Is Poverty a Binding Constraint on Growth in Sub-Saharan Africa?

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Abstract: Is poverty a binding constraint on economic growth in Sub-Saharan Africa? Plausible theories abound, but the empirical cross-country growth literature is indecisive and is likely to remain so. We argue that the most promising directions for research involve microeconomic investigations of the effects of poverty on productivity. We review the dominant mechanisms through which these effects may emerge and suggest specific avenues for country-based research.

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1. Introduction

The literature on pro-poor growth studies the links from national growth strategies and patterns to poverty outcomes. Understanding these links is important, and other framework papers will suggest promising research approaches at the country level. But a 'nexus' between poverty and growth implies a two-way relationship. The purpose of our paper is to look at the other direction of the nexus: the links from poverty to growth.

By poverty we mean a state in which household consumption is below some absolute purchasing power standard. Our discussion will also consider vulnerability, defined in terms of the risk of falling below in a given time period. Figure 1 uses survey data from Chen and Ravallion (2008) to compare the prevalence of consumption poverty in sub-Saharan Africa since 2000 with that of other developing regions. Africa is by far the poorest region in the world. If there are links from poverty to growth in the development process, then certainly Africa is the main place to worry about them and accommodate them in the formation of growth strategies.

Our central argument is that the most promising directions for country-based research on the links from poverty to growth involve microeconomic investigations of the effects of poverty on productivity. The bulk of our paper is devoted to reviewing the dominant mechanisms through which these effects may emerge, both from a macro and from a micro perspective. We close by suggesting specific avenues for country-based research.

2. Development traps: framing the issues

At the economy-wide level, a link from poverty to growth is a link from the level of income per capita, y, to the growth rate of income per capita, g. In functional notation, $g = f(y; z)$, where z is a vector of underlying growth determinants or *fundamentals*. The Solow (1956) growth model provides a familiar example and we use it here as a point of departure.

2.1 A growth-theory perspective

Figure 2 shows a neoclassical production function $y = A \cdot k^{\alpha}$, where k is the capital stock per worker, $A > 0$ is the level of total factor productivity (TFP), which we treat here as a constant, and $\alpha \in (0,1)$ is the share of capital in national income. For given rates of saving, depreciation, and population growth (s, δ and n), the capital stock per worker is stationary when saving is just sufficient to keep the capital stock per worker from falling or, equivalently, when output per worker is a multiple $(n+\delta)/s$ of the capital stock per worker. Steady states therefore occur at all intersections of $A \cdot k^{\alpha}$ with $[(n+\delta)/s] \cdot k$. Given diminishing returns to capital, there is only one such intersection with a positive capital stock. At this steady state, the value of income per worker, $y^* = [A \cdot s/(n+\delta)]^{\alpha/1-\alpha}$, is a continuous function of the vector of fundamentals $z = [A, s, n, \delta, \alpha]$.

The phase diagram for the Solow model shows a monotonically decreasing relationship between growth and income, holding z constant (Figure 3). This configuration implies that for a given set of fundamentals, the poorer a country is, the faster it grows. This property, known as *conditional convergence*, is widely viewed as the central implication of the model (Mankiw, Romer and Weil 1992). A stronger version—*absolute convergence*—applies if cross-country differences in the fundamentals are small: in this case all countries approach the same steady state and along the transition path the proportional difference between any two incomes shrinks over time. These convergence properties continue to hold if TFP grows at an exogenous rate common across all countries; in this case economies approach a steady-state growth path rather than a constant income level.[2]

The Solow model therefore offers a simple account of the link between income and growth: holding the fundamentals constant, poor countries grow faster than rich ones, because low income indicates a scarcity of capital and therefore a high return to

[2] The details depend on how technological progress enters the production function. Our underlying production function is $Y = A \cdot K^{\alpha} L^{1-\alpha}$, where Y, K and L are total output, capital stock, and labor. Technological change is Hicks-neutral in this case, and generates a long-run growth rate of $g_A/(1-\alpha)$ where g_A is the growth rate of A. The more familiar textbook case features labor-augmenting technological change; the production function is $Y = K^{\alpha}(A \cdot L)^{1-\alpha}$ case and the long-run growth rate is g_A.

investment. The force of this link is greater if international capital mobility is stronger, but it holds even in a financially closed global economy.

As Pritchett (2004) puts it, absolute convergence fails big time, both over centuries and in data from the post-WWII period. Quah (1997, 2001) and others study the empirical distribution of cross-country incomes per capita after 1960 and argue that the way in which absolute convergence fails is not random. By contrast with a situation in which some countries are endowed with low-income fundamentals, others with medium-income, and others with high-income, the empirical distribution shows a tendency to develop twin peaks over time. Two *convergence clubs* can be distinguished, one of which has gone through a largely irreversible historical process of industrialization and development and the other of which—comprising the UN's least-developed countries, Collier's (2007) bottom billion, or larger groups below some development threshold—has not. The lagging growth performance of Sub-Saharan Africa plays a major role in global divergence since 1960, and most of the continent continues to fall within the low-development group (Berthélémy 2007, Ndulu and O'Connell 2007, Sachs *et al.* 2004).

Not surprisingly, the Solow model does considerably better empirically once the fundamentals are allowed to differ across countries. The standard approach in the growth literature is to estimate a linearized version of $g = f(y;z)$ using cross-country panel data. When this is done, the parameter that captures $\partial f / \partial y$ is robustly negative and statistically significant (Mankiw, Romer and Weil 1992, Hoeffler 2002). Barro (1991), Sachs and Warner (1997) and others go further, retaining the conditional convergence term but implicitly modeling the Solow fundamentals as functions of deeper determinants. In this approach $z = z(w)$, where w may include policy variables, geographical determinants of productivity, or institutional aspects of the investment environment; the growth equation becomes $g = f(y;w)$.

Within the growth literature, the leading theoretical alternative to the neoclassical approach is the endogenous growth tradition initiated by Romer (1986) and Lucas (1988). This approach models the productivity term in $A \cdot k^{\alpha}$ as a stock that can be accumulated through purposive investment activity—in human capital for example, or research and development. Since knowledge is a public good, this process is subject to positive externalities that scale up the productivity impact of any individual's investment. In the

simplest "*AK*" versions of endogenous growth theory, the aggregate production function becomes $y = \widetilde{A} \cdot \widetilde{k}$, where $\widetilde{k}$ is a broad concept of reproducible capital and $\widetilde{A}$ is a constant (the average product of broad capital) that can differ across countries. These economies display constant returns to broad capital and therefore have no steady state level of income. The conditional convergence term is absent in the growth equation, which now becomes $g = f(z)$ or $g = f(w)$.

2.2 Development traps

The twin peaks phenomenon identifies a set of countries that remained poor after 1960. But did these countries fail to grow *because they were poor*? Equivalently: is low income self-perpetuating at the national level? So far our answer is no. Within the neoclassical and AK traditions, persistently low income is driven by weak fundamentals and not by low income *per se*. Low income may be persistent but it is not self-perpetuating, unless the fundamentals themselves are functions of income.

If $z = z(y; w)$ or $w = w(y)$, then of course things are more complicated. Holding constant any fundamentals that do not depend on income (call these x), we now have $g = f(y; x)$. The impact of income on growth, $\partial f / \partial y$, can now easily be non-monotonic. Figure 4 shows an example studied by Solow (1956) himself, in which TFP follows a logistic curve, rising smoothly from $A = 1$ to $A = 3$ as a country traverses a middle range of capital stocks per worker. Here $A = A(k)$ or, implicitly, $A = A(y)$.[3] The phase diagram is now non-monotonic (Figure 5), implying that poor countries may grow more slowly than otherwise-identical rich countries.

If $\partial f / \partial y$ is sufficiently non-monotonic, the growth equation $g(y; x)$ crosses the horizontal axis more than once. Crossings with $\partial g / \partial y > 0$ define *thresholds* below which income falls and above which it rises, while crossings with $\partial g / \partial y < 0$ are locally stable steady states.

The development economics literature is full of theoretical models in which the aggregate economy has two locally stable steady states; recent overviews include Hoff

[3] Here $y = A \cdot k^{\alpha}$, so $k = k(A,y)$. Substituting $A = A(k)$ yields the implicit function $A(y)$. In Figures 4 and 5, we use $\alpha = 0.4$ and $A = 1 + [2/(1 + \exp(a–k)]$, with $a = 15$ for the multiple equilibrium case and $a = 8$ for the persistence case.

and Stiglitz (2001), Sachs *et al.* (2004), and Azariadis and Stachursky (2005). While the lower of these equilibria is commonly called a *poverty trap*, the reference to poverty is potentially misleading. Income is lower in the bad equilibrium than in the good equilibrium, but the relationship of the low-income equilibrium to any absolute income standard is unclear. Moreover, if productivity grows at a common global rate it is the cross-country ratios of income, not the levels, that approach a steady state. We therefore follow Berthélémy (2007) in referring to these low-income equilibria as *development traps*.

There are good reasons, moreover, to discount the tendency of theoretical treatments to focus on multiplicity *per se*. In terms of policy significance, there is little distinction between a world in which low income is one of a number of long-run equilibria and one in which low income is associated with very slow growth. In either case a large enough temporary boost to the capital stock can produce a long-lasting improvement in the growth path, in sharp contrast with the decline in growth that would occur in a conditional-convergence world with fixed fundamentals. Observationally too, the two cases may be equivalent or nearly so: in both cases low income can persist over a long period and twin peaks can emerge in the cross-sectional distribution of national incomes (Kremer, Onatski and Stock 2001). In our view, therefore, multiplicity is too strong a criterion for thinking about links from income to growth. In what follows, we define a development trap as any situation in which low average income holds back aggregate economic growth for an extended period (Azariadis and Stachursky 2005, Quah 2001).

2.3 Productivity and accumulation

The traps in Figure 5, whether they constitute distinct low-income equilibria or not, are driven by a phase of sharply increasing returns to aggregate investment. Azariadis and Stachursky (2005) associate this phase with diffuse externalities to household- and firm-level investments in human capital or industrial technology. Other mechanisms may of course be relevant as well, since at this high level of aggregation A comprises *any* influence on the relationship between output per worker and the concave function k^{α} of

physical capital per worker.[4] We discuss a variety of potential mechanisms throughout this paper.

Early trap models, however, often focused on capital accumulation rather than on productivity (references appear in Sachs *et al.* 2004). A subsistence floor for consumption, for example, can generate a positive correlation between saving rates and income, so that the $[(n+\delta)/s]\cdot k$ locus becomes strictly convex over some range. Theories of the demographic transition can have a similar effect, by generating a negative correlation between fertility rates and income (perhaps indirectly, through the impact of education and labor-market opportunities on female labor force participation). If these effects are strong enough, the phase diagram can become non-monotonic even if the production function itself displays diminishing returns. Low income can then persist over long periods and, as in the $A(k)$ case, this possibility is present even if the long-run equilibrium is unique and identical across countries.

While saving and fertility-based traps may have some relevance for Sub-Saharan Africa, the global growth evidence is more decisive on the importance of persistent differences in productivity. Figure 6 illustrates this point using a celebrated argument from Lucas (1990). Using data from 1990, Lucas pointed out that if the USA and India occupied the same diminishing-returns production function, the roughly 11:1 ratio of observed real GDPs per capita would require a ratio of physical capital per worker of about 400:1 ($=11^{1/\alpha}$, where α is the share of capital in GDP, assumed to be 0.4). The actual ratio was an order of magnitude lower, at less than 20:1. Moreover, if the ratio of capital stocks per worker were really 400:1, the marginal return to capital would be $400^{1-\alpha} \cong 36$ times larger in India than in the USA. No conceivable tax differential or difference in country risk could then prevent capital from flowing from New York to Delhi. But the reverse was true: capital flowed from Delhi to New York. There was no way, Lucas argued, that the USA and India could occupy the same neoclassical production function. If the USA was at a point like 2 in Figure 6, India had to be at a point like 4, on a different and strictly inferior production function.

[4] One of the most obvious—which we will not pursue here—is that physical or human capital may be systematically overestimated in poor countries. Prichett (2000) and Hsieh and Klenow (2007) argue that this is the case for physical capital, and Manuelli and Seshadri (2007) argue that it is the case for human capital.

