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Fractal Poverty Traps

Abstract: This paper offers an informal theory of fractal poverty traps that lead to chronic poverty at multiple scales of socio-spatial aggregation. Poverty traps result from nonlinear processes at individual, household, community, national and international scales that cause the coexistence of high and low equilibrium levels of productivity and income and high and low rates of economic growth. Multiple equilibria result from key threshold effects that exist at all scales due to market failures and nonmarket coordination problems. Key implications of fractal poverty traps include (i) the importance of recognizing meso-level phenomena in addition to conventional micro- and macro-level issues, (ii) inter-connections across social-spatial scales that foster or ameliorate chronic poverty, (iii) the importance of identifying and overcoming thresholds at which accumulation and productivity dynamics bifurcate, and (iv) the significant potential role of transitory donor and government interventions and safety nets to ignite sustainable growth among the poor.

1. Introduction

At least one-fifth of the world's population suffers extreme poverty, living on less than $1/day. In Sub-Saharan Africa alone, the share of total population living in extreme poverty has remained stuck at between 45 and 50 percent for the past fifteen years, with population growth bringing the total number of extreme poor in Africa to more than 290 million people.[1] Although extreme poverty is most widespread in Africa as a share of population, it has likewise stabilized as a share of population in Latin America, while Asia's vastly larger population translates into nearly three times as many people in extreme poverty on that continent. Increasing the incomes of the more than 1.2 billion people living in extreme poverty by $1/day per person would require an extra $450 billion per year in direct income gains to these poor people, not counting associated income gains to others. Such a staggering figure suggests a need for strategic focus and the necessity of igniting sustained growth among the poor, not just aiming for one-off gains. This requires a clear conceptualization of the nature and causality of poverty. This paper offers a contribution toward meeting that need.

[1] This and other poverty statistics in this paragraph come from the World Bank's Global Poverty Monitoring system on the web at http://www.worldbank.org/research/povmonitor/.

We focus on two key aspects of the nature of poverty[2]. The first concerns its dynamics: how human well-being evolves over time. We know that much poverty is transitory.[3] People commonly suffer – or even choose – short-term income losses that push them below an inherently arbitrary poverty line for a relatively brief period of time. Then they recover without explicit external assistance. While even transitory poverty is plainly undesirable, the capacity of the transitorily poor to rebound quickly from downward shocks typically causes policymakers and scholars to focus more attention on those who remain poor for more extended periods of time. Attention is therefore focusing more than ever on "chronic" or "persistent" poverty.[4]

Consider a crude comparison of poverty dynamics in Côte d'Ivoire, Ethiopia, South Africa and the United States, based on four separate studies (Figure 1).[5] The leftmost point on each country series in Figure 1 reflects the headcount poverty measure at one point in time, as measured against the US dollar/day per person poverty line noted in parentheses. The subsequent points depict the percentage of the population that was poor in both the initial period and the subsequent survey period(s). This graphic captures the crucial distinction between persistent and transitory poverty. If all poverty were chronic, the lines would all be horizontal, as those who were poor in the initial survey period would always remain poor. Conversely, if all poverty were transitory, the lines would collapse to the x axis quite rapidly.

Several key hypotheses jump out of a graphic such as this. First, international differences in headcount poverty measures appear noticeably less than the differences in persistent poverty measures at horizons of a year or more. For example, although in 1993, one headcount measure of poverty in the United States reached 22.3 percent, less than one quarter of those households remained poor one year later, and only 5.3

[2] Poverty is a multi-dimensional phenonema encompassing low income or consumption, high vulnerability to shocks, and lack of voice or power. In the interests of brevity, in this introductory section we rely on the standard income and expenditure poverty conceptualization. But as should become apparent as the paper progresses, our theory of fractal poverty traps aims explicitly at linking the standard economic view of consumption or income poverty with the concepts of vulnerability and voicelessness, especially as all three are linked through asset holdings and mechanisms of production and exchange.

[3] See in particular Baulch and Hoddinott (2000) and the various studies cited there.

[4] For example, the recent special issue of *World Development* edited by Hulme and Shepherd (2003).

[5] We must emphasize the crudeness of these comparisons. The welfare measures and poverty lines were not constructed in precisely the same way across the different countries nor are the South Africa or Ethiopia data from nationally representative samples. We are merely drawing on others' published results to make a basic qualitative point. We recommend against making any specific, quantitative inferences off comparisons between these imperfectly comparable series.

percent of the American population was poor for two years continuously, with a median time in poverty of merely 4.5 months (Naifeh 1998). With the exception of Ethiopia – where the data reflect semi-annual measures using an extremely low poverty line of $0.23 per person per day and thus reflect high rates of churning only around a level of extreme deprivation – none of the other countries plotted exhibit such a drop off in household poverty over time. Although the United States suffers a high headcount rate of poverty – albeit, measured against a relatively high poverty line equivalent to $15.05 per person per day for a family of four, more than 65 times the Ethiopia poverty line used here – most poverty in the United States is transitory and the percentage of the population that is persistently poor is relatively small.

Second, most of the poor in the African cases appear to be persistently poor. In Côte d'Ivoire and Ethiopia, 85 and 52 percent, respectively, of the poor remained poor one year later, while in South Africa 66 percent of the poor remained poor five years later. Although these comparisons are necessarily crude, they nonetheless underscore an important qualitative point: it is not just the *magnitude* of poverty but, perhaps even more and more importantly, the *nature* and *duration* of poverty that differentiates much of the developing world from the United States and other wealthy countries. Where anti-poverty policy in the wealthy countries largely revolves around the provision of safety nets to cushion people against short-term shocks and to help them "get back on their feet again" quickly, in the developing countries the task is necessarily far more challenging. The persistent poverty of developing countries is of grave concern not only because of the severe material deprivation it represents, but equally because of the hopelessness that such dim prospects can induce, with severe cultural, moral and political implications.

Such observations give particular salience to the concept of *poverty traps* into which people may fall and have some difficulty escaping. The basic idea of poverty traps turns on the existence of multiple dynamic equilibria, as posited by Allyn Young, Paul Rosenstein-Rodan, Gunnar Myrdal and other classic development theorists of the early and mid-20th century. The dynamics of convergence toward one or another equilibrium depends on where one sits initially relative to critical thresholds at which the path dynamics of income growth and asset accumulation bifurcate. People, communities and entire nations or multinational