_t=w_t h_t+n_{t+1}w_t\gamma\bar{h}(T-s_t).$$

In addition to the standard first-order conditions for life-cycle consumption, the choices of n_{t+1} and s_t yield

$$\frac{\psi\theta}{s_t}\leq\lambda_t n_{t+1}w_t\gamma\bar{h}, \tag{1a}$$

$$\frac{\psi}{n_{t+1}}=\lambda_t[\tau w_t h_t-(T-s_t)w_t\gamma\bar{h}], \tag{1b}$$

where λ_t is the Lagrange multiplier.

[5]Galor and Moav (2002) generalize this specification by allowing for a separate utility weight on the quantity and quality of children. They then go on to develop an evolutionary theory in which households raise the weight they place on the quality of their children over the course of economic development. Adopting this more flexible specification would increase the ability of our model to fit the stylized facts.

[6]Alternatively, $\bar{s}$ may be interpreted as a minimum amount of schooling needed for the child to be productive.

Equation (1a) says the marginal utility of additional child quality must be equated to the marginal value of consumption lost from allowing children of working age to attend school. The strict inequality holds when the marginal cost of educating children beyond the schooling received in their early years, $\bar{s}$, exceeds the marginal benefit. In this case, parents are content to set $s_t = \bar{s}$.

Equation (1b) says the marginal utility of additional children must be equated to the marginal value of lost consumption. Consumption is lost from having additional children because we assume the cost of children exceeds the earnings that older children bring to the household.

Solving the model gives us the following demand functions for children, schooling, and financial assets for retirement (a_{t+1}):

$$n_{t+1} = \frac{\psi}{(1+\beta+\psi)(\tau - \gamma(T - s_t)(\bar{s}/s_{t-1})^{\theta})}, \tag{2a}$$

$$s_t = \max\left[\frac{\theta(\tau(s_{t-1}/\bar{s})^{\theta} - \gamma T)}{\gamma(1-\theta)}, \bar{s}\right], \tag{2b}$$

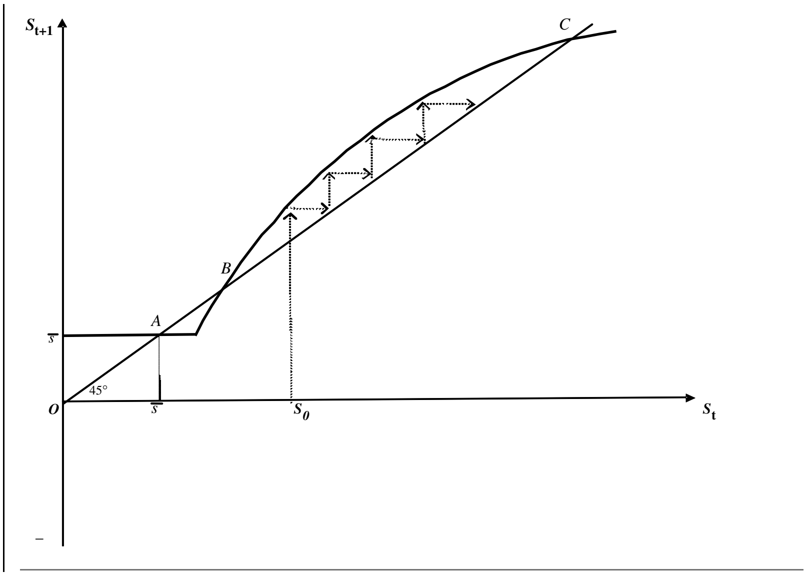
$$a_{t+1} = \left[\frac{\beta}{1+\beta+\psi}\right] w_t h_t. \tag{2c}$$

Assuming that s_{t-1} is sufficiently high, a dynamic results that causes economic growth and a demographic transition. The quantity and quality of children are both affected by the net cost of children, that is, the cost of rearing and schooling children less the income that children generate for the family. Greater schooling raises adult earnings relative to older children's earnings. This raises the net cost of having children, causing fertility to decline. Lower fertility and greater consumption decrease both the quantity and the value of forgone earnings from schooling children, so schooling rises further.

Note that the sole factor driving fertility down is the rise in schooling. The dynamic is independent of the after-tax rental rates on physical and human capital. A higher rental rate paid to human capital raises the earnings of both parents and children but does not affect *relative* earnings or the net cost of children. Thus, the evolution of schooling and fertility is unaffected by the determinants of human capital rental rates, such as fiscal policy, technological change, and physical capital accumulation.

Because the effect of schooling has a diminishing effect on human capital formation and wages, the transition equation given by Equation (2b) would exhibit the standard properties of neoclassical growth if not for one additional feature. Children receive a minimum level of schooling or learning ($\bar{s}$) while they are young and unable to work. This creates a nonconvexity in the transition equation, where the schooling during childhood must be greater than or equal to $\bar{s}$.

Figure 1. Dynamics of Schooling



Source: Authors' calculations.

Figure 1 sketches the schooling transition equation. The vertical intercept of the graph is at $\bar{s}$ rather than at its usual position at the origin. This implies that the graph intersects the 45° line three times, at points A, B, and C. The nonconvexity in the transition equation is created by the existence of $\bar{s}$, the minimum level of schooling for young children, drawn here to be less than the schooling level at point B. For schooling to increase over time, the schooling level for parents must be to the right of B or, more generally, greater than the maximum of the schooling levels associated with point B and $\bar{s}$. Starting to the right of B will cause schooling to rise, but in relatively small increments. As schooling rises, the increments in schooling across generations become larger, until the economy nears the stable steady state at C, when the increments converge to zero. So, *provided schooling is sufficiently high initially*, the model predicts relatively small increments in schooling initially, an acceleration of schooling in the middle of the transition, and then a slowdown as the steady state is approached. Lord and Rangazas (2006) show that this model fits the qualitative pattern observed over the past two centuries of U.S. history.[7]

[7]Lord and Rangazas (2006) use a more general model that endogenizes the schooling of young children and includes formal and informal production. Their earlier working paper, Lord and Rangazas (2004), shows that the simplified version used here replicates the facts well during periods where growth is driven by the rise in schooling of working-age children.

Firms

Production takes place within standard neoclassical firms that combine physical capital (K_t) and human capital (H_t) to produce output from a Cobb-Douglas technology

$$Y_t = K_t^{\alpha}(D_t H_t)^{1-\alpha}, \tag{3}$$

where D_t is a productivity variable associated with production in firms. The productivity variable, D, is a function of disembodied technology, A, and government capital per adult worker, G, and is given by

$$D_t = A_t^{1-\mu} G_t^{\mu}, \tag{4}$$

where $0<\mu<1$ is a constant parameter. We assume that A progresses at the exogenous rate q. This specification of the impact of government capital is similar to Aschauer (1989) and Clarida (1993).

Firms operate in perfectly competitive factor and output markets. This implies the profit-maximizing factor mix must satisfy

$$r_t + \delta = (1-\sigma_t)\alpha g_t^{\mu(1-\alpha)} k_t^{\alpha-1}, \tag{5a}$$

$$w_t = (1-\sigma_t)(1-\alpha) A_t g_t^{\mu(1-\alpha)} k_t^{\alpha}, \tag{5b}$$

where δ is the rate of depreciation on physical capital, σ is the income tax rate (net of transfers back to the private sector), $g \equiv G/A$, and $k \equiv K/AH$.