Mankiw, Romer and Weil (1992) responded to Lucas by introducing human capital as a third factor of production. They specify a neoclassical production function of the form $Y = \overline{A} \cdot K^{\alpha} H^{\beta} L^{1-\alpha-\beta}$, where H is the stock of human capital and $\alpha + \beta < 1$ implies diminishing returns to broad capital. When squeezed into the form $y = Ak^{\alpha}$, this function can generate cross-country differences in *measured* total factor productivity, A, even if actual TFP, $\overline{A}$, is the same across countries: $A = \overline{A} \cdot h^{\beta}$, where h is human capital per worker.[5] Low levels of human capital can then help explain the coexistence of low incomes with low marginal returns to investment.

Incorporating human capital goes some way towards resolving Lucas's puzzle, but country income differences remain too large to be accounted for by differences even in broad (physical plus human) capital per worker, in the absence of some phase of strongly increasing returns.[6] Hall and Jones (1999) document this point in detail, showing that TFP differences account for the bulk of international differences in income even after controlling for measured human capital. A similar point emerges in conventional growth-accounting exercises. Comparing growth in Africa with growth in other developing regions, Ndulu and O'Connell (2007) find that differences in conventionally-measured physical and human capital per worker account for only about half of Africa's shortfall between 1960 and 2000.

Income-dependent saving and fertility behavior are therefore unlikely, on their own, to explain Africa's failure to industrialize. The reason is that these mechanisms work through capital scarcity, and in a world of diminishing returns this means high returns to investment, not low returns. Irrevocably hostile fundamentals can, of course, explain a confluence of low income and low returns to investment (as in a conventional conditional convergence world), but in such cases poverty is an effect rather than a cause

[5] While human capital 'acts like' an international productivity difference when output per worker is related to observed differences in physical capital per worker, the dynamics of growth depend on precisely how human capital enters the production function and how it is produced over time. In another widely-cited paper, Lucas (1988) endogenized human capital accumulation and showed that externalities to the production of human capital could end up releasing the economy from diminishing returns, producing an *AK* structure or even aggregate increasing returns.

[6] Lucas estimated a 5:1 ratio of human capital per worker and showed that an 11:1 ratio of incomes then implied a ratio of capital stocks per worker of just over 70:1 (USA:India) and a ratio of marginal products of capital of about 13:1 (India:USA). These are still way too large; see Banerjee and Duflo (2005) for further discussion.

of slow growth. If development traps are empirically important, therefore, other mechanisms must be at work to keep the productivity of capital low when income itself is low.

2.4 Poverty in the binding constraints approach

We point out below that the theory of development traps is well ahead of empirical evidence. For that reason it is also well ahead of policy, at least in the area of growth strategy where traps suggest potentially large payoffs to policy intervention but the literature provides little guidance on where and how to intervene.[7] To develop this point we briefly consider the role of poverty in the *binding constraints* framework of Hausmann, Velasco and Rodrik (2005).

Hausmann, Velasco and Rodrik (2005) motivate a flexible and country-focused approach to growth-oriented policy reform by appealing to a variant of our one-sector growth equation $g = f(z)$. In their framework the steady-state growth of output per worker is given by $g = \sigma \cdot [(1-\tau) \cdot r - \rho]$, where σ is the intertemporal elasticity of substitution between consumption in successive periods; $r = r(a, \theta, v)$ is the social rate of return on capital; τ is the tax rate on capital (so that $(1-\tau) \cdot r$ is the private return on capital); and ρ is the interest rate at which the country's residents can borrow in world markets. The social rate of return depends on firm-level TFP, given in their notation by a, on an index θ of the externalities to private investment, and on an indicator v of the availability of complementary factors of production, including public infrastructure capital or human capital.[8] The tax rate τ is to be interpreted broadly; it can refer to actual or expected taxes and to either formal or informal levies on private returns. Rodrik (2007) describes the growth diagnostics approach as follows:

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[7] "The new literature on poverty traps has yet to focus on issues of policy design." (Bowles, Durlauf and Hoff 2006, p. 11).

[8] The underlying model differs from the Solow model in 3 main respects. First, the aggregate production function does not display diminishing returns; this is an endogenous-growth '*AK*' model, with *r* taking the place of *A*. Second, investment demand responds to the return on capital, where in the Solow model there is no behavioral investment function. Third, the economy here is at least potentially open to international capital flows. The latter two features can readily be incorporated in versions of the neoclassical growth model.

> These two equations [for *g* and *r*] summarize the possible factors that can affect growth performance. An exercise of *growth diagnostics* simply consists of reviewing and analyzing these factors to ascertain which of these factors is the most binding constraint on growth. As the analysis above reveals, all factors (including market distortions and policy wedges) are likely to matter for growth and welfare. The challenge is to identify the one that provides the largest positive direct effect, so that even after taking into account second-best interactions and indirect effects, the net impact of a policy change is beneficial (and hopefully sizeable). [Rodrik 2007, p. 64, italics in original]

Hausmann *et al.* (2005) develop a diagnostic algorithm of sorts by translating their growth equation into a hierarchical analysis of potential growth constraints (see Table 1).[9] At the highest level, the framework distinguishes constraints that reduce the return to private investment or entrepreneurship, $(1-\tau)r$, from those that increase the cost of finance, ρ. On the 'low private returns' side, the key distinction is between constraints that undermine the social return to investment and entrepreneurship, generating a low *r*, and those that undermine the private appropriability of returns, generating a high τ. These categories can in turn be broken down further: low social returns may be driven by geographical constraints, low levels of human capital, or bad infrastructure, while low appropriability may be a result of government failures, in the form of high and/or uncertain taxes, corruption, poor enforcement of property rights, or macroeconomic instability; or market failures, in the form of information externalities (e.g., productivity spillovers) or coordination externalities. On the cost-of-finance side, the authors distinguish costly international finance from costly domestic finance and, within the latter, constraints associated with low domestic saving from those associated with ineffective financial intermediation.

Notice that in contrast to the neoclassical model the level of income, *y*, does not appear directly in the Hausmann *et al.* (2005) growth equation. The reason for this is that the underlying production function has an endogenous-growth structure with constant

[9] See Rodrik's web page for links to country studies that use the growth diagnostics approach to identify binding constraints.

returns to capital (an 'AK' model[10]). Low income can nonetheless affect growth indirectly, as we have been emphasizing, via the vector of fundamentals $z = [\sigma, a, \theta, v, \tau, \rho]$; or, equivalently, via the 10 channels identified in Table 1. Thus while poverty plays no explicit role in the Hausmann *et al.* analysis, it can in principle act as a binding constraint on growth, by activating other constraints. Examples might include credit market failures that rule out collateral-free borrowing (poor intermediation); a low opportunity cost of violence leading to a high risk of armed conflict (insecure property rights); a low fiscal capability to address constraints of geography and infrastructure (low social returns); and predatory taxation of capital on behalf of a poor majority (micro risks). We discuss some of these further in section 3.

The growth diagnostics framework makes an important distinction between growth constraints associated with high social returns to investment and constraints associated with low social returns ('social' here simply means 'economy-wide': the concept refers to impacts on discounted aggregate output). The former category implies some combination of market and/or government failures, and therefore has the enticing feature of potentially invalidating the classical tradeoff between equity and efficiency. Hoff and Stiglitz (2001) and Banerjee and Duflo (2005) argue that the absence of this tradeoff is an empirically important feature of the economic environment in low-income countries. The argument these authors are making is two-fold: first, that resources are allocated inefficiently because of incomplete markets and/or misguided policies and second, that these inefficiencies are biased against the poor (see also World Bank 2005). We return to these themes below, in our discussion of microeconomic poverty traps. But two key points follow immediately. First, when the equity/efficiency tradeoff is absent, poverty-alleviation policies may acquire what Ray (1998) calls a *functional* justification: they improve overall economic performance. Growth strategies that miss this point may fail to produce growth. Second, however, the precise form of such policies is unclear. The binding constraints approach relies heavily on the principle of policy targeting, which states that effective interventions tend to be those that most closely target the sources rather than the symptoms of distortions (Rodrik 2007, p. 90). Even in the presence of a microeconomic poverty trap, direct redistribution to the poor may or may not qualify,

[10] The per-worker production function is $y = r \cdot k$, so r corresponds to A in the production function $Y = A \cdot K$.

depending on the ancillary costs of such a policy and the returns to alternative reforms. China's agricultural reforms of the 1980s, for example, are generally regarded as having been massively progressive and growth promoting. But these focused more on changing production incentives at the margin than on redistributing existing resources (a distinction emphasized by Chenery *et al.* 1975; see Qian 2003 on China's reforms).

Some of the constraints that Hausmann *et al.* place in the second category, of reducing the social returns to investment in physical capital and entrepreneurship, are associated with low levels of human and/or public infrastructure capital. These forms of capital may themselves carry high social returns, in which case their scarcity again points to market and/or government failures that may invalidate the equity/efficiency tradeoff. Credit market imperfections that prevent the poor from making high-yielding investments in human capital provide one example; the under-provision of productivity-enhancing public goods in poor areas proves another. But other constraints that keep social returns low can raise more difficult – and conventional – tradeoffs. Geographical constraints, for example, may reduce the returns to a wide range of public and private investments, as argued by Faye *et al.* (2004) and Collier and O'Connell (2007) for landlocked and resource-poor countries in Africa. In such cases growth may in effect be prohibitively expensive, in the sense that for known technologies an investment program capable of overcoming natural constraints reduces appropriately discounted GDP.[11] In such cases the appropriate locus for redistribution would be primarily international rather than national.[12] As is traditional in public economics, such intervention would appeal to intrinsic rather than functional justifications, drawing on inequality aversion, universal rights, or other ethical frameworks.

2.4 Empirical work on economy-wide development traps

Given our discussion, it should not be surprising that the growth literature remains indecisive about the empirical relevance of development traps. Cross-country growth regressions do not tend to be directly informative. At issue is the shape of the phase

[11] And could therefore not be financed privately, even in a perfectly functioning world capital market with sovereign debt guarantees.

[12] An important tactical issue, in turn, would be whether geography is truly the binding constraint on growth, or whether other constraints (e.g., poor governance) are likely to undermine the effectiveness of an externally financed public investment program.

diagram relating the level of income to its growth rate, perhaps conditional on some exogenous fundamentals—the relationship we have called $f(y;x)$ above. The growth literature, instead, estimates structural models of the form $g = f(y;z)$ where some or all of the z may be functions of y as well as of x.

Research on development traps *per se* has focused almost exclusively on whether conditions are such as to favor multiple equilibria. Support comes from Quah (1993, 1996), who studied the evolution over time of the empirical distribution of national incomes and documented the emergence of a bimodal (twin peaks) pattern comprising distinct and largely stable groups of high- and low-income countries. Bloom, Canning, and Sevilla (2003) also find that the data favor two groups over one; and they show that the level of steady-state income and the probability of exiting the low-income group depend on rainfall and other aspects of tropical geography. The latter variables play the role of deep fundamentals or "x" variables in our terminology, suggesting the presence of a geographically-based development trap. The mechanisms through which this trap operates, however, remain unclear.

Berthélémy and Varoudakis (2002) find some evidence in cross-country data of threshold effects associated with financial development. Berthélémy (2007) studies country-by-country growth trajectories over time, looking for the 'inverted U' configurations suggested by Figure 5. He argues that while institutional factors, investment rates, and demographic features were broadly similar between low-income countries that experienced take-offs after 1950 and those that did not, the former group had achievements significantly higher rates of primary education before growth accelerated.

Elsewhere in the growth literature the empirical support for development traps has tended to be weaker.[13] Kraay and Raddatz (2007) find that saving rates vary with aggregate income, but not in a manner capable of generating development traps. Easterly

[13] Chatterji (1992) focuses on the gap between each country's income and the income of the USA (viewed as the technological frontier). He regresses this variable in 1985 on a cubic equation in lagged values from 1960. The constant term is omitted, so by construction a gap of zero constitutes a steady state. The nonlinear terms are statistically significant and imply two additional steady states: an unstable threshold at 6:1 (corresponding roughly to Brazil or Malaysia in 1960) and a stable high-gap equilibrium at 30:1. This is not, however, a development trap in the sense we have emphasized, since countries in the high-gap equilibrium grow at the rate of the technological leader.

(2006) and Johnson, Ostry and Subramanian (2007) conclude that the saving rates of poor countries are not low enough to generate an accumulation-based trap. Kraay and Raddatz (2007) look for evidence of increasing returns to capital that are strong enough in the aggregate to generate a trap; they fail to find such evidence, either in the developing-country literature or in their own cross-country estimates for Africa. Rodriguez (2008) also focuses on increasing returns, but only in the manufacturing sector given their greater plausibility there; and he restricts attention to growth accelerations or collapses on the grounds that spillovers should only prevail on the transitions *between* locally stable equilibria. He finds no evidence of increasing returns during growth accelerations. There is evidence of increasing returns during growth collapses, but since the events that precipitate such collapses operate through measured productivity almost by definition (the capital stock itself does not collapse), there is little evidence here of a trap mechanism.

3. Microeconomic poverty traps

We have defined a development trap as a situation in which income increases can become self-perpetuating: $\partial g / \partial y > 0$ over some interval of y. A poverty trap, from this perspective, is a development trap that is activated when income is near or below some standard of absolute deprivation. This approach to poverty traps accommodates global heterogeneity in incomes, but it ignores the important role played by within-country inequality, both in the growth literature and in the formulation of country-level growth strategies. A transparent way to bring these considerations on board is to define an economy-wide poverty trap as a situation in which aggregate growth is constrained by the low incomes *of the poor*.

It is not obvious, of course, that accommodating intra-national inequality strengthens the theoretical case for economy-wide poverty traps. The classical economists, for example, viewed inequality as good for growth. Workers were consumers rather than savers, and comprised the bulk of the population; international financial markets were closed. Investment had to come from saving by the wealth-owning classes, and this meant that growth required a high income share for capitalists (see Galor and

Moav 2004[14]). But more recent theories deemphasize accumulation, as we have emphasized, and feature a variety of mechanisms through which inequality can undermine productivity and growth. The growth evidence, as well, points increasingly to negative impacts of inequality on growth (Bénabou 1996).

More importantly for our purposes, accommodating within-country inequality focuses attention on what we will call *microeconomic poverty traps* – situations in which low income may be self-perpetuating for households or local communities. To see why, suppose that households below and above the poverty line receive average per-capita incomes y_P and $y_N > y_P$ respectively. The economy's growth rate is a weighted average of income growth within the two groups, so defining *h* as the poverty headcount ratio and $\theta = h \cdot y_P / y$ as the share of the poor in overall national income, we have $g = \theta \cdot g_P + (1-\theta) \cdot g_N$. The response of overall growth to a one-time change in the incomes of the poor is therefore

$$\partial g / \partial y_P = \theta \cdot \partial g_P / \partial y_P + (1-\theta) \cdot \partial g_N / \partial y_P .$$

An economy-wide poverty trap holds, in our definition, if $\partial g / \partial y_P > 0$ over some empirically relevant range of incomes of the poor. Microeconomic poverty traps $(\partial g_P / \partial y_P > 0)$ are not a necessary condition for this to occur, because the final term in the equation could in principle be positive. But as θ rises, an overall trap becomes increasingly less plausible in the absence of mechanisms that make poverty self-perpetuating at the household level.[15] Table 2 estimates the consumption share of the poor in various regions, using the lowest poverty line ($1.25 a day) and drawing on consumption surveys conducted since 2000. At 25 percent of GDP, the consumption

[14] Lewis (1954) brought this tradition into development economics. Lewis, like Ricardo, had to struggle with the role of landowners, a wealth-owning class prone in the classical view to consumption rather than saving.

[15] Of course, it is also unlikely that low incomes among the poor could seriously constrain growth opportunities for the rich – so that $\partial g_N / \partial y_P > 0$ – if poverty were a temporary phenomenon at the household level. Thus Azam (2007), for example, argues that deprivation among the poor can increase the threat of armed rebellion, an argument that relies not just on low current income, but also on limited prospects for future income (Collier and Hoeffler 2002). But persistent poverty is not the same thing as self-perpetuating poverty – just as, in the neoclassical model, permanently adverse fundamentals are consistent with conditional convergence, not with development traps.

share of the poor in SSA is double their share in the East Asia and Pacific region and three times their share in South Asia. A higher poverty line would of course scale this 25% figure up further.

These observations suggest that research on microeconomic poverty traps may have an important role to play in improving the knowledge base for growth strategies in Africa. In the remainder of this section we briefly review the relevant theory, in light of our earlier discussion. Section 4 then looks at approaches to assessing the empirical relevance of microeconomic traps.

3.1 Microeconomic trap mechanisms

To set the stage for our discussion of microeconomic traps, consider three caricatures of how microeconomic heterogeneity might be accommodated within a one-sector growth analysis. The first assumes complete and competitive markets in general equilibrium: its close relationship to the neoclassical growth paradigm will be apparent. The second captures a market failure that undermines aggregate efficiency and is biased against the poor: borrowing requires collateral, and the poor have no collateral. The third creates inefficiency through a political distortion: the rich dominate political institutions and use their power to prevent the poor from setting up firms as entrepreneurs.

In each case we follow the lead of Banerjee and Duflo (2005) and focus on how capital markets allocate available resources among heterogeneous uses. To introduce heterogeneity we assume that individuals are endowed with projects of limited size that only they can implement. These projects use capital to produce a homogeneous output, and their productivity varies across individuals. For simplicity we impose diminishing returns at the individual level by assuming that each project can use up to 1 unit of capital (with constant returns), after which the marginal return goes to zero. This is not necessary for our argument provided that each project has an upper limit of the amount of capital it can employ (Banerjee and Duflo 2005). Again for simplicity, we assume that there are no imperfections in goods or labor markets.

Complete and competitive markets

Suppose that capital markets work perfectly. At a point like 3 in Figure 6, the country's very small capital stock would flow into the hands of the small proportion of the population possessing the highest-productivity projects. These entrepreneurs would earn rents on their superior skills or ideas; other households would be workers. Households lacking productive labor or high-yielding investment projects could end up severely disadvantaged, but the initial distribution of capital across households would be irrelevant to the set of projects implemented, and any household capable of saving would receive a return equal to the (high) economy-wide marginal return to capital. If there were diminishing returns at the microeconomic level, moreover, this would provide some impetus for convergence of incomes across households: other things equal, for example, households with low initial education would have an easier time borrowing to finance education than households with initially higher attainment. The standard tradeoff between equity and efficiency would prevail; redistributive policies would be costly in terms of efficiency but potentially justifiable on ethical grounds. Poverty traps would be absent, whether economy-wide or at the microeconomic level.

As noted by Banerjee and Duflo (2005), an aggregate production function with diminishing returns exists in this economy, despite the heterogeneity of projects at the microeconomic level. Moreover, in this economy capital markets achieve dynamic efficiency in the sense of maximizing the economy's end-of-period capital stock over any finite horizon, subject to the sequence of aggregate consumption up to that period (Burmeister 1980[16]).

Regressive market imperfections

Suppose instead that imperfections of information and enforcement induce lenders to use wealth as collateral. Access to credit is now severely restricted for poor households, and capital markets fail to equalize the returns to capital across projects. The average marginal product of capital across poor households is higher than the average marginal

[16] If the economy's horizon is itself finite, this economy will be consumption efficient as well, in the sense that aggregate consumption cannot be increased in any period without decreasing it in some other period. Much stronger conditions are required to establish consumption efficiency in an infinite-horizon setting, even with full and complete markets, because finite-horizon behavior by successive generations can produce over-accumulation of capital. See Burmeister (1980) for details.

product for the non-poor, because the poor have (some) high-yielding projects that are going unexploited while the non-poor are investing to the point of low marginal returns.

In this setting there is no well-behaved aggregate production function running through point 4, and the one-sector growth model may fail even as a first-order approximation (Banerjee and Duflo 2005). We know that dynamic efficiency fails, but we cannot analyze the development process without knowing more about how resources are actually allocated in the economy. Elegant models have been developed to this end by Galor and Zeira (1993), Bénabou (1996), and Aghion and Bolton (1997). In these models the level and growth of aggregate output depends on the distribution of income and wealth (see also World Bank 2005). These models often emphasize inequality rather than poverty *per se*, but they generate poverty traps when the relevant market failures are triggered by low absolute income or wealth, as in models of collateral-based lending. Stretching our example a bit, credit market failures may bear particularly strongly on investments in human capital, given legal limitations on borrowing against future wages.

Politically-generated distortions

Now suppose that information and enforcement problems are absent but that political power is monopolized by a wealthy elite that is determined to exclude a poor majority from access to resources and political power (Adam and O'Connell 1999, Engerman and Sokoloff 1997). Institutions are built over time to reflect the interests of the elite; these institutions influence the size and the nature of public expenditures (Alesina and Rodrik 1994, Persson and Tabellini 1994) and, in our example, prevent the non-elite from operating as entrepreneurs rather than workers.

To take the most extreme case, suppose that the economy's capital is allocated lexicographically: first to any member of the elite group willing to borrow, and only next, if an excess supply of capital remains at the economy-wide level, to members of the non-elite. Within the two groups, for simplicity, capital is allocated efficiently, so as to equalize marginal products across projects. Figure 7 shows an example in which the elite comprise 1/3 of the population and the productivity of projects is drawn randomly from the same distribution for each group. The aggregate production function has a sharp nonconvexity at a capital stock sufficient to finance all of the projects of the elite. If we

model saving and population growth as in the Solow model, an economy-wide development trap emerges. Unless the aggregate capital stock is well clear of a threshold (in Figure 7, at a capital stock of roughly 16), income stays low for an extended period.

This development trap implies a poverty trap in our narrower sense if it is perpetuated by the low incomes of the non-elite. Engerman and Sokoloff (1997) argue that in highly unequal Latin American societies, low levels of income and education have worked to prevent the non-elite from mounting effective legal or institutional counter-attacks against regressive policies.

From a standard public finance perspective, of course, redistribution does not have to be regressive to undermine growth[17], or to generate a link from poverty to growth. Some prominent alternative theories argue that poverty undermines the investment environment for the wealthy. In an unequal but otherwise well-functioning democracy, for example, the median voter holds little capital and may therefore support a growth-reducing platform of high capital taxation and aggressive redistribution (Bénabou 1996). In a similar vein but focusing on armed conflict, Azam (2007) and Bates (2007) develop theories of civil war and rebel activity in which poverty undermines investment by the rich – and drives existing assets abroad – by reducing the opportunity cost of violence among the non-elite. Theories of crime may operate similarly. These approaches differ sharply from our case at the microeconomic level, however: in our case social returns are higher among the poor than the rich, while in these theories the reverse is true.

3.2 Further mechanisms

The previous sub-section illustrated two broadly plausible channels from poverty to growth in Africa: one operating through the interaction of poverty and market imperfections and the other through the effect of poverty on political and economic institutions. We argued that these channels can help explain why entire economies may fail to develop, as well as suggesting specific mechanisms through which sub-groups

[17] When markets are complete and competitive, any intervention to redistribute resources produce a deadweight loss, unless the government has access to non-distortionary instruments (Atkinson and Stiglitz 1980). The equity/efficiency tradeoff, from this perspective, is an implication of a more general 'redistribution/efficiency' tradeoff.

remain poor. Here we take a brief look at some additional mechanisms operating under these headings.

Additional growth-reducing interactions may occur between poverty and financial market imperfections. For instance, if credit markets fail for the poor, savings may be too low to build assets sustainably and escape poverty definitively; discrete, complementary or "lumpy" investments may be needed to increase productivity above a minimum threshold, and that may not be possible when incomes are too low; or there may be economies of scale from which the poor may not be able to benefit and that can discourage them from making progressively increasing productive physical and human capital investments. Finally, the absence of credit and insurance markets may induce highly risk averse behavior at low income levels, leading to low investment in education, high fertility, and avoidance of risky but potentially high-yielding innovations (Dercon 2002, 2005).

Another plausible example of a micro development trap is nutritional. Dasgupta and Ray (1986) assume that production requires a caloric intake that exceeds the body's resting requirement (the basic metabolic rate). Work effort is then subject to a threshold effect, whereby small increases in nutritional intake, once basic requirements are met, generate disproportionate increases in productivity. Redistribution in favor of the poor can enhance both equity and economy-wide productivity (Dasgupta and Ray 1987).

Carter and Barrett (2006) emphasize an analogy between household-level income dynamics and our development trap analysis in the presence of market imperfections. Thus while households may have characteristics (skills and/or preferences) that tie down their ultimate equilibrium welfare level, the path to this ultimate equilibrium can display nonlinearities and varying returns to scale, giving rise to the same kind of state-dependence we emphasized with our non-monotonic phase diagrams. Similar interactions can in principle arise through neighborhood effects involving corruption and other adverse conformity and peer group influences, self-reinforcing individual and social beliefs, coordination failures, and externalities. These effects can lead to economically and socially inferior equilibria (Mookherjee and Ray 2001, Mookherjee 2006).