Capital Market Equilibrium

The firm's demand for private physical capital intensity is given by Equation (5). The supplies of private capital come from the household's asset demand for retirement assets and the human capital they rent to the market,

$$K_{t+1} = a_{t+1} N_t, \tag{6a}$$

$$H_t = h_t N_t + \gamma \bar{h}_t (T - s_t) N_{t+1} \equiv N_t \tilde{h}_t, \tag{6b}$$

where $\tilde{h}_t \equiv h_t + \gamma \bar{h}_t (T - s_t) n_{t+1}$. Substituting Equations (2c), (5b), and (6b) into Equation (6a) gives the equilibrium difference equation for physical capital intensity,

$$k_{t+1} = \left[\frac{\beta}{1+\beta+\psi}\right] \frac{(1-\sigma_t)(1-\alpha) g_t^{\mu(1-\alpha)} k_t^{\alpha} h_t}{(1+q) n_{t+1} h_{t+1}^{A}}. \tag{7}$$

Government

The government in charge of fiscal policy is composed of a fraction ε of the population of households N_t. Government officials value their own consumption (c_t^g) as well as the welfare of the representative citizen according to the period utility function, $\ln c_{t+1}^g + \phi U_{t+1}$, where ϕ is a positive preference parameter that gauges the relative weight the government places on the welfare of private households. The current government also cares about the government as an ongoing institution (that is, they care about the future operations of the government and the welfare of future government officials) and the welfare of the country's future citizens. The preferences of the government are given by

$$\sum_{t=0}^{\infty} \beta^i (\ln c^g_{t+i} + \phi U_{t+i}). \tag{8}$$

The government budget constraint, per young household, is

$$c^g_{t+i} \varepsilon N_t = \sigma_{t+i} Y_{t+i} - G_{t+i+1} N_{t+1}. \tag{9}$$

The left-hand side of Equation (9) gives the government's consumption expenditures. The right-hand side is the difference between government tax revenue, net of transfers, and government expenditures on public capital. Public capital evolves according to the equation

$$G_{t+1} = I^g_t + (1 - \delta^g) G_t, \tag{10}$$

where I^g_t is government investment and δ^g is the rate of depreciation of government capital.

The government chooses sequences of tax rates and government capital to maximize the discounted utility of government officials and private households, given by Equation (8), subject to the budget constraint and capital accumulation equation given above.[8] In addition, the government takes into account how its policy choices affect all private sector decisions. This includes only Equation (7), since Equations (2a) and (2b) are independent of fiscal policy.[9] Finally, to obtain analytical solutions, we assume $\delta = \delta^g = 1$, so that over our 20-year periods, the capital stocks fully depreciate. The solution to the government's problem is (see Appendix)

$$\sigma_t = \sigma = \frac{(1 - \alpha\beta)(1 + \beta\mu\phi(1 - \alpha)\gamma)}{1 + (1 - \alpha\beta)\phi\Gamma}, \tag{11a}$$

$$g_{t+1} = \frac{\beta\mu(1 - \alpha)}{(1 + q) n_{t+1}} k^{\alpha}_t g^{\mu(1-\alpha)}_t \tilde{h}_t, \tag{11b}$$

$$k_{t+1} = \frac{\beta(1 - \sigma)(1 - \alpha)}{(1 + \beta + \psi)(1 + q) n_{t+1}} \frac{k^{\alpha}_t g^{\mu(1-\alpha)}_t h_t}{\tilde{h}_{t+1}}, \tag{11c}$$

where $\Gamma \equiv 1 + \beta + 1 + (\psi/\beta) + (\beta\alpha(1 + \beta) + \beta(\alpha - 1) + \psi\alpha)/(1 - \alpha\beta)$.

[8]We do not study optimal government debt or monetary policy in this setting. These policies are obviously important extensions left for future work.

[9]We assume that the government can commit to its policy choices in advance. For a discussion of commitment issues in regard to the setting of fiscal policy, see Ljungqvist and Sargent (2004, Chapter 22).

One can show that the constant tax rate σ is decreasing in ϕ. From Equation (11b), the public saving rate out of national income is a constant, $\beta\mu(1-\alpha)$. Thus, a more selfish government, with a lower ϕ, will collect more in taxes but invest *a smaller fraction of tax revenue* in public capital—so as to maintain the *same* investment rate out of national income.

It is important to note that the model is recursive. The private sector schooling and fertility dynamics can be solved independently of fiscal variables and physical capital intensity. The fertility-schooling dynamic then plays a role in determining the dynamics of government and private capital intensity, for a given optimal tax rate.

Steady-State Equilibria

A country with sufficiently high initial schooling will experience growth and converge to a steady state as determined by Equations (2) and (11). However, if $s_{t+1} = \bar{s}$, it may be the case that $\dfrac{\theta(\tau - \gamma T)}{\gamma(1 - \theta)} < \bar{s}$. If this is true, then $s_t = \bar{s}$ and the economy is in a poverty trap where neither schooling nor fertility change over time. For an economy with this initial condition, the only possible dynamic stems from the government and private physical capital accumulation in Equation (11). Thus, initial conditions may cause economies with identical structures to come to rest at very different steady-state equilibria, with one steady state having higher values of h, g, and k, and lower levels of n, than the other.

It is also possible that economies differ in terms of the weight, ϕ, that their governments place on household welfare in setting fiscal policy. Economies with higher ϕ will have higher private capital/labor ratios and higher levels of public capital. This will cause higher worker productivity, even if the steady values of s and n are the same.

Thus worker productivity may differ either because of a poverty trap or because of policy differences. The next question is whether these sources of income differences are quantitatively important.

III. Cross-Country Income Differences

To investigate the potential of the model to generate income difference across countries, consider the following two steady-state equilibria, where s, n, g, and k are constant. The "poor-country" equilibrium is characterized by (1) a poverty trap, $s_t = \bar{s}$; and (2) a selfish government, $\phi^{poor} < \phi^{rich}$. The "rich-country" equilibrium is characterized by (1) $s = T$ (full-time schooling), (2) $n = 1$ (one child per parent), and (3) a government that sets net tax rates in a manner similar to the United States at the end of the 20th century; that is, $\sigma = 0.15$.

Calibration

To quantify the model's predictions about income differences across these two equilibria we calibrate the parameters to the rich-country steady state.

Table 1. Selected Low-Income Countries with Large Governments, 1985

Country	G/Y	$y^{US}/y^{country}$
Angola	0.36	11
Burkina Faso	0.29	33
Central African Republic	0.44	17
Comoros	0.49	10
Ethiopia	0.28	40
The Gambia	0.37	17
Mozambique	0.31	33
Uganda	0.28	33
Average	0.32	24

Source: Heston, Summers, and Aten (2002).

The physical capital income share, α, is set to the standard value of 1/3. The output elasticity for public capital, μ, is set to 0.30, somewhat less than the values estimated by Aschauer (1989) and Clarida (1993). However, the values of α and μ place $\mu(1-\alpha)$ at 0.2, an intermediate value of the estimates surveyed by Glomm and Ravikumar (1997). Based on Lord and Rangazas (2006), we set $\gamma = 0.28$ and $T = 0.50$. This implies potential earnings of a child that are about 14 percent of an adult's earnings. The annualized after-tax return to capital is set to 4 percent, the after-tax real rate of return to capital in the United States at the end of the 20th century (Poterba, 1999; Table 1). The annualized rate of growth of exogenous technological change, q, is set to 1.0 percent (Rangazas, 2002, 2005). This is intended to reflect a worldwide, transferable component of exogenous technological change.

The remaining parameters are set to match certain targets. We set ϕ^{rich} to match $\sigma = 0.15$, about the ratio of government purchases to GDP in the United States.[10] In the rich steady state, we targeted $n = 1$, $s = 0.5$ (children spend all their available time in school, similar to the current value in the United States) and a value of k consistent with an after-tax return of 4 percent.

In the poor-country equilibrium, we targeted $n = 3.5$, which implies seven children per couple. Despite the fertility decline in Africa over the past two decades, many of its poorest countries have total fertility rates of seven children per woman (Bongaarts, 2002). In addition, the parameter settings must be consistent with an optimal schooling level below $\bar{s}$. The minimal schooling level for young children is set to 0.08. This value implies that children in the rich country spend 6.25 times as much time in school over their childhood than do children from poor countries. So if poor children

[10]The values of government consumption G/Y for the United States and the poor countries are from the Penn World Tables (Heston, Summers, and Aten, 2002). These values for G/Y are relatively low for both the United States and the poor countries.