Some of sub-Saharan Africa's geographic and economic features would appear to make it theoretically more prone to micro development traps (Sachs *et al.* 2004). Some of

these features would be relatively high transportation costs, relatively small market sizes and a relatively high disease burden (Bloom et al. 2003). Sub-Saharan Africans live disproportionately far from coastal ports and this is compounded by relatively small internal market density. They also mostly live in the sub-humid or arid tropical areas with no or difficult access to irrigation. Sub-Saharan Africa also bears a relatively severe burden of endemic tropical diseases, the most important being malaria. Some of these features might be difficult to change using individual effort. But larger-scale investment in changing them, such as infrastructure and transportation investment, might plausibly yield disproportionate benefits to the poor and to overall growth.

As a final observation we note that trap-like mechanisms can readily interact at a sectoral or general-equilibrium level that is between the aggregate and microeconomic levels we have been emphasizing. As in big-push theories of development, complementarities may exist between the various types of input needed to foster development: basic road infrastructure, provision of electricity, availability of major ports, presence of an educated labor force, *etc*. Increasing capital in any one of these dimensions in the absence of investment in the others might produce little or no effect. Mwabu and Thorbecke (2004) argue that market-failures and institutional failures may reinforce each other in low-income African countries where a large share of the population is rural. Thus difficulties in enforcing contracts, poorly functioning capital and credit markets, and poorly-functioning land and labor markets may interact to encourage subsistence activities, illiquid investments and growth-reducing behavior; these micro traps may then be compounded by problems of insecurity, poor levels of public goods and services, disproportionate taxation of agricultural output, and poor infrastructure, arguably caused by institutions that do not take sufficiently into account of the interests of rural dwellers.

4. Microeconomic poverty traps: evidence

There are important difficulties in providing formal evidence of the existence and nature of development traps, both at the micro and at the macro levels. First, changes in growth constraints may impact growth only after some time. For instance, although many health and education policies might have a plausible positive impact on productivity, there can

be important delays between the timing of the investment and the timing of the returns. The productivity impact of better health and education depends mostly on the interaction of health and education with productive capital and the labor market, and that can take place a long time after the health and education investment has taken place.

A further difficulty is that investment at the individual and community levels may be complementary to macro investments in larger-scale infrastructure and social services. This suggests that investigation of the rewards to micro (and macro) investment might need to take into account the economy-wide levels of prices and factors, and that may not be easy to do in environments in which these change little.

Finally, in providing evidence on micro development traps, one must beware the difficulties created by endogeneity of the behavioral variables of interest and unobserved heterogeneity in the determinants of output and productivity. Some of the individual variables that can be associated with development traps (such as fertility behavior) may in fact be jointly determined with levels of living standards. It is the joint distribution of these variables and living standards that can be the source of the development trap; attempting to alter one variable and not the others might not be enough to take households out of the development trap. Similarly, the presence of unobserved heterogeneity might misleadingly suggest that living standards are determined by some development trap indicators (such as geographic location), whereas in fact it may simply be that some of the unobserved variables that explain the geographic location of households also explain their levels of living standards.

Despite these caveats, there are several ways in which the existence of micro development traps can be suggested. We briefly describe a few of them and provide suggestive evidence that these can matter particularly in Africa.

4.1 Poverty in Africa

By absolute standards, income poverty in Africa is both widespread and greater than in any other region of the world. Unlike in most other regions of the world, it has also failed to decrease significantly in the last decades. Table 3 shows that the proportion of individuals living below 1 dollar per day has fallen considerably over the last three decades in Asia and in the Pacific. In Africa, the proportion has remained roughly stable

at around 40 percent since the 1980's. Table 4 shows that Africa will probably soon contain the largest absolute number of poor people on earth, larger than in East Asia or in South Asia, where absolute population sizes are larger. Table 4 also shows that the total number of the poor in the world has fallen by more than 600 million between 1981 and 2005; in Africa, it has increased by 135 million. This suggests that Africa is lagging not only in relative but also in absolute terms.

4.2 Poverty or inequality traps?

Above we characterized a poverty trap as a situation in which $\partial f / \partial y_P < 0,$ where y_P is a measure of the prevalence of poverty in a given country. In such a situation, a process of distribution-neutral growth – in which all incomes rise at roughly equal rates, so that measures of inequality remain unchanged – tends to be self-reinforcing, through its impact on the incomes of the poor. In the growth model of Galor and Moav (2004), for example, low levels of economy-wide human capital form a binding constraint on investment in physical capital. The scarcity of human capital, in turn, is concentrated among the poor, who cannot borrow to finance their children's education. Inequality is bad for growth in the sense that for a given average income, greater inequality generates a lower level of human capital investment. But any general improvement in living standards – even one accompanied by a mild increase in inequality – reduces the share of the population subject to the credit market constraint. Ultimately it is poverty, rather than inequality, that constrains growth in this model.

Some development traps may of course be activated by inequality rather than by poverty *per se*. For example, above we cited the potential role of social and economic inequalities in sustaining political institutions that impair development. The 2006 *World Development Report* (World Bank 2005) makes a broader appeal to the potential importance of relative deprivation in the growth process:

> "Equity is complementary to the pursuit of long-term prosperity. Greater equity is doubly good for poverty reduction. It tends to favor sustained overall

development, and it delivers increased opportunities to the poorest groups in a society."[18]

'Equity' here can of course refer to equality of opportunity (e.g., access to markets and public services) as much as to equality of earnings or consumption. But distribution-neutral growth is unlikely to overcome constraints that are grounded in either type of inequality. Such concerns are potentially relevant for Africa, where inequality is high by comparison with other regions (and comparable to Latin America; see Table 4). Within Africa, of course, their relevance may vary considerably (Figure 8): inequality in parts of southern Africa is among the highest in the world, while Mauritius has low inequality even by the standards of OECD countries.

4.3 Correlates of poverty in Africa

The poor in Africa are heterogeneous in nature and can be found in any social classes. But, both across country and across time, there are characteristics that tend to be systematically correlated with poverty. The nature of these characteristics is also suggestive of the factors that can induce development traps.

Household poverty is systematically positively correlated with household size, the absence of adults of working age, and the presence of children and elderly people. These are structural socio-demographic characteristics that evolve slowly and that can be difficult to change by one's own will. Family formation, fertility decisions and productive arrangements are examples of factors that affect structural demographic characteristics and that depend on what can be long-lasting cultural norms. These characteristics naturally tend to perpetuate themselves across generations. They are also subject to neighboring effects.

The poor usually lack physical and financial assets as well as income. Poverty is also highly correlated with being landless. When the poor do own land, that land is often relatively unproductive, difficult to access and/or difficult to irrigate. It is also difficult to improve and exchange it in formal land markets.

[18] François Bourguignon, Senior Vice President and Chief Economist of the World Bank, in the introduction to the 2006 *World Development Report*.

Subsistence agriculture is nevertheless the main source of income for many of the poor in Africa. Agricultural output also tends to be one of the most volatile sources of income and one in which it is the most difficult in which to invest in economies with weakly functioning credit and land markets. Again, this may be difficult to change if the factors involved extend well beyond the reach of individuals.

The poor also have a relatively lower level of human capital and educational achievements. Poverty is further very much associated with employment and occupational status. For instance, in South Africa, of the 18 million below a semi-official poverty line in 2004, 14 million lived in workerless households; most of them contained working-age but unemployed people (Meth 2007). Hence, in addition to having lower levels of human capital and skills, the poor are often unable to sell their labor in a reasonably free and competitive labor market.

Non-monetary indicators of well-being also tend to be worse for the income-poor than for the others. This is true for indicators such as child mortality rates, stunting, wasting, and the incidence of illness. Moreover, access to health care is typically more difficult for the poor. The poor also frequently suffer from hunger and malnutrition, in addition to illness and weak health. This can further deteriorate the productive value of their human capital.

Undernutrition has indeed been found to lower productivity (Strauss 1986, Deolalikar 1988). Malnutrition in children tends to decrease their learning and future productivity, see for instance Glewwe *et al.* (2001). All of this suggests that inequality in income and in nutrition may decrease total productivity (and its growth).

Poverty also tends to be associated with being a member of ethnic minorities and racial groups. These groups tend to face higher income poverty and greater deprivation of schooling and health achievements and to benefit less from infrastructure investment and other types of public goods and services. Poverty is also associated with weak participation in social and political processes, and is sometimes reflected in exploitative relationships that can again deny the poor access to markets and to public and private goods and services.

4.4 Spatial development traps

Household-level studies systematically find that the characteristics of the region of residence are correlated with living standards and poverty, even after controlling for other household characteristics. One systematic finding of that poverty tends to increase with the distance from major cities and from the coast. This also explains why poverty as measured by most well-being indicators tends to be greater in rural areas.

Although there are several ways in which location can influence poverty directly through purely geographic effects, the association between geography and infrastructure, access to public services and market quality is also usually very strong.

Poorer areas are indeed often isolated in several ways. Geographically speaking, they are usually farther away from formal input and output markets. Such distance implies poor work opportunities or exclusion from areas and enclaves in which growth is concentrated. The markets that are geographically close are relatively less developed. Nonfarm employment, for instance, can be scarce and seasonal. Poorer areas also tend to have lower access to public services, such as education and health.

Ayadi *et al.* (2005) argue that in Tunisia rural roads have played an important role in helping the rural poor connect to urban markets and services, and that this has improved their living conditions. Although no estimates of the returns to this infrastructure are presented, such estimates could be implicitly taken as evidence for the existence of development traps, especially if they differed significantly across areas.

A disproportionate number of the poor are also located in areas where arable land is scarce or is of relatively bad quality, or where droughts, floods and other environmental shocks generate relatively high levels of community-level risk. This generates lower agricultural productivity and/or greater vulnerability. Both of these tend to decrease investment in physical (and often in human) capital.

Whether spatial externalities create a development trap is certainly of interest. This would be the case for instance if living in a poor area meant a lower return to one's investment, and if one could not invest elsewhere because of imperfect capital markets. For this, it is not enough to know whether living standards are correlated with space (ceteris paribus). It is also needed to rule out that this comes from a correlation between space and some unobserved household characteristics.

Panel data can be useful in such a context. With such data for rural China, Jalan and Ravallion (2002) find that capital seemed to have geographically divergent impacts on household consumption growth (controlling for observed and unobserved household characteristics). They argue that since poorer areas have access to lower levels of productivity-enhancing public goods (such as transportation infrastructure), households in those areas are hampered with lower productivity on their human and capital investments. This discourages them from making such investments and thus make them subject to a spatial development trap.

4.5 Correlates of chronic and temporary poverty

Suggestive evidence of the existence of development traps can also be obtained from evidence on the distribution of chronic and transient poverty. It is indeed plausible that characteristics associated to chronic poverty, or those that reduce the likelihood of exiting (temporarily or definitively) poverty, may be characteristics that are also associated with the presence of development traps.

Some types of households are likely to suffer more from chronic and/or transient poverty. The correlated characteristics differ somewhat across space, but some (such as asset holdings) often play a consistently key role. As for snapshot poverty, the distribution of chronic and transient poverty is both spatially correlated and dependent on various household characteristics (Okidi and McKay 2003). Exits out of and entries into poverty are usually explained mainly by demographic and employment changes. This suggests that structural household shifts, such as household composition changes (death of a household member, dissolution, marriage, migration), or shifts in environmental parameters (increased incidence of involuntary unemployment for instance) can be the causes of important changes in well-being (Woolard and Klasen 2004).

Some household characteristics, such as household size, educational levels, unskilled labor power and low levels of asset holding, also tend to influence the probability of moving in and out of poverty regardless of the initial poverty status (Bokosi 2006, Barrett *et al.* 2006).

The determinants of chronic poverty and vulnerability are often similar. One reason for this might be that vulnerability, which is bred by variability in well-being, also

impedes the ability to exit chronic poverty. The chronically poor are indeed often found in less secure environments, and are those whose assets are too low to cope adequately with shocks. The coping strategies can in fact involve sacrificing long-term improvements (for instance, by decumulating human and physical capital) in order to address shorter-term needs.

4.6 Imperfect markets and subsistence traps

Market failures are pervasive in low-income countries and in some cases even the rudimentary institutional underpinnings of market activity are absent (Hoff and Stiglitz 2001). Banerjee and Duflo (2005) cite extensive evidence that the returns to capital are not equalized across firms or households. Hsieh and Klenow (2008) compare marginal products of capital at the factory level and show that if the capital stock were allocated as efficiently within narrowly-defined industries in China and India as it is in the USA, TFP would be 30-50 percent higher in China and 40-60 percent higher in India. As noted earlier, Banerjee and Duflo (2005) take this argument further by citing evidence that market failures affect poor households disproportionately (see also World Bank 2005).

One suggestive evidence of the existence of imperfect market traps is that farm yields (output per acre) in poor countries tend to be lower the larger the landholding (see Binswanger *et al.* (1995) for a review of the evidence). A possible explanation is the existence of factor and credit market failures that hinder the reallocation of land sizes. If this were the case, then redistributing land from large landholders to smaller ones would raise total output. The existence of credit market failures also leads individual incomes to be an increasing concave function of their past value. Evidence of this is reported in Lokshin and Ravallion (2001) for Russia and in Jalan and Ravallion (2001) for rural China – see also Ravallion (2004) for a review.

The poor, who tend to have access to agricultural land in lower quantity and quality, are typically unable or unwilling to improve such plots, in part because their income is near subsistence and because they lack sufficient access to credit. The fact that the poor tend to suffer more from malnutrition and illness also decreases their ability to work, to generate consistent streams of income, and to invest in their human and physical capital. Without sufficiently large levels of assets such as capital, land or human capital,

the poor must rely on selling unskilled work. This generates low incomes, and thus, in the presence of imperfect capital markets, a low ability to invest for the future.

4.7 Gender-based traps

The existence of gender-associated differences in well-being and poverty is also suggestive of development traps, this time generated within the household. These traps can exist for the same reason that development traps may exist at the household and macroeconomic levels, that is, for reasons of market imperfections and power-protecting institutions leading to growth-reducing and discriminatory environments.

An increasingly important strand of the micro-economic literature prods into the intra-household allocation of resources. This is difficult to do because many indicators of well-being are reliably observable only at the household level. One of the systematic correlates of individual-level well-being (based on indicators such as educational achievements or health status) is, however, gender. Women and girls indeed tend to have lower educational achievements in Africa. They are also often more vulnerable to health shocks, such as those associated with pregnancy and birth giving. They also tend to wield less power in family and community-level decision-making instances.

4.8 Mobility and time dependency

State dependence arises when the probability of exiting a state (such as poverty) depends on the past distribution of such states, in addition to the characteristics that affect past and current states. In such cases, two households with identical characteristics may yet display different probabilities to enter or exit poverty if they differ in their distributions of previous poverty statuses.

There is some evidence of state dependence in poverty dynamics, which may be stronger in some environments (such as in urban areas) than in others (Islam and Abebe 2007). This is difficult to infer formally, however, since initial poverty statuses may be correlated with unobserved characteristics of the household.

Woolard and Klasen (2004) find that most of the mobility observed in South Africa is related to demographic and employment changes. They also believe that this is suggestive evidence of four types of development traps, associated with large initial

household size, poor initial education, poor initial asset endowment and poor initial employment. Some of the initial level and changes in demographic and employment variables can be choice variables and can also be endogenous to levels and future expected changes in living standards. Care must therefore be used in inferring the existence of a development trap too quickly. But some of the demographic or employment changes may indeed be determined by purely exogenous external shocks (such as deaths or changes in employment in an environment of high involuntary unemployment such as in South Africa) that are difficult to reverse by the mere will of households. In this case, the fact that changes in characteristics are correlated with subsequent poverty dynamics can indeed be taken as suggestive evidence of household-level development traps.

A related approach assesses the extent of intergenerational mobility as well as indicators of inequality of opportunity. Cogneau *et al.* (2006) for instance finds that two countries with relatively low cross-sectional income inequalities, Ghana and Uganda, also display relatively high intergenerational mobility and low inequality of opportunity (estimated by comparing the achievements of individuals conditional on the social origins and characteristics of parents). This can be done without panel data, so long as information on more than one generation is available. Again, the implications in terms of the existence of a development trap must be used with care because of possible problems of correlation of unobserved characteristics across generations.

4.9 Asset traps

An interesting approach to elicit evidence of the existence of development traps uses dynamic data on consumption and assets. The approach considers the evolution of assets in comparison to the assets expected to be needed to exit poverty. Mobility in living standards may be of little use if periods of relative prosperity are not used to accumulate assets. A failure to accumulate assets during good times may indeed mean that a household will eventually be pushed back to subsistence levels when worse times come. An important issue is therefore whether chronically poor households use temporary exits from poverty to move onto a trajectory of asset accumulation, in such a way that they

would at some point exit the risk of chronic poverty. Which micro-level and community characteristics are associated with the ability to embark on such a trajectory?

One procedure that has been used to investigate this is to compute the consumption value that assets provide, and to estimate how much assets are needed for households to consume above a poverty threshold. Assets vary in sizes and in nature, and it is therefore important to use both the quality and the quantity of assets of which households can dispose to generate consumption. In Adato *et al.* (2006) for instance in the context of South Africa, three types of assets are used to build an asset index: human capital (education), natural and productive capital (such as land, livestock, and equipment), and unearned/transfer income.

Adato *et al.* (2006) also hypothesize that temporary shocks to income and consumption can have permanents effects on living standards. To see this, it is useful to consider Figure 9 drawn from their paper. This shows asset values at later periods ($\Lambda(A_t)$) as a function of asset values at initial periods ($\Lambda(A_0)$). A 45-degree line is also drawn to show when initial and later assets are equal. For example, imagine that a household starts with initial assets below $\Lambda(\underline{A}_m)$. Its next-period assets will be lower than the initial level. Given the local slope of the $\Lambda(A_t)$ line, these assets will eventually converge to $\Lambda(A^*_p)$, a development trap equilibrium. The only possibility to escape this trap is to experience a jump in assets above $\Lambda(\underline{A}_m)$, a threshold that Adato *et al.* (2006) call the "Micawber threshold". Above that Micawber threshold, assets will eventually converge to $\Lambda(A^*_c)$. Note that even if the assets of a household are above $\Lambda(\underline{A}_m)$ for some time, a shock to those assets that push them below $\Lambda(\underline{A}_m)$ will make household assets converge to $\Lambda(A^*_p)$, the low-equilibrium trap, and therefore to a longer-term development trap.

The shape of South African 1993-1998 asset dynamics as estimated by Adato *et al.* (2006) is shown in Figure 10. Taking into account confidence bands, there does seem to be evidence of a Micawber threshold at around twice the poverty line. In fact, a household that initially enjoyed an asset index of more than three times the poverty line could be pushed to a lower equilibrium of less than the poverty line if an asset shock moved it below the Micawber threshold of twice the poverty line. The estimated pattern of asset dynamics would therefore predict that such a household could experience a drop in expected longer-term assets from more than three times the poverty line to a lower

equilibrium of less than the poverty line. This would indeed be quite a severe change in the living standards of that household, both in the short and in the longer term.

Suggestive evidence of the existence of development traps can also be obtained by examining the correlates of the evolution of assets across time. Assets can be less volatile and easier to measure than consumption and income. The evolution of assets is usually linked to the educational level of the household head, to the availability of employment, to land ownership, to family composition, and to geographical isolation (Burke *et al.* 2007).

4.10 Micro political economy

There is also interesting community-level evidence that local institutions may sometimes be biased against the poor. The poorer the community, the more important this may in fact be, since in poorer environments the elites may be more risk averse than elsewhere. This may make the elite want to capture power to a greater extent than otherwise to protect themselves against such greater risk. It may also interact with ethno-social polarization of communities, which can increase power capture. Galasso and Ravallion (2005) find for instance that those villages in Bangladesh where the distribution of land is more unequal are also less good at targeting the poor, possibly because this is also where the poor are less influential in village decision making.

4.11 Behavioral micro-simulation models

This approach models the differences in living standards as the interaction of a set of behavioral functions (see Bourguignon *et al.* 2005). In such studies, a small number of microeconomic models, such as earnings generation, labor market participation, education demand equations and fertility behavior, are estimated. These models can be inter-related, in that fertility may for instance affect labor market participation (and the reverse). The parameters of the models are then used to provide counterfactuals. These counterfactuals can serve to predict how living standards differ across space or how they vary across time. Most importantly, they can suggest a micro-level explanation for these differences, in the spirit of the influential contributions of Oaxaca (1973) and Blinder (1973). Since many of the variables that are used as regressors are probably endogenous

themselves, this evidence can be best understood as associative, as opposed to causal, decompositions of variations in distributions of living standards. But they still have the merit of being more micro-based than most other types of attempts at understanding variations in living standards in time and in space.

Those studies that have been implemented have been mostly on Latin America and East Asia (see again Bourguignon *et al.* 2005). The sources of changes that have been investigated include changes in education and in human capital, changes in labor force participation and in employment, changes in occupational structure and informality, and changes in the socio-demographic composition and in the area of residence of households (due to migration). It is also important to take into account changes in the returns to these household characteristics and choice variables, including changes in the return to schooling (which are the result of shifts in both the demand and in the supply of skilled workers). For instance, if the returns to education are convex, then an increase in schooling for the poorer may still not lift them up as much as for the richer; for income inequality to fall and for a development trap not to operate, the education of the poor would need to increase disproportionately more than that of the rich.

4.12 Pro-poor growth

Whether growth is good for the poor is an issue on which much policy and academic debate has taken place recently. See, among many others, Bourguignon (2003), Bruno *et al.* (1998), Dollar and Kraay (2002), Eastwood and Lipton (2001), and Ravallion (2004). The evidence from this literature may be of some use in analyzing the links from poverty to growth. It is now well understood, for example, that the structure of growth influences the degree of poverty reduction. Reversing that link, it follows that the various socio-economic sectors do not all contribute equally to growth. For instance, we may want to ask whether there is any evidence that it is the growth in the poorest individuals' living standards that seem to drive overall growth. This is akin to investigating the "dominant view today […] that inequality is not a final outcome of growth but plays a central role in determining the rate and pattern of growth." (Bourguignon 2004, p.14).

In Zambia, for instance, Thurlow and Wobst (2006) find that the (modest) growth observed in the 1990s came mostly from growth in agricultural and rural output. They

conjecture that the collapse of the mining and manufacturing sectors in the 1990s may have removed some of the growth-reducing distortions present in Zambia (perhaps induced by political economy considerations) and thus permitted new sources of growth to arise. Similarly, in Tunisia, a growth strategy based on the development of labor-intensive and export-oriented manufacturing and female labor market participation may have eased some of the labor and capital market imperfections that hampered the poor and helped them generate growth (Ayadi *et al.* 2005).

More broadly, considering whether and how growth has been pro-poor can shed light on the factors that limit the participation of the poor in the growth process. Some useful lines of enquiry are suggested by Agence Française de Développement *et al.* (2005); see also Pattillo *et al.* (2005). These include assessing the sectoral and geographical sources of growth; estimating how initial socio-economic conditions correlate with growth (fertility, population density, local inequality, climatic instability, proximity to markets, access to productive assets); and asking whether it is the poor's or the rich's incomes that seem to drive overall growth. This evidence can be correlated with time, with country, and/or with policy interventions.

The pro-poor literature's preoccupation is whether growth trickles down to the poor; the development trap literature asks instead whether the poor help generate growth. Identification of causality is unlikely in such a setting. Pro-poor evidence can nevertheless be suggestive of which circumstances are better at generating broader-based growth. Such evidence can also be used (with care) to suggest ways in which policy may be handled to stimulate growth that comes from, and impacts on, those that are more deprived.

4.13 Summarizing

Our discussion in sections 1-4 suggests the following set of observations.

- Low income has coexisted with slow growth for a large number of countries since 1960, most of them in Sub-Saharan Africa. This is consistent with development traps but does not imply them.

- The theoretical literature suggests a wide range of mechanisms through which low income can be self-perpetuating. While the literature focuses primarily on extreme cases that generate thresholds and multiple equilibria, we favor a broader definition of development traps that relies on non-monotonicity of the phase diagram relating growth to income.
- More than one development trap mechanism may be operative in any country or time period. The growth evidence nonetheless broadly favors mechanisms that operate through measured productivity rather than through factor accumulation.
- Questions about multiplicity, and even about non-monotonicity of the growth process as a function of income, are difficult to resolve econometrically given the brief period and non-experimental nature of the aggregate growth data.
- Holding average income constant, greater poverty means greater inequality. The growth literature suggests that inequality can undermine growth by widening the scope of market failures and/or generating resource conflicts between poor majorities and rich minorities.
- Microeconomic research suggests that market failures disproportionately penalize the poor. There is ample scope for country-level research to document this phenomenon and explore its links to household incomes and wealth.

5. Avenues for country-specific research

The theoretical discussion and the review above of some of the empirical evidence suggest several research routes through which to explore the existence and the nature of possible development traps in Africa. Which route should be followed depends primarily on the availability of suitable micro-level data, though it can certainly also depend on the country context.