Table 2. Calibrated Parameter Values

Parameter	Target
γ 0.2800	Relative child's earning
T 0.5000	Relative child's wage rate
τ 0.1646	Steady-state fertility (poor)
θ 0.4049	Steady-state schooling (rich)
α 0.3333	Standard value for capital share
μ 0.3000	Intermediate empirical estimate
ψ 0.2956	Steady-state fertility (rich)
β 0.4999	Steady-state return to capital (rich)

Source: Authors' calculations.

Table 3. Steady-State Worker Productivity Differential: Rich Vs. Poor Countries

Rich-to-Poor Ratios	Model Prediction
k^{α}	3.68
$g^{\mu(1-\alpha)}$	2.09
$\tilde{h}/[1+n(T-s)]$	3.68
y	28.25

Source: Authors' calculations.

spend 2 years in school, then rich children spend 12.5 years in school (assuming school years of equal length). Finally, we set ϕ^{poor} in the poor country so that $\sigma = 0.35$.

Table 1 gives examples of poor countries (one-tenth of U.S. worker productivity, denoted by $y^{US}/y^{country}$, or less) with levels of $\sigma = G/Y$ that are at least double those of the United States.[11] Table 2 summarizes the parameter settings.

Worker Productivity Differences

Table 3 presents the steady-state worker productivity ratio, across rich and poor countries, generated by the model. The features included in the model cause the rich country to be more than 28 times richer than the poor country. The decomposition of the worker productivity ratio in Table 3 is based on the

[11]There is also the issue of differences in the tax base across rich and poor countries. Poor countries have much larger informal sectors that go untaxed. This causes poor countries to collect a small fraction of output in taxes with the same tax rate. An informal sector is needed to capture this and other important features of poor economies. We discuss this extension in the conclusion.

following expression for worker productivity:

$$y_t = \frac{k_t^{\alpha} A_t g_t^{\mu(1-\alpha)} \tilde{h}_t}{1 + n_{t+1}(T - s_t)}. \tag{12}$$

The poverty trap causes the term $\tilde{h}_t/(1+n_{t+1}(T-s_t))$, average human capital per worker, to be 3.7 times higher in the rich country for two reasons. First, because $s_t = 0.5$ in the rich-country equilibrium and $s_t = \bar{s} = 0.08$ in the poor-country equilibrium, adult human capital differs across countries. This causes output per worker in the rich country relative to that in the poor country to be 2.10, a value similar to that estimated by Hall and Jones (1999) using a much different approach. Second, the high fertility in the poor country implies that their workforce contains a sizable fraction of young workers, who are less productive than adult workers because they have less strength and experience (captured by $\gamma = 0.28$). This causes worker productivity to be 1.75 times higher in the rich country. This determinant of low worker productivity has been overlooked in previous studies.

The poverty trap also causes low values of k and g. High population growth increases the size of next period's workforce relative to the current period's savers.[12] This spreads saving and capital accumulation more thinly across workers in the future, lowering k. Lower values of k and $\tilde{h}$ also lower the tax base and reduce public investment for any given tax rate. Differences in ϕ raise tax rates and further reduce private saving and private capital formation. Indirectly this also lowers public capital formation by reducing the level of national income and the tax base. These various effects that serve to lower public and private physical capital intensities cause worker productivity to be 7.7 times higher in the rich country. This is more than four times as high as the productivity ratio that Hall and Jones (1999) attribute to differences in capital intensity. There are several reasons as to why the estimate in Table 3 is higher.

In Table 3 we are assuming that the poor country is a perfectly closed economy. In the next section, we open the economy to international capital flows. This reduces the differences in capital intensity across rich and poor countries, although not completely. Because the typical poor country is neither perfectly open nor perfectly closed, our estimates would bound the Hall and Jones estimates, if not for other considerations that suggest their estimates may be too low.

[12]The large effects on worker productivities are accentuated in a three-period model. With only three periods, the population of households that are saving compared to the future workforce is unrealistically small. In addition, the high fertility rate, without a high rate of mortality, will imply a large increase in the size of the future workforce. Both these features cause the capital accumulation financed by the current period's saving to be more thinly spread over the next generation of workers than in a model with many periods of work (and saving) and with the high death rates that mediate population growth in poor countries.

Pritchett (2000) estimates that the actual capital stock in poor countries is only between 57 and 75 percent of the officially measured stock. Thus, in poor countries the level of government consumption is underestimated and the level of investment is overestimated. This causes estimates of productivity differences that are based on direct estimates of the capital stock differences to be too small.

The Hall and Jones approach also treats private and public investment as perfect substitutes in production. The estimates of the output-elasticity of public capital suggest that this is not the case; the elasticity for public capital is less than two-thirds the elasticity for private capital (Glomm and Ravikumar, 1997). Because poor countries have relatively more public capital, the perfect-substitutes assumption overstates the productivity of the capital stock in poor countries. This, in turn, lowers the estimated role of capital differences in explaining worker productivity differences.

IV. Policy Experiments

The previous section identified some potentially important sources of income differences across countries. The question now is whether there are aid policies that can effectively eliminate the sources of poverty. We begin with a standard form of unconditional aid as our baseline for comparison—budget support. We then consider four policies: one opening the economy to international capital flows, two education policies aimed at eliminating the poverty trap, and a policy reform aimed at eliminating antigrowth domestic fiscal policy.

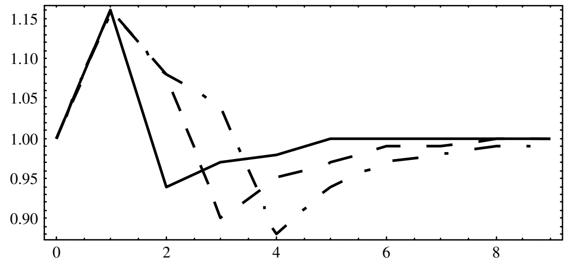
Unconditional Aid: Budget Support

We first consider *unconditional* aid that takes the form of budget support to the poor country's government. This will serve as a baseline to compare against other aid policies that are *conditional* in the sense that they are tied to specific policy changes.

Radelet, Clemens, and Bhavnani (2006) report that current aid flows average about 5 percent of the recipient countries' GDP. Our model is calibrated to match poor countries with large governments where government purchases comprise one-third of GDP. So the average aid flow is 15 percent of the net tax revenue used for government purchases. We consider aid flows equal to 15 percent of net tax revenues with varying duration: one, two, and three periods (or 20, 40, and 60 years). The impact of these aid flows on the growth rate in worker productivity is presented in Figure 2.

The initial steady-state growth rate of the economy is 1 percent. The aid inflows increase growth rates initially, but only by modest amounts. In the initial period, growth rates rise to 1.15 percent. The modest initial increase in growth rates results from the fact that the government will save and invest a fraction of the aid, causing public capital to increase. Greater public capital raises the marginal product of private inputs and the rental rate on

Figure 2. Worker Productivity with Unconditional Aid



Source: Authors' calculations.

Note: Annualized growth rates in worker productivity over time for unconditional aid policies beginning in period 0. The aid provided is 15 percent of the government budget. The solid line represents the effects of giving aid for a single period, the dashed line shows the effects of aid provided for two periods, and the dash-dot line shows the effects of aid provided for three periods.

human capital, which raises private saving and private physical-capital accumulation.