5.1 Asset traps

In the event that household-level panel data on and assets are available, the existence of asset traps can be tested by estimating asset dynamics through a regression of current assets against past assets. The greater the number of time periods, the better, since availability of several time periods can help isolate the effects of household heterogeneity

from true asset dynamics. (This is because the availability of two periods only provides one point on a figure like Figure 9, and it may be hazardous to link these points across households if households differ in unobserved variables.). The estimated asset dynamics can then serve to establish whether several asset equilibria exist, and if so, which of these equilibria are stable or unstable.

If consumption/income data are also available, equilibrium values can then compared to the asset levels that are expected to be needed to exit poverty. One can also try to infer whether there exist consumption thresholds below which assets are dynamically depleted (in part because of capital market imperfections), and whether there is a risk that an individual will enter a long spell of chronic poverty if a series of negative income shocks (even of a short duration) occurs. Evidence of non linearities in asset dynamics will also be useful and can, in particular, suggest the possible existence of Micawber thresholds.

5.2 Mobility, chronic and transient poverty, and state dependence

In the same spirit as in the previous point, and with the availability of panel data, regressions of changes in living standards can be made on initial levels and changes in household and community level characteristics. The measures of living standards can involve the usual money-metric ones such as consumption or income, but they can also include less standard ones such as indicators of education, health, employment or occupational status.

With panel data, suggestive evidence of the existence of development traps can also be obtained from evidence on the distribution of chronic and transient poverty. This can show which characteristics are associated with chronic and transient poverty, respectively, and can indicate which households are more mobile and/or more vulnerable to shifts in living standards. It will be particularly useful to estimate for instance if it is structural household shifts, shifts in environmental parameters, or unobserved factors that cause changes in well-being.

Mobility can, however, only be for the short term. Because of this it will be useful to dispose of panel data covering more than two time periods in order to be able to

estimate both the probabilities to exit poverty and those to re-enter it, conditional on initial characteristics.

If intergenerational data are available – perhaps because panel data over a long time period exist, or more likely because data on parents and children can be found in the same cross-section data – then, one can estimate the relationship between the conditions of parents (education, health, income) and those of their children. If a non-linear relationship is found – for instance, if the relationship is convex – then this may be suggestive evidence of an intergenerational development trap.

In the absence of panel data, but with the availability of several cross-section datasets, one can still assess the existence of economic mobility by socio-economic groups. The unit of analysis is then a group of individuals that can be followed across time. How the relative and/or absolute situation of that group changes across time is an indicator of the mobility.

5.3 Simulation models and correlates of poverty

Modeling differences in living standards across space and time as the interaction of a set of equations can be useful to understand how such variables as earnings generation, labor market participation, family formation, and education can interact in association with overall living standards. This can be done in the context of statistical simulation models that may or not rely on a set of behavioral models. The parameters of the models can be used to estimate the share of the differences (across space) and of the changes (across time) in living standards accounted for by changes in structural household characteristics, by differences in the parameters of the model, and by unobserved shocks, in the spirit of the Oaxaca-Blinder decompositions.

Although panel data are not required for such an exercise, they can be useful to estimate fixed effects across households and/or communities. The availability of more than one set of cross-section data is certainly desirable since it would otherwise be difficult to estimate the impact of time on the distribution of living standards.

This exercise can *inter alia* serve to assess whether the poorer in some environment are lagging behind either because their characteristics are not improving in line with those of the rest, or because the model parameters on these characteristics

(which can sometimes be interpreted as returns to these characteristics) are falling in relative or in absolute terms. This can be suggestive of factors associated with development traps. This can be done for monetary as well as for non-monetary indicators of living standards.

An important application of the above can be made to the issue of the intra-household allocation of resources and well-being. This requires indicators of living standards that are reliably observable at the level of the individual, such as educational achievements, health or anthropometric indicators. Particular focus can be put on investigating the existence of possible gender traps, by estimating for instance whether the evolution of living standards for girls and women is hindered by the evolution of their characteristics and/or by the returns to these characteristics.

5.4 Markets and institutions

In the event that data on participation in social and political processes are available, one can attempt to estimate whether the poor are relatively speaking excluded from these processes. This can be done using quantitative or qualitative data, including data generated from qualitative interviews and focus group discussions. It can also be useful to assess the correlates of access to public goods and services, and see how these vary across time. Evidence that the poor are relatively more constrained in such access, and that this situation is not improving over time, can be taken as suggestive evidence of market and socio-political exclusion. It will be useful to categorize the evidence according to other indicators of political power, such as land ownership, political participation, or proportions of ethnic minorities and racial groups.

In such an exercise, it is better to consider not only access availability, but also the quality of the available goods and services. Evidence on the quality of the goods and services provided by the State (such as health care and schooling quality) may suggest that national and local institutions may be biased against the poor in ways that pure access data do not reveal. The poorer the community, the more important this bias may be. The correlates of accessibility to private markets can also be estimated, by assessing for instance whether the poor can and do exchange assets, products and inputs in formal land, output and input markets.

A fruitful avenue for investigating the existence of micro development traps is described in Banerjee and Duflo (2005). This searches for evidence on whether the marginal returns to assets differ importantly across households and firms. If capital market failures are correlated with poverty and development more generally, then this will lead to poverty persistence.

5.5 Geographic traps

Cross-section data can be used to estimate the spatial correlates of living standards and poverty when controlling for household characteristics other than regions of residence. This can serve to explore the finding poverty tends to increase with the distance from major cities and from the coast, by estimating for instance whether actual distance to markets, infrastructure, access to public services and market quality are correlated with levels of living standards.

When geographically-differentiated cross-section data across more than one period (in order to attempt to account for unobserved heterogeneity across space) are available, it can be possible to estimate separately the effects on living standards of pure location (which might not change) from the effects of variables that can more easily vary, such as transportation infrastructure.

5.6 Pro-poor evidence

Assessing the correlates of whether growth has been pro-poor requires at least two cross-section datasets. It does not, however, require panel data. Evidence on the sectoral and geographical sources of growth can suggest which factors limit the participation of the poor in the growth process. This can be done by estimating how initial socio-economic conditions at the household and local levels correlate with growth, and how this varies with initial levels of living standards. This evidence can be tentatively correlated with time and/or policy interventions.

6. Conclusions

Is poverty a binding constraint on growth in Sub-Saharan Africa? At the aggregate level, we have taken an indirect approach to this question, asking instead whether poverty is

what activates one or more of the constraints on productivity that are widely viewed as potentially relevant in low-income countries. There is plenty of theoretical work to suggest that the answer may be yes, and much of the cross-country growth evidence - given the correlations between income and all other variables - is consistent with important non-monotonicities in the reduced-form relationship between the level and growth rate of aggregate income. But the place for further work, we argue, is at the microeconomic level. We have argued in favor of projects that focus sharply on one of the mechanisms we have reviewed. Country-based research that assesses the empirical relevance of specific links from poverty to productivity, in specific contexts, will help redress the present imbalance between theory and evidence and ultimately strengthen the basis for policy.

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Table 1: Growth diagnostics à la Rodrik *et al.* (2004)

Low return to economic activity	**Low social returns**		**Poor geography**
			Low human capital
			Bad infrastructure
	Low appropriability	**Government failures**	**Micro risks: property rights, corruption, taxes**
			Macro risks: financial, monetary, fiscal instability
		Market failures	**Information externalities: "self-discovery"**
			Coordination externalities
High cost of finance			**Bad international finance**
		Bad local finance	**Low domestic saving**
			Poor intermediation

Source: Rodrik (2007), Figure 2.1, p. 66. The table classifies potential constraints on private investment and entrepreneurship. 'Social' returns here refer to economy-wide returns; i.e., impacts on GDP. The references to "low returns" and "low appropriability" refer to low private returns and low ability of private agents to appropriate the social returns to their own activity.

Table 2: Headcount ratios, Gini coefficients, and consumption shares of the poor

Region	number of surveys	Regional averages		
		Headcount ratio, h (%)	Gini coefficient, G	Approximate consumption share of the poor, θ (%)
SSA	38	50	44	25
LAC	2	0	47	0
SASIA	3	21	40	8
EAP	7	29	39	13
MENAT	7	4	39	1
ECA	23	6	33	2

Source: World Bank, povcal data. The headcount and Gini are calculated from consumption survey data taken in 2000 or later, and using $1.25 (ppp) a day as the poverty line. We have calculated the approximate consumption shares of the poor for each country are calculated as follows: if the poverty headcount is 43%, the approximate consumption share of the poor is the sum of the shares of the lowest 4 consumption deciles plus 3/10 of the share of the 5th decile. This will be slightly upwardly biased due to inequality of incomes within deciles.

Table 3: Percentages of the world population living below $1 a day, by region

Regions	**1981**	**1993**	**2005**
East Asia and Pacific	66.8	35.4	9.3
Eastern Europe and Central Asia	0.7	2.1	2.2
Latin America and Caribbean	7.7	6.0	5.6
Middle East and North Africa	3.3	1.5	1.6
South Asia	41.9	29.3	23.7
Sub-Saharan Africa	42.6	46.4	39.9
Total	41.4	27.0	16.1

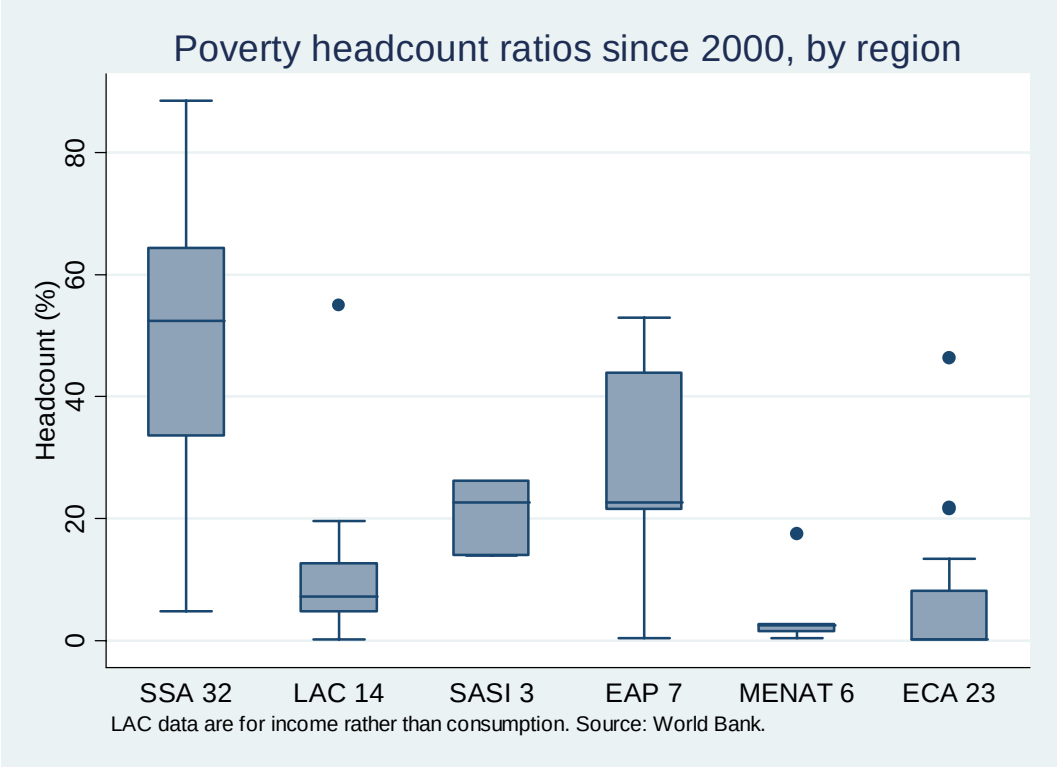
Source: Ravallion and Chen (2008).