After the first period, growth rates fall. The economy is unable to sustain even the modest increase in growth rates for two reasons. First, because the aid flow is only temporary, the rise in public saving cannot be sustained. Second, there are diminishing returns to public and private investment that would cause growth rates to decline back to the steady-state level, even if aid inflows were permanent. Growth rates eventually dip below the steady-state level for several periods because the rise in the public and private-capital intensity cannot be sustained and the economy must revert to the initial steady-state capital intensities. In short, unconditional aid temporarily, but not permanently, shifts the economy's transition equations upward. With no permanent structural change in the economy's dynamics, it must return to its original steady state. As noted by Radelet, Clemens, and Bhavnani (2006), budget support will raise growth rates temporarily. However, our model suggests that there are no long-term income benefits from unconditional budget support.

Opening the Economy

Section III assumes that the poor country's economy is perfectly closed. What happens if the economy is opened to trade and international capital flows? What will be the effect on different generations of households in the poor country? Will opening the economy make the poor country's government better off or will it oppose the policy?

To answer these questions, the model must first be re-solved under the assumption that the economy is open and that private capital flows will equate the poor country's interest rate to the exogenous world interest rate (which we take to be the steady-state interest rate in the rich country). Next, the dynamic path under the open-economy assumption is computed as the economy goes through the transition from the initial closed-economy steady state to the open-economy steady state. Unlike most neoclassical growth models, the "small" poor economy will *not* adjust to the new steady state in a single period when interest rates are equalized in an open-world capital market. This is because the government's *public* capital accumulation will adjust *gradually* to the opening of the economy. Equation (5a) shows that interest rates can be equalized as a result of private capital adjustments alone. Finally, welfare comparisons are made to see who benefits and who loses from opening the economy, an analysis that includes computing the welfare effect on the poor country's government itself.

After the economy is opened, the poor country's r will converge to the world interest rate r^w, which we take to be the steady-state interest rate of the rich country. The equilibrating force is assumed to be private capital mobility. The poor country's private-capital intensity will then be determined by substituting r^w in Equation (5a) and then solving for the new value of k. Note that this does not mean that k is equated across rich and poor countries because g may differ across countries. Smaller values of g lower the marginal product of k and imply that smaller values of k are needed to drive the return to physical capital down to the world interest rate.

With k determined internationally, the government's optimal policy will change. The government now maximizes Equation (8), not subject to Equation (7), as in the closed economy, but subject to the k determined by international capital markets as described above. The optimal policy in an open economy becomes

$$\sigma = \frac{\beta(1-\alpha)}{\beta + \phi[\psi + \beta(1+\beta)]}, \tag{13a}$$

$$g_{t+1} = \frac{B\sigma}{(1+q)n_{t+1}} \left(\frac{\alpha(1-\sigma)}{1+r^w}\right)^{\frac{\alpha}{1-\alpha}} g_t^{\mu} h_t^A, \tag{13b}$$

where $B = \dfrac{\mu\beta + \phi\mu(\beta(1+\beta)+\psi)}{1+\phi\mu(\beta(1+\beta)+\psi)}$ (see the Appendix for the derivation). The coefficient B represents the share of the government budget that is invested in public capital. The product $B\sigma$ is the share of national output that is invested in public capital.

Fiscal Policy in an Open Economy

One can evaluate the effect of opening the economy on the fiscal policy of the poor country. Consider the extreme case where $\phi = 0$. We then have $B^{open} \equiv \beta\mu > \beta\mu\dfrac{1-\alpha}{1-\alpha\beta} \equiv B^{closed}$, $\sigma^{open} \equiv 1-\alpha < 1-\alpha\beta \equiv \sigma^{closed}$, and $(B\sigma)^{open} = \beta\mu(1-\alpha) = (B\sigma)^{closed}$, where all inequalities hold when future utility is discounted, that is, when $\beta < 1$. Thus, opening the economy lowers the tax

Table 4. Fiscal Policy in Closed and Open Economies

Fiscal Parameter	Closed Economy	Open Economy
σ	0.35	0.26
B	0.29	0.31
σB	0.10	0.08

Source: Authors' calculations.

Note: σ is the income tax rate (net of transfers to the private sector); B is the share of the government budget invested in public capital; σB is the share of national output invested in public capital.

rate and raises the portion of the budget that is invested but leaves the fraction of national output invested the same.

The fiscal policy differences are a result of the *timing* of the impact of fiscal policy on private capital formation in open vs. closed economies. In a closed economy, government policy affects private capital formation by affecting the after-tax wage of savers that fund the *next* period's private capital intensity. In an open economy, government policy affects private capital intensity by affecting the marginal product of private investments in the poor country—reducing it with higher tax rates and raising it with higher public capital intensity. International capital flows will anticipate and respond to these changes in private returns to investment, until the after-tax returns to investment are equalized across countries. Thus, in an open economy, government policy has a more *immediate* effect on private capital formation—this period's policy affects *this* period's capital intensity rather than this period's saving flow and the *next* period's capital intensity. With discounting of the future ($\beta < 1$), the cost to the government of high taxes and low public investment is lower in the closed economy. In a sense, opening the economy disciplines the government and makes private capital formation more responsive to policy changes. The government reacts to the new environment by choosing a more ''pro-growth'' fiscal policy stance.

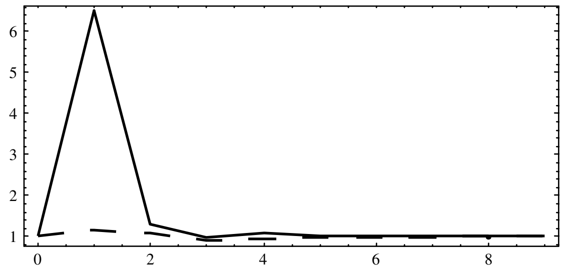
Table 4 gives the fiscal policies in open and closed economies for the calibration in Table 2, where $\phi = 0.7461$.

The result with $\phi = 0.0$ extends to higher values of ϕ; taxes are lower and the fraction of the government budget invested is higher in an open economy. However, the share of national output that is invested in public capital is lower in the open economy when $\phi > 0$, because B rises less than σ falls when the economy is opened. Thus, opening the economy lowers the economy's rate of investment in public capital.

Growth Effects of Opening the Economy

Figure 3 shows the effects on worker productivity of opening the economy to foreign investment. Growth accelerates in the first period as the capital inflow

Figure 3. Opening the Economy to Capital Flows



Source: Authors' calculations.

Note: Annualized growth rates in worker productivity over time from opening the economy compared with a two-period unconditional aid policy. Unconditional aid flows are 15 percent of government budgets in each of the two periods. The solid line represents an open economy; the dashed line represents two periods of unconditional aid.

narrows the poor country's gap in private capital intensity with rich countries. The capital inflow raises the recipient country's national income and tax base, offsetting the reduction in the rate of investment in public capital. Public capital intensity rises over time, to a new, albeit lower, steady-state value. The increase in public capital intensity raises the marginal product of private capital and causes private-capital intensity to increase further. The modest additional increases in public and private capital intensities keep growth in worker productivity above the rate of technological change until period 4, when the economy has approximately converged to its new physical capital intensities. The growth effects of opening the economy to capital mobility dwarf those of the unconditional aid policy. Moreover, these effects are permanent in nature: because the change in the economy is structural, the new steady state is characterized by higher permanent per capita incomes.

The extent to which inflows of private capital narrow productivity differences in the long run is given in Table 5. Comparing Table 5 with Table 3, one sees that worker productivity gaps are narrowed by opening the economy. The rich country's advantage in worker productivity is now less than one-third of what it was in a closed-economy setting, although a nine-fold difference still remains.

Welfare Effects of Opening the Economy

There are clear gains in worker productivity from opening the economy. However, not all generations benefit from the opening. The policy affects the welfare of households by affecting factor prices. Households prefer higher current wages for themselves and higher future wages for their children. They also benefit from higher interest rates on their life cycle saving. Opening the economy will raise wages and lower interest rates as capital flows into the economy. For *most* generations there is a net gain in utility from these factor price adjustments (the effect of higher wages is greater than the effect of lower

Table 5. Steady-State Worker Productivity Differential: The Effect of Openness

Rich-to-Poor Ratios	Model Prediction
k^{α}	1.41
$g^{\mu(1-\alpha)}$	1.73
$\tilde{h}/[1+n(T-s)]$	3.68
y	8.98

Source: Authors' calculations.

interest rates). This is *not* true for the initial generation of young households who are alive at the time the policy is introduced. Their current wages are unaffected by the capital inflows (because the initial capital intensity is fixed) and yet their interest rates are significantly lowered. The sharp drop in interest rates with no change in current wages causes their welfare to fall. Thus, welfare falls for the first generation and rises for all others.

The government in the poor country enjoys an increase in public consumption each period—the increase in the tax base from capital inflows offsets the drop in tax rates. The gain in consumption by the government elite, along with the discounted gain in utility to all future generations, is larger than the loss in welfare of the initial generation. Thus, the poor government would want to open the economy, on economic grounds, in our setting.

This finding is obviously sensitive to the particular calibration chosen. If the initial capital intensities were smaller, or if the poor country's government had a higher rate of time preference, then one might find that the poor country opposes the opening. We plan to investigate these possibilities in future work.

Eliminating the Poverty Trap

Schooling is low in the poor country because the value of forgone earnings associated with sending older children to school is high. The value of forgone earnings is high because households have many children and because parental earnings are low. The poverty trap can be removed if parental earnings are increased relative to the earnings of older children. This would make it more costly to have many children (because of the forgone wages and parents' consumption associated with child rearing) and it would lower the relative value of children's work in total family income.

Using aid to encourage poor countries to increase the schooling of *younger* children (that is, to increase $\bar{s}$) will increase earnings but will not remove the poverty trap.[13] This policy would not raise the earnings of

[13]Aid-financed spending on the human capital of young children can be defended on other grounds. If intergenerational capital markets are imperfect, investments in human capital of young children have very high returns (see Rangazas, 2002 and 2005).

parents *relative* to those of older children (because they both receive the higher levels of education when they are young children). What is needed is more schooling of *older* children, so that when they become parents their earnings (based on $s_t > \bar{s}$) sufficiently exceed the earnings of their older children (based only on $\bar{s}$)—thereby making children more costly and relatively less important in generating family income.[14]

One policy that can remove the poverty trap is similar to Mexico's Progresa program.[15] Governments would subsidize the forgone earnings of older children who attend school. A sufficiently high subsidy would raise s_t sufficiently higher than $\bar{s}$, so that a transitional dynamic would result, sending the poor country to point *C* in Figure 1. The potential advantage of identifying and eliminating poverty traps is that aid need not be ongoing. Once sufficient aid has been provided to eliminate the poverty trap, no further aid is necessary.

To begin the analysis of the subsidy policy, let the policy parameter η denote the fraction of forgone earnings of older children that the government returns to the household. This introduces the expression $\eta w_t \gamma \bar{h}_t (s_t - \bar{s}) n_{t+1}$ on the right-hand side of the household lifetime budget constraint from Section I. In the face of the subsidy, household behavior becomes

$$n_{t+1} = \frac{\psi}{(1+\beta+\psi)(\tau - \gamma(T - s_t + \eta(s_t - \bar{s}))(\bar{s}/s_{t-1})^{\theta})}, \tag{14a}$$

$$s_t = \max\left[\frac{\theta(\tau(s_{t-1}/\bar{s})^{\theta} - \gamma T + \gamma \bar{s}\eta)}{\gamma(1-\theta)(1-\eta)}, \bar{s}\right]. \tag{14b}$$

The subsidy increases the optimal schooling level and, if it is sufficiently high, the optimal schooling level is pushed above $\bar{s}$. For a given level of s_t, fertility is also encouraged by the subsidy. However, if the subsidy raises s_t enough, then fertility will fall.

Of course, the subsidy must be financed out of tax revenues. In addition, as older children work less in order to attend school, the tax base shrinks. So government revenue is reduced by two factors in the first period—the subsidy payment and the decline in the tax base. This implies that government consumption and investment will fall initially, which may offset, or at least mediate, the early growth effects of the policy. As the stock of human capital rises and increases the tax base, government consumption and investment eventually rise.

[14]Older children here are children of working age (10 years old or older).

[15]In 1997 Mexico began Progresa, a program designed to increase human capital in poor families by paying families to send their children to school and to visit health care providers. Grants are paid directly to the mothers and cover about two-thirds of what the child would receive for full-time work (Krueger, 2002).

Growth Effects of the Progresa Program

Table 6 and Figure 4 present the effects of a subsidy paid for a single period that is similar in size to that offered in the Mexican Progresa program, $\eta = 0.67$. The relatively large subsidy is more than enough to boost the economy out of the poverty trap and creates something close to a "growth miracle." The large rise in schooling and fall in fertility create strong direct (via human capital per worker) and indirect (via physical and public capital intensities) growth effects for a number of periods. As in the case of opening the economy, the growth effects dwarf those of budget support and lead to large permanent increases in income levels.

Welfare Effects of the Progresa Program

An advantage of the Progresa program is that no generation is hurt by the policy. Although the positive welfare gain is quite small for the first generation, because they do not directly benefit from the higher schooling, it is significant from the second generation onwards. With sizable welfare gains after the first period, combined with large increases in the tax base, the government's welfare increases because of the policy change.

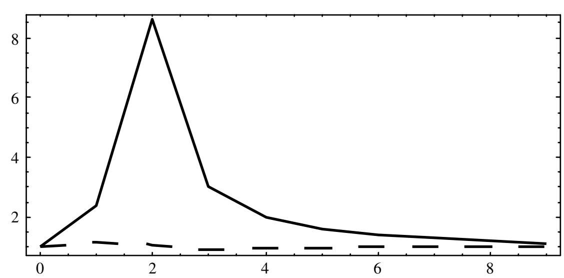
Other policies designed to increase schooling do not necessarily generate universal private sector benefits. We compare the welfare effects of the

Table 6. The Progresa Program: Schooling and Fertility Effects

Period	1	2	3	4	5	6	7	8	9	10
s	0.29	0.34	0.37	0.41	0.43	0.45	0.47	0.48	0.49	0.49
n	2.5	1.2	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Source: Authors' calculations.

Figure 4. The Effects of the Progresa Program



Source: Authors' calculations.

Note: Annualized growth rates in worker productivity over time from the Progresa program compared with a two-period unconditional aid policy. Unconditional aid flows are 15 percent of government budgets in each of the two periods. The solid line represents Progresa; the dashed line represents two periods of aid.

Progresa policy against a compulsory schooling policy that generates the same increase in schooling. This requires that the first generation of students spend 0.29 of their time endowment in school, as under the Progresa policy. After that point, the minimum school requirement of 0.29 is nonbinding and schooling will follow the same path as that displayed in Table 6.

The growth effects of compulsory schooling are actually stronger than those of the Progresa policy. This is because, without the government subsidy, families will choose fewer children relative to the Progresa policy, which subsidizes the cost of schooling children. The steeper decline in fertility increases the economy's growth rates marginally above those in Figure 4. However, because the initial family is forced to send their children to school more than they consider optimal, they are made worse off. The government, on the other hand, prefers compulsory schooling. The fact that compulsion eliminates the need for a subsidy and raises growth and tax revenue to a greater degree more than compensates for the decrease in welfare for the initial generation.[16]

Eliminating Antigrowth Fiscal Policy

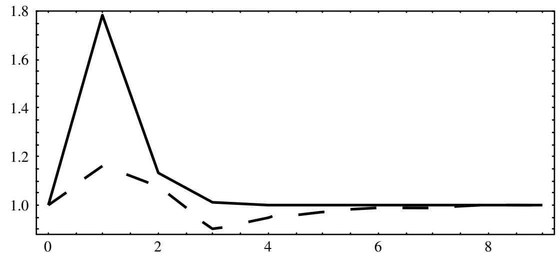
Attempting to reform conventional fiscal policy is a very common target for aid policy. We now consider the effects of imposing a fiscal policy in the poor country that would bring it in line with the fiscal policy of the rich country. In particular, we compute the effects of imposing the σ and B of the rich country, where the optimal values are 0.15 and 0.67, on the poor country, where the optimal values in the open economy are 0.26 and 0.31.