Table 4: Numbers of people (in millions) living below $1 a day, by region

Regions	**1981**	**1993**	**2005**
East Asia and Pacific	921.7	588.7	175.6
Eastern Europe and Central Asia	3.0	4.1	10.2
Latin America and Caribbean	28.0	29.0	30.7
Middle East and North Africa	5.6	3.8	4.7
South Asia	387.3	381.2	350.5
Sub-Saharan Africa	169.4	245.2	304.2
Total	1515.0	1286.7	876.0

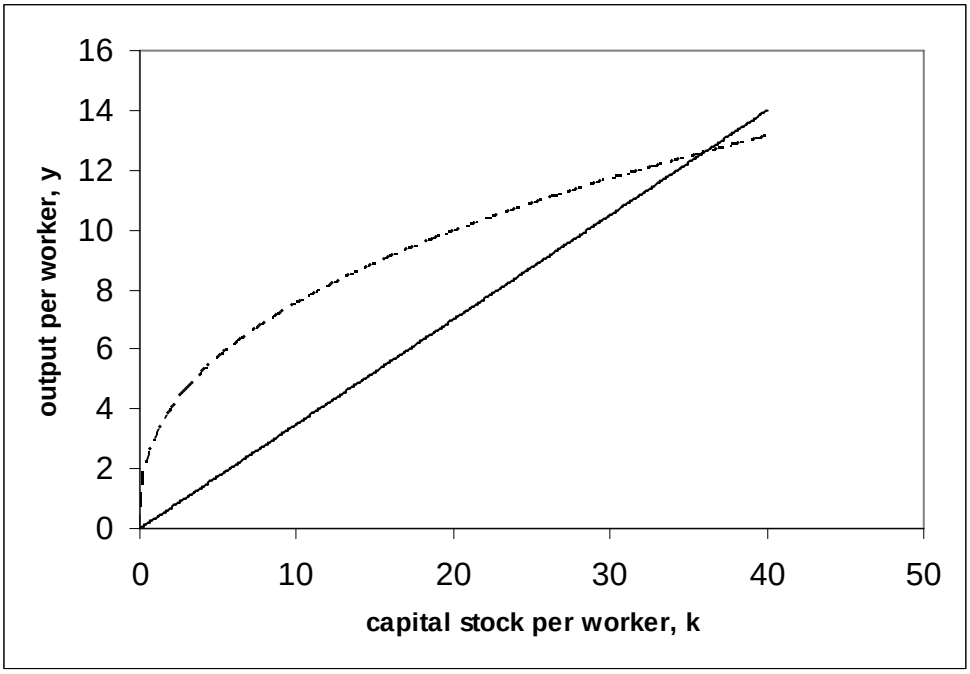
Source: Ravallion and Chen (2008).

Figure 1: Percentage of population below $1 (ppp) of consumption per day



Notes: Headcounts are defined as the percentage of the population below $1 (ppp) of consumption per day. The boxes enclose the central half of the distribution of headcounts for each region; the horizontal line within the box is at the regional median. The 'whiskers' extend to the maximum and minimum values for the region, excluding outliers which are shown as dots.
LAC = Latin America and Carribean; SASI = South Asia; EAP = East Asia and Pacific; MENAT = Middle East, North Africa, and Turkey; ECA: Europe and Central Asia. Industrial economies are excluded.
Source: World Bank, Povcal online database.

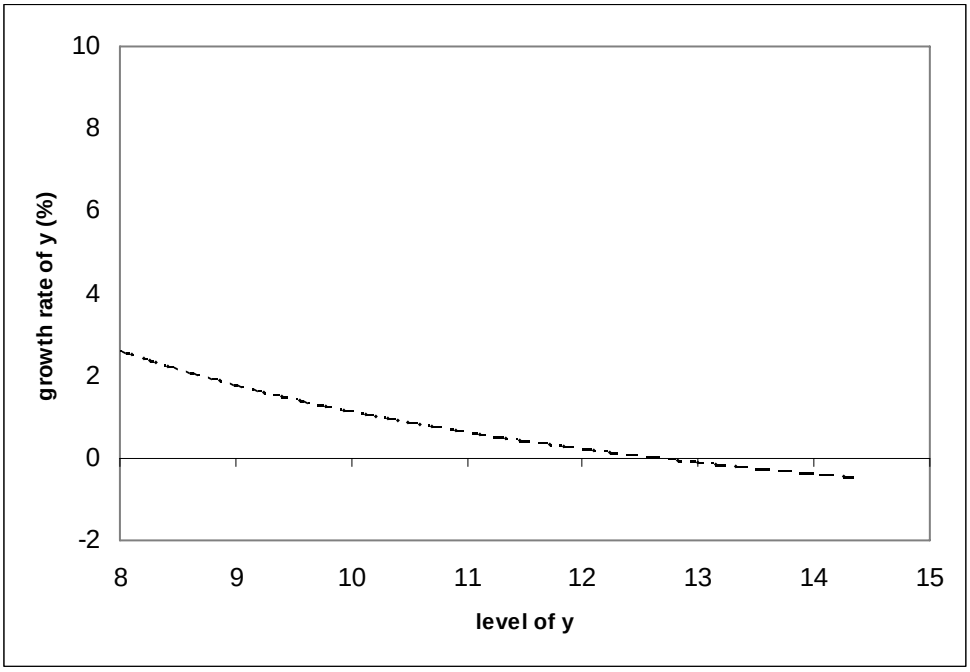
Figure 2: The Solow model



Source: Authors' calculations.

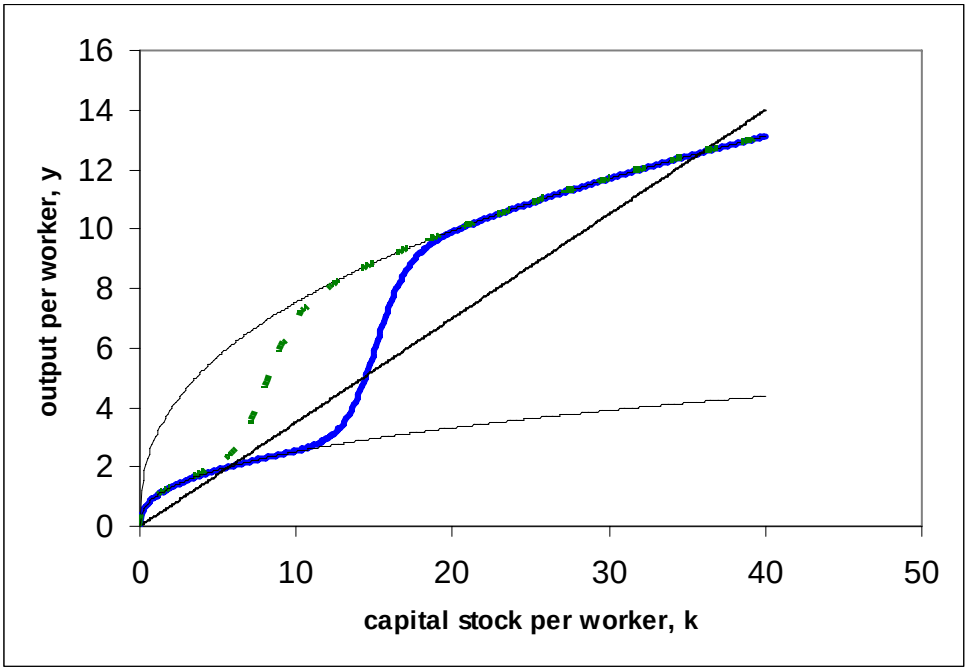
Note: The dotted line is the per-worker production function $y = A \cdot k^{\alpha}$, for $A = 3$ and $\alpha = 0.4$. The straight line is $[(n+\delta)/s] \cdot k$, for $n = 0.03$, $\delta = 0.04$ and $s = 0.20$. The steady state occurs where these two loci cross or, equivalently, where total saving $s \cdot y$ equals the amount of investment required to keep the capital stock per worker from falling, $(n+\delta) \cdot k$. To the left (right) of this intersection, the capital stock per worker is rising (falling).

Figure 3: Phase diagram for the Solow model



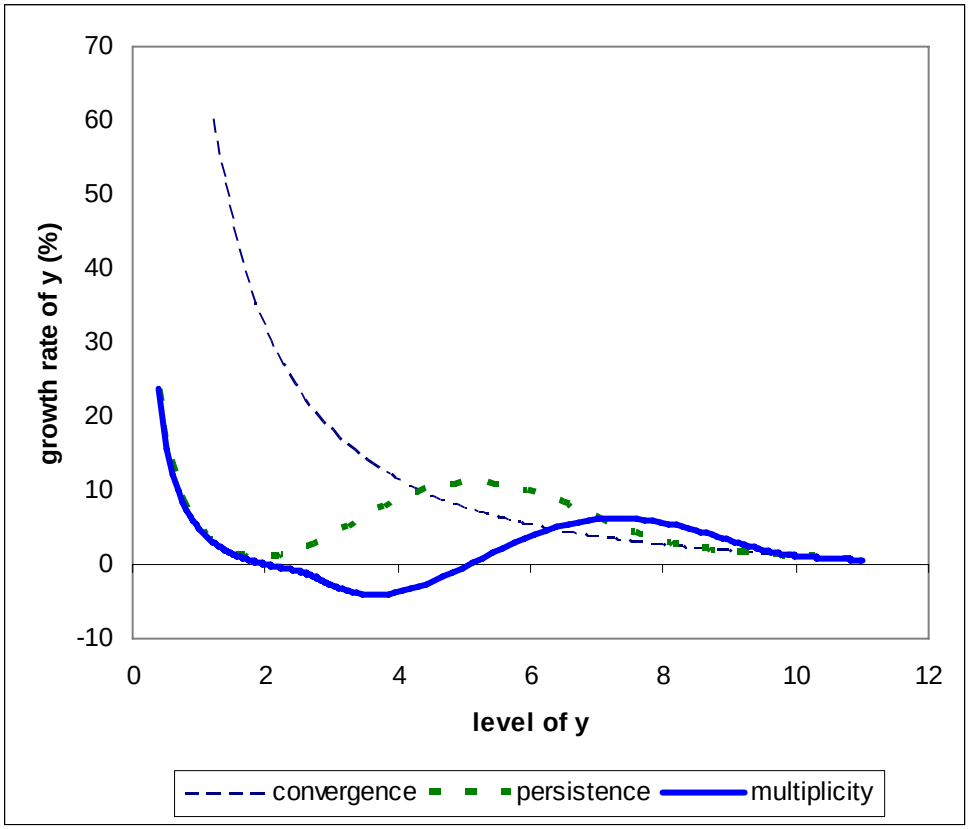
Source: Authors' calculations, based on the Solow model in Figure 2.

Figure 4: Variable productivity models



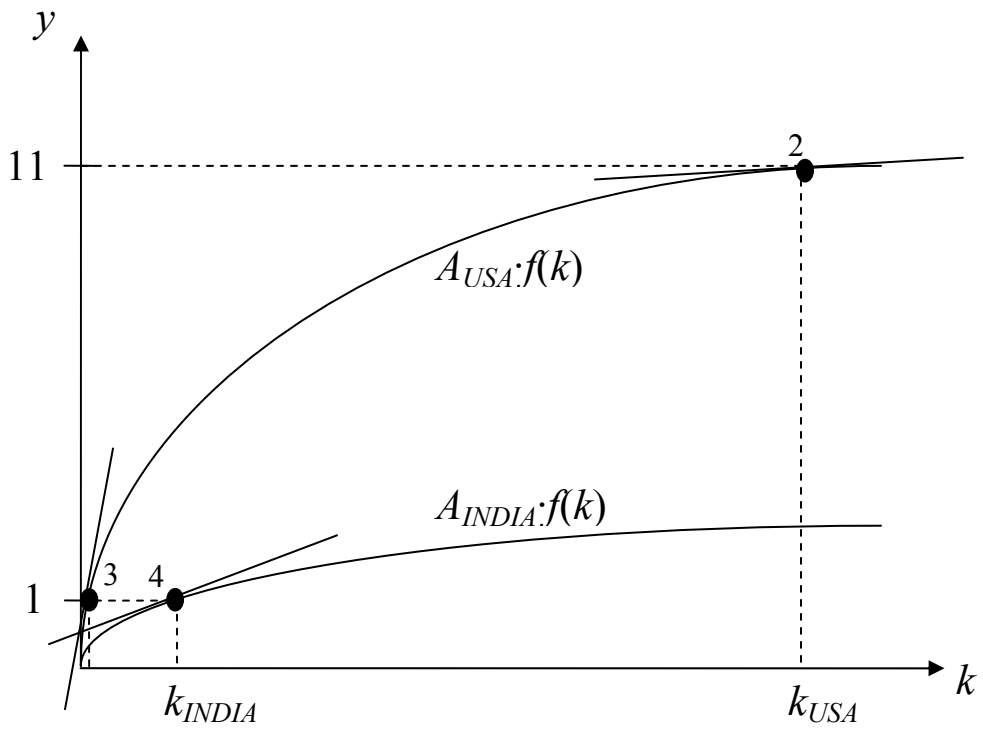
Notes: The upper and lower concave production functions take the form $y = A \cdot k^{0.4}$, with $A = 1$ and $A = 3$. The production functions drawn with heavy solid or dashed lines use $A = 1 + [2/(1 + \exp(a–k)]$, with $a = 15$ for the multiple equilibrium (solid) case and $a = 8$ for the persistence (dashed) case.