Growth Effects of Fiscal Policy Reform

The effects of fiscal reform on worker productivity are given in Figure 5. These effects are relatively modest and short lived. In part, this is due to the fact that we begin the policy experiment from a perfectly open economy. Opening the economy brings the fiscal policy of the poor government closer to that of the rich government (Table 4). This has the effect of making the differences in tax policy less dramatic and the returns to accumulating private and public capital smaller (because capital intensities are higher in the open economy than in the closed economy). Because the poor economy is relatively close to the rich country in capital intensities to begin with (Table 5), the transition to a new steady state is short.

[16]Our model abstracts from tuition costs. The government can raise schooling by increasing tuition subsidies. Doepke (2004) and Lord and Rangazas (2006) study the historical impact of government tuition subsidies in England. They find that lower tuition has modest effects on schooling and growth. Lower tuition reduces the cost of all children and, in particular, young children who would have attended school in any case. This raises fertility for several periods and slows the demographic transition. Thus, something like a Progresa program or compulsory schooling is needed to generate a quick demographic transition and rapid economic growth.

Figure 5. The Effects of Fiscal Reform



Source: Authors' calculations.

Note: Annualized growth rates in worker productivity from fiscal reform compared with two periods of unconditional aid of 15 percent of the government budget. The solid line represents fiscal reform; the dashed line represents two periods of aid.

Welfare Effects of Fiscal Reform

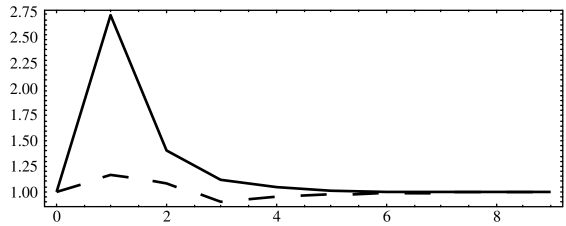
All generations experience a significant gain from the fiscal reform. This is because of the growth effects (Figure 5) and because of the direct effects of lower taxes. Of course, the government is worse off since it has been moved from its optimal fiscal policy.

V. The Aid Cost of Reform

We have examined five policies to promote growth in developing economies. The impact of the policies on growth differed significantly and so did their aid cost. The unconditional aid policy comes at a price and delivers no long-term benefits. Openness and the Progresa-style education subsidy deliver large and sustained increases in income. They also increase the welfare of the poor country's government and thus should be readily accepted. However, openness hurts the initial generation of private households, and thus may not increase the government's welfare for all calibrations. At a minimum, the government may use the fact that the current generation is hurt as a "bargaining chip" to induce some aid compensation for opening the economy. Strategic considerations also enter in the case of the Progresa program. The government prefers compulsory schooling and it may use this as a threat to induce aid compensation for going forward with the Progresa program.

The domestic fiscal reforms, on the other hand, would certainly be opposed by the poor country's government. Aid dollars would have to be used to "purchase" the fiscal reforms from the poor country's government, in compensation for its losses. We can assess the aid cost of fiscal reform by calculating the minimum amount of aid needed to keep the poor country's government indifferent to the reforms. We compute the aid cost as a permanent flow of aid, expressed as a fraction of the poor government's budget. The aid flow must be permanent because the government will want to renege and revert to its optimal fiscal policy as long as it stays in power.

Figure 6. Fiscal Reform with Required Aid



Source: Authors' calculations.

Note: Annualized growth rates in worker productivity over time from the fiscal reform vs. a two-period unconditional aid policy. The required aid is a permanent flow equal to 87 percent of the government budget. Unconditional aid flows are 15 percent of government budgets over each of the two periods. The solid line represents fiscal reform; the dashed line represents two periods of aid.

Of course, the aid flow will also change the amount that the government invests (although the government consumes most of the aid flow, some is invested), and thus the growth effects of the fiscal reforms will be larger than those without aid—an added benefit of the aid that goes beyond purchasing the reforms per se. The growth effects are given in Figure 6.

The growth effects are higher than in Figure 5 because the government chooses to invest some of the aid. The amount of aid required to purchase reforms is very high. Aid equal to more than 87 percent of the poor country's budget is needed. Because the poor country's budget increases as the country grows, the absolute flow of aid must increase over time—long after the growth rate effects of the reforms have been exhausted.

VI. Aid Failures

No robust correlation between aid and growth has been identified in the econometric literature (for example, Easterly, Levine, and Roodman, 2004). There are several possible econometric reasons for the absence of a clear positive relationship; for example, *endogeneity of aid flows* (aid is targeted to slow-growing economies), *specification error* (the relationship between aid and growth is highly nonlinear), and *measurement error* (all aid, including aid not intended to generate growth, are lumped together in a single measure). Our analysis is consistent with three other possible reasons for the lack of correlation.

Unconditional Aid Is Not Growth Promoting

Our results suggest that unconditional aid, including aid whose conditions are not adequately enforced, will not deliver long-term gains in income. The boost to growth from unconditional aid is short-lived and so modest that it could easily be overshadowed by other developments—for example, the negative shocks to the economy that trigger the scaling up of unconditional aid.

Domestic Conflict over Growth Policies

Although there are policies that can generate rapid growth and sustained increases in income, there is likely to be domestic conflict over which policy to pursue. The government favors opening the economy and compulsory schooling, but the current generation of private households will oppose both policies. The current generation of private households favors the Progresa program, a program the government views as clearly inferior to compulsory schooling. These conflicts may undermine attempts to achieve domestic consensus on which growth-promoting and poverty-reducing policies to implement. Such lack of ownership could even delay or undermine the negotiation and implementation of conditional aid agreements with donors.

Prohibitive Aid Cost

Fiscal reforms are often a key component of the conditions for receiving aid. Our analysis suggests that fiscal reforms are likely to be the least successful of the policies we examined. First, the growth effects of fiscal reform are relatively modest and short lived. Second, the aid cost of "buying" the reforms from the poor country's government is enormous. Unless foreign aid keeps flowing in sufficient quantities, the recipient government will do what it can to revert to a high-tax, low-investment regime. In fact, the cost of maintaining effective reforms will increase over time as the government's budget, and the potential to increase government consumption, grows. In practice, aid is far less than what is necessary to keep the government indifferent, thus dooming fiscal reforms from the beginning.

Even if the aid is carried out in sufficient amounts indefinitely, there will be little correlation between aid and economic growth in the data. The growth effects occur early on, while the aid continues into the future during periods when the growth effects have long since vanished. If aid is cut somewhat, rather than increased, then there will be a reversion in fiscal policy and growth. Thus, aid will be flowing to a country experiencing negative growth.

VII. Conclusion

This paper proposes the adoption of calibrated dynamic general equilibrium models of growth and development as a framework for evaluating the effectiveness of foreign aid policies, alongside econometric techniques and case studies. In applying this method to development aid, we argue that four guiding principles should be followed.

- The underlying model must first be able to replicate important growth facts before it is used in assessing aid policy.
- The microeconomic sources of poverty must be identified in order to sharpen policy remedies and to make welfare comparisons of alternative policies.

- The objectives of the domestic government must be modeled so that the policy responses to aid reforms can be accounted for and welfare effects used to calculate the required aid cost of reforms.
- Some insight should be provided into why econometric methods have not been able to identify a robust positive correlation between aid and economic growth.

In this paper, we developed a very simple model that illustrates how the four principles can be applied. Even though the analysis demonstrates the potential benefits of the approach, our prototype model must be modified to match certain key facts of development before its recommendations for aid policy can be taken seriously. In particular, it would be important to extend the model to include an informal sector, as in Lord and Rangazas (2006). In addition, economic growth is almost uniformly associated with (1) a demographic transition (2) an economic transformation from informal to formal methods of production and (3) a rising share of government spending as a fraction of GDP—Wagner's Law. A two-sector model would allow us to directly address fact (2). Although we capture fact (2) with the current model, Lord and Rangazas (2006) show that facts (1) and (2) are likely connected. The inability of governments to effectively tax the informal sector is likely related to fact (3).

Another important extension is to consider additional possible conflicts of interest that prevent or drive up the aid cost of pro-growth policies. For example, recent work on the political economy of education offers new insights into potential sources of conflicts. Galor, Moav, and Vollrath (2005) use a two-sector model with agriculture and manufacturing to explore the link between the economic transformation and the public provision of education. They assume that human capital is not productive in agriculture, which makes landowners reluctant to finance any part of public education. As the economy develops, physical capital replaces land as a source of wealth. Unlike land, physical capital is complemented by human capital in production. Thus, in this model, political support for public financing of education rises over time. Extensions of this framework to include fertility choices would result in a theory capable of addressing all three features of growth mentioned above, in addition to introducing a new source of policy conflict.

Potential conflicts may also arise in models with income inequality. For example, Galor and Moav (2004) assume initial wealth differs across households. In the presence of credit constraints, this causes the marginal propensity to save and invest in human capital to differ across households. "Rich" households invest efficiently in human capital and own physical capital. "Poor" households own no physical capital and their human capital investments are below efficient levels. This structure introduces a possible source of conflict over aggregate policies. It also allows one to examine the interaction between economic growth and income inequality, a central concern of policymakers.

APPENDIX

Optimal Fiscal Policy in a Closed Economy

Domestic fiscal policy is determined by maximizing Equation (10) subject to the government budget constraint and the accumulation equations for private and public capital. The private household's indirect utility function may be written as

$$U_t = U_0 + \bar{U}_t + (1+\beta)\ln w_t + \beta \ln(1+r_{t+1}) + \psi \ln w_{t+1},$$

where U_0 is a constant and $\bar{U}_t = (1+\beta)\ln h_t + \psi \ln n_{t+1} + \psi \ln h_{t+1}$ is independent of fiscal policy. For the purpose of setting optimal fiscal policy, the government can then be modeled as choosing tax rates and public capital to maximize

$$\sum_{i=0}^{\infty} \beta^i (\ln c^g_{t+i} + \phi\{(1+\beta)\ln w_t + \beta \ln(1+r_{t+1}) + \psi \ln w_{t+1}\}), \tag{10'}$$

subject to Equations (5) and (7)–(9).

Substituting the constraints into the objective function and collecting common terms yield the following equivalent problem:

$$\begin{aligned} \max_{\{\sigma_{t+i}, g_{t+i}, k_{t+i}\}_{i=1}^{\infty}} & \sum_{i=1}^{\infty} \beta^{i-1} \ln\left[\sigma_{t+i-1} k^{\alpha}_{t+i-1} g^{\mu(1-\alpha)}_{t+i-1} h^A_{t+i-1} - g_{t+i}(1+q) n_{t+i}\right] \\ & + \phi \sum_{i=1}^{\infty} \beta^{i-1} \{[\beta(\alpha-1) + \psi\alpha + \beta\alpha(1+\beta)] \\ & \ln k_{t+i} + \mu(1-\alpha)[(\beta+\psi) + \beta(1+\beta)] \ln g_{t+i} \\ & + [\beta + \psi + \beta(1+\beta)] \ln(1-\sigma_{t+i})\} \\ & + \sum_{i=1}^{\infty} \lambda_{t+i} \left\{ \left[\frac{\beta}{1+\beta+\psi}\right] \frac{(1-\sigma_{t+i})(1-\alpha) k^{\alpha}_{t+i-1} g^{\mu(1-\alpha)}_{t+i-1} h_{t+i-1}}{(1+q) n_{t+i} h^A_{t+i}} - k_{t+i} \right\}, \end{aligned}$$

where λ is the multiplier associated with the private capital accumulation constraint.

To solve this sequence problem, begin by differentiating to get the first-order conditions for $\sigma_{t+i}, g_{t+i}, k_{t+i}, \lambda_{t+i}$. Next, substitute into the first-order conditions the "guess" $(1+q)n_{t+i+1} g_{t+i+1} = B\sigma n_{t+i} k^{\alpha}_{t+i} g^{\mu(1-\alpha)}_{t+i} h^A_{t+i}$, where B is an undetermined coefficient. Finally, solve the first-order conditions for B, σ_{t+i}, g_{t+i}, and k_{t+i} to get Equation (11).

Optimal Fiscal Policy in an Open Economy

In an open economy, the government's problems can be written so that they solve

$$\begin{aligned} \max_{\{\sigma_{t+i}, g_{t+i}\}_{i=1}^{\infty}} & \sum_{i=1}^{\infty} \beta^{i-1} \ln\left[\sigma_{t+i-1}\left(\frac{(1-\sigma_{t+i-1})\alpha}{1+r^w}\right)^{\frac{\alpha}{1-\alpha}} g^{\mu}_{t+i-1} h^A_{t+i-1} - g_{t+i}(1+q) n_{t+i}\right] \\ & + \phi[\psi + \beta(1+\beta)] \sum_{i=1}^{\infty} \beta^{i-1} \left\{\frac{1}{1-\alpha} \ln(1-\sigma_{t+i}) + \mu \ln g_{t+i}\right\} \end{aligned}$$

This problem differs from the closed-economy problem because private capital intensity is now determined by international capital flows rather than by domestic saving. In a closed economy, government policy affected private capital formation by affecting the after-tax wage of savers that funded the subsequent period's private capital intensity. Now, government policy affects private capital intensity by affecting the marginal product of private investments in the poor country—reduced by higher tax rates and raised by higher public capital intensity. In an open economy, government policy has a more *immediate* effect on private capital formation—this period's policy affects *this* period's capital intensity rather than this period's saving flow and *next* period's capital intensity.

Differentiating with respect to σ_{t+i} and g_{t+i} generates first-order conditions. As before, guess a solution for g of the form

$$(1+q)n_{t+i+1}g_{t+i+1} = B\sigma_{t+i}\left(\frac{\alpha(1-\sigma_{t+i})}{1+r^{w}}\right)^{\frac{\alpha}{1-\alpha}} g^{\mu}_{t+i}h^{A}_{t+i}.$$

Substitute into the first-order conditions and solve for σ_{t+i} and B to get the solution in the text.

REFERENCES

Adam, C., and D. Bevan, 2004, "Aid and the Supply Side: Public Investment, Export Performance, and Dutch Disease in Low-Income Countries," Department of Economics Discussion Paper No. 201 (Oxford, Oxford University), Available via the Internet: http://www.economics.ox.ac.uk/Research/wp/pdf/paper201.pdf.

Agénor, P.R., 2004, *The Economics of Adjustment and Growth*, (Cambridge, Massachusetts, Harvard University Press, 2nd ed).

———, N. Bayraktar, and K. El Aynaoui, 2005, "Roads Out of Poverty? Assessing the Links Between Aid, Public Investment, Growth and Poverty Reduction," Policy Research Working Paper No. 3490 (Washington, World Bank).

Arellano, C., A. Bulíř, T. Lane, and L. Lipschitz, 2005, "The Dynamic Implications of Foreign Aid and its Variability," IMF Working Paper 05/119 (Washington, International Monetary Fund).

Aschauer, D., 1989, "Is Public Expenditure Productive?" *Journal of Monetary Economics*, Vol. 23 (March), pp. 177–200.