Figure 5: Phase diagrams for variable productivity models



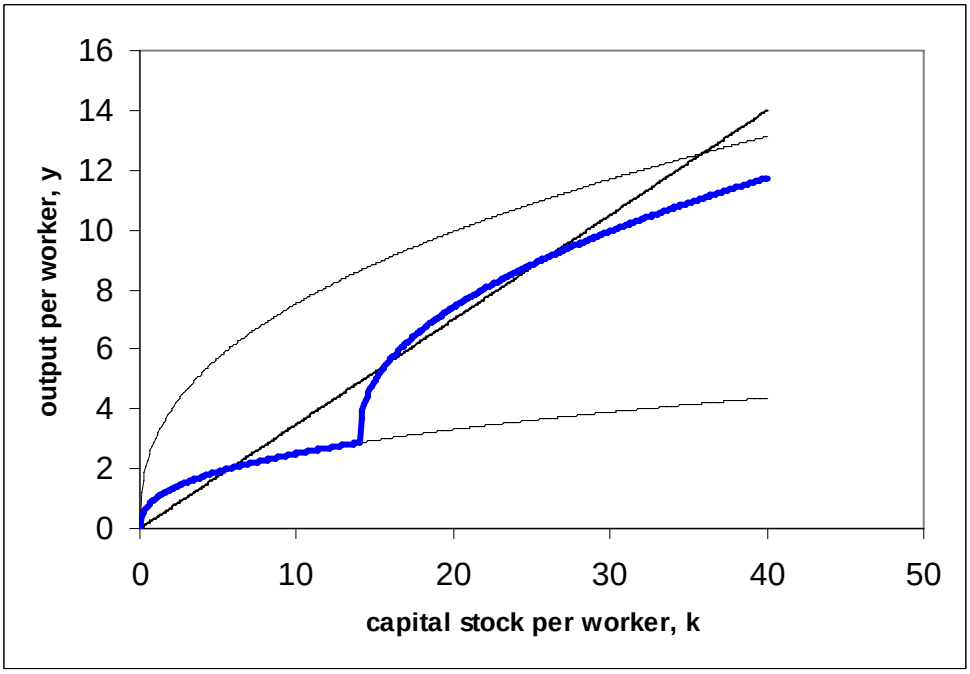
Notes: The phase diagrams correspond to the uppermost concave production function in Figure 4 ($A = 3$) and to the two production functions with convex portions.

Figure 6: The growth facts imply large productivity differences.



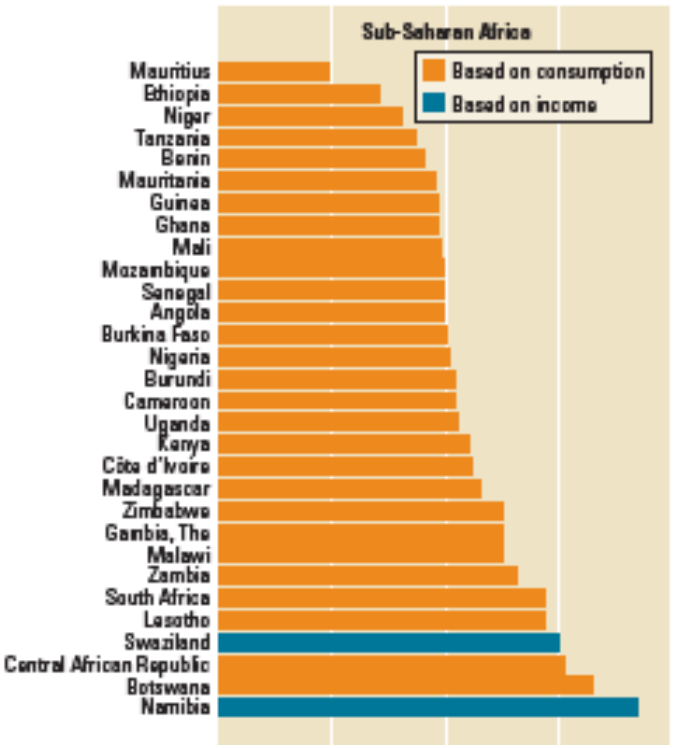
Notes: The tangents at points 2, 3 and 4 show the marginal product of capital.

Figure 7: Regressive political distortions



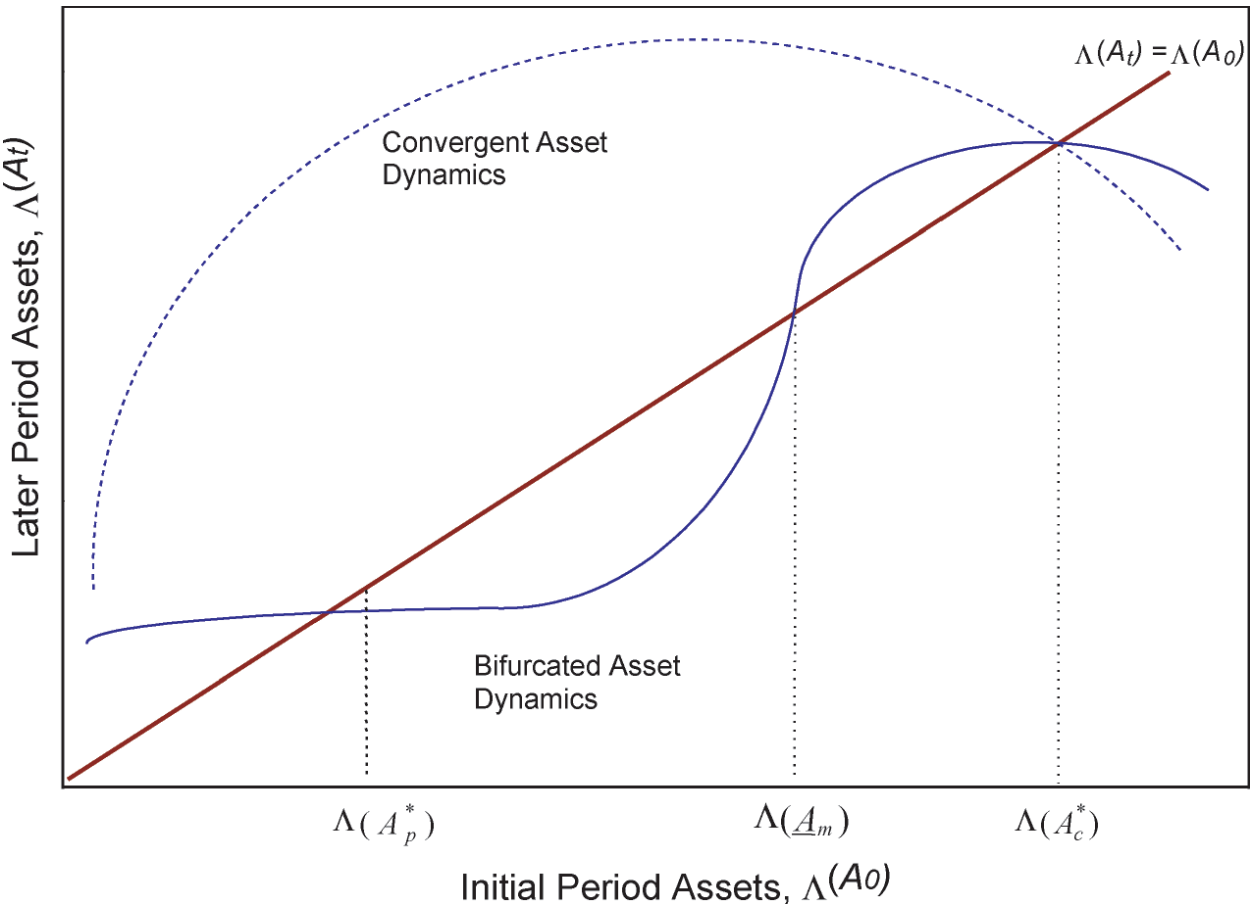
Notes: The upper dotted line shows an aggregate production function along which all feasible projects are ordered from most to least productive. The straight line is the output required to generate saving sufficient to just replace the existing capital stock, as in the Solow model. If all feasible projects are implemented the total required capital is 42. All individuals draw a project randomly from the overall distribution of returns. The political elite comprise 1/3 of the population, and their projects are implemented (on an efficient basis within the elite, the most productive first) before any project of the non-elite is implemented. At the kink, where $k = 14$ (= 42/3), the elite have run out of projects to implement. Any additional capital is allocated efficiently among projects of the non-elite. In the configuration shown, there are two locally stable equilibria with a threshold of about $k = 16$.

Figure 8: Within-country inequality



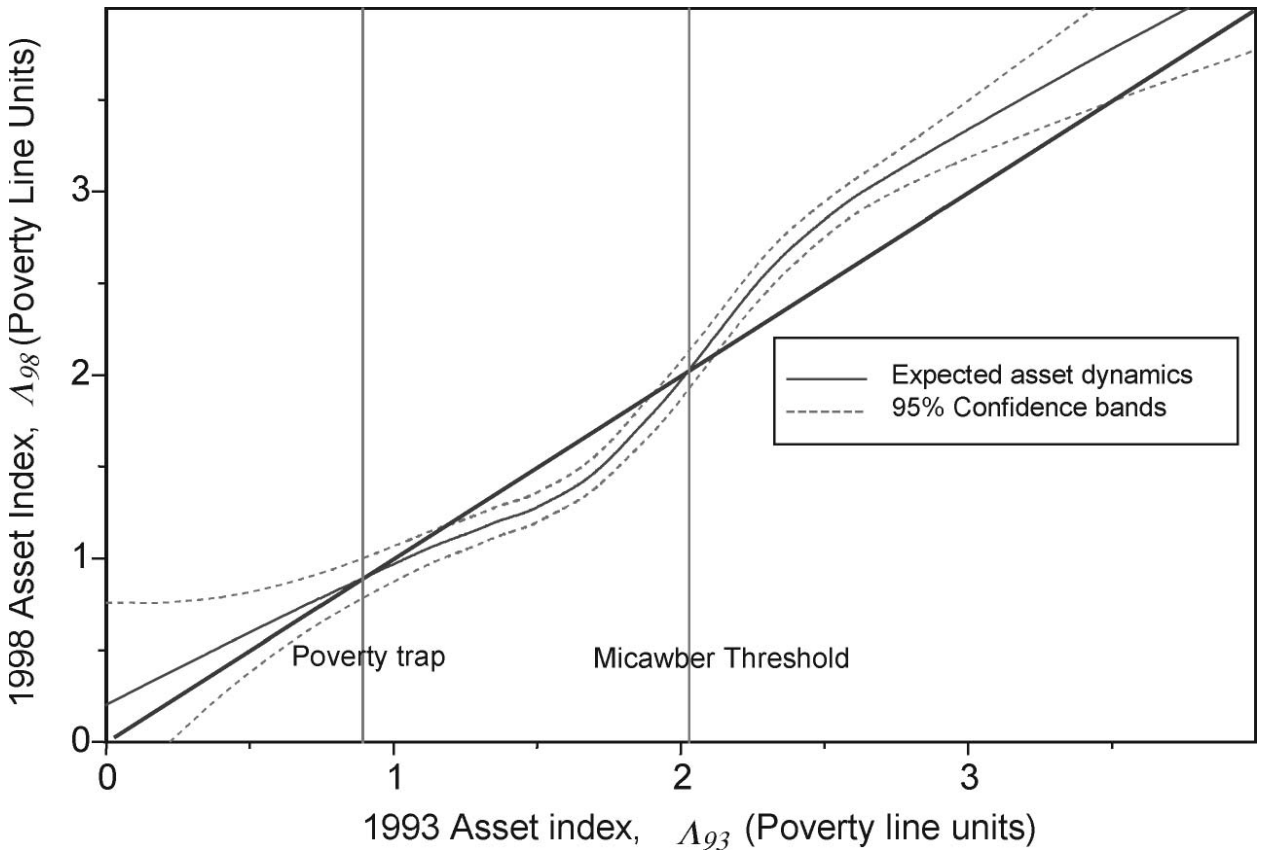
Source: World Bank 2005.

Figure 9: Asset dynamics with a Micawber threshold



Source: Adato *et al.* (2006)

Figure 10: Estimated asset dynamics in South Africa



Source: Adato *et al.* (2006)