Auerbach, A., and L. Kotlikoff, 1987, *Dynamic Fiscal Policy* (Cambridge, United Kingdom, Cambridge University Press).

Azariadis, C., and J. Stachurski, 2005, "Poverty Traps," in *Handbook of Economic Growth*, Vol. 1A, ed. by P. Aghion and S. Durlauf (Amsterdam, North-Holland).

Bongaarts, J., 2002, "The End of the Fertility Transition in the Developed World," *Population and Development Review*, Vol. 28 (September), pp. 419–443.

Chatterjee, S., G. Sakoulis, and S. Turnovsky, 2003, "Unilateral Capital Transfers, Public Investment, and Economic Growth," *European Economic Review*, Vol. 47 (December), pp. 1077–1103.

Chatterjee, S., and S. Turnovsky, 2004, "Substitutability of Capital, Investment Costs, and Foreign Aid," in *Economic Growth and Macroeconomic Dynamics: Recent Developments in Economic Theory*, ed. by S. Dowrick, R. Pitchford, and S. Turnovsky (Cambridge, United Kingdom, Cambridge University Press).

———, 2005, "Financing Public Investment through Foreign Aid: Consequences for Economic Growth and Welfare," *Review of International Economics*, Vol. 13 (February), pp. 20–44.

Clarida, R.H., 1993, "International Capital Mobility, Public Investment and Economic Growth," NBER Working Paper No. 4506 (Cambridge, Massachusetts, National Bureau of Economic Research).

Clemens, M., S. Radelet, and R. Bhavnani, 2004, "Counting Chickens When They Hatch: The Short-Term Effect of Aid on Growth," Working Paper No. 44 (Washington, Center for Global Development), Available via the Internet: http://www.cgdev.org/content/publications/detail/2744.

Deardorff, A., and R. Stern, 1990, *Computational Analysis of Global Trading Arrangements* (Ann Arbor, Michigan, University of Michigan Press).

Doepke, M., 2004, "Accounting for Fertility Decline During the Transition to Growth," *Journal of Economic Growth*, Vol. 9 (September), pp. 347–383.

Easterly, N., Levine, and D. Roodman, 2004, "Aid, Policies, and Growth: Comment," *American Economic Review*, Vol. 94 (June), pp. 774–780.

Feldstein, M., 1998, "Refocusing the IMF," *Foreign Affairs*, Vol. 77 (March/April), pp. 20–33.

Galor, O., and O. Moav, 2002, "Natural Selection and the Origin of Economic Growth," *Quarterly Journal of Economics*, Vol. 117 (November), pp. 1133–1191.

———, 2004, "From Physical to Human Capital Accumulation: Inequality and the Process of Development," *Review of Economic Studies*, Vol. 71 (October), pp. 1001–1026.

———, and D. Vollrath, 2005, "Land Equality and the Emergence of Human Capital Promoting Institutions," Working Paper 2005–03 (Providence, Rhode Island, Brown University).

———, and D.N. Weil, 2000, "Population, Technology, and Growth: From Malthusian Stagnation to the Demographic Transition and Beyond," *American Economic Review*, Vol. 90 (September), pp. 806–828.

Glomm, G., and B. Ravikumar, 1997, "Productive Government Expenditures and Long-Run Growth," *Journal of Economic Dynamics and Control*, Vol. 21 (January), pp. 183–204.

Greenwood, J., and A. Seshadri, 2005, "Technological Progress and Economic Transformation," in *Handbook of Economic Growth*, Vol. 1B, ed. by P. Aghion and S. Durlauf (Amsterdam, North-Holland).

Hall, R., and C. Jones, 1999, "Why Do Some Countries Produce So Much More Output Per Worker Than Others?" *Quarterly Journal of Economics*, Vol. 114 (February), pp. 83–116.

Hazan, M., and B. Berdugo, 2002, "Child Labour, Fertility, and Economic Growth," *Economic Journal*, Vol. 112 (October), pp. 810–828.

Heston, A., R. Summers, and B. Aten, 2002, "Penn World Table Version 6.1," Center for International Comparisons at the University of Pennsylvania (CICUP).

Isard, P., L. Lipschitz, A. Mourmouras, and B. Yontcheva, 2006, "Foreign Aid and Macroeconomic Management: Overview and Synopsis of Key Lessons," in *The Macroeconomic Management of Foreign Aid: Opportunities and Pitfalls*, ed. by P. Isard and others (Washington, International Monetary Fund).

King, R., and S. Rebelo, 1993, "Transitional Dynamics and Economic Growth in the Neoclassical Model," *American Economic Review*, Vol. 83 (September), pp. 908–931.

Krueger, A., 2002, "Economic Scene: A Model for Evaluating the Use of Development Dollars, South of the Border," *New York Times*, May 2, Section C.

Ljungqvist, L., and T. Sargent, 2004, *Recursive Macroeconomic Theory* (Cambridge, Massachusetts, MIT Press, 2nd ed).

Lord, W., and P. Rangazas, 2006, "Fertility and Development: The Roles of Schooling and Family Production," *Journal of Economic Growth*, Vol. 11, pp. 229–261.

———, 2004, "Family Production and Economic Growth," University of Maryland Baltimore County Seminar Series, October 6.

Manuelli, R., and A. Seshadri, 2005, "Human Capital and the Wealth of Nations," unpublished; Madison, Wisconsin, University of Wisconsin-Madison), Available via the Internet: http://www.ssc.wisc.edu/~manuelli/research/humcapwealth nation5_05.pdf.

Moav, O., 2005, "Cheap Children and the Persistence of Poverty," *Economic Journal*, Vol. 115 (January), pp. 88–110.

Parente, S., and E.C. Prescott, 2000, *Barriers to Riches* (Cambridge, Massachusetts, MIT Press).

Poterba, J., 1999, "Rate of Return to Corporate Capital and Factor Shares: New Estimates Using Revised National Income Accounts and Capital Stock Data," NBER Working Paper No. 6263 (Cambridge, Massachusetts, National Bureau of Economic Research).

Pritchett, L., 2000, "The Tyranny of Concepts: CUDIE (Cumulated Depreciation Investment Effort) is not Capital," *Journal of Economic Growth*, Vol. 5 (December), pp. 361–384.

Pronk, J., 2001, "Aid as a Catalyst," *Development and Change*, Vol. 32 (September), pp. 611–629.

Radelet, S., M. Clemens, and R. Bhavnani, 2006, "Aid and Growth: The Current Debate and Some New Evidence," in *The Macroeconomic Management of Foreign Aid: Opportunities and Pitfalls*, ed. by P. Isard and others (Washington, International Monetary Fund).

Rajan, R., and A. Subramanian, 2005, "What Undermines Aid's Impact on Growth?" IMF Working Paper 05/126 (Washington, International Monetary Fund), Available via the Internet: http://www.imf.org/external/pubs/ft/wp/2005/wp05126.pdf.

Rangazas, P., 2002, "The Quantity and Quality of Schooling and U.S. Labor Productivity Growth (1870–2000)," *Review of Economic Dynamics*, Vol. 5 (October), pp. 932–964.

———, 2005, "Human Capital and Growth: An Alternative Accounting," *Topics in Macroeconomics*, Vol. 5, No. 1 (Berkeley, California, Berkeley Electronic Press), Available via the Internet: http://www.bepress.com/bejm/topics/vol5/iss1/art20/.

Rodrik, D., 1999, *The New Global Economy and Developing Countries: Making Openness Work* (Washington, Overseas Development Council).

———, ed. 2003, *In Search of Prosperity: Analytic Narratives on Economic Growth* (Princeton, New Jersey, Princeton University Press).

———, 2005, "Growth Strategies," in *Handbook of Economic Growth*, Vol. 1A, ed. by P. Aghion and S. Durlauf (Amsterdam, North-Holland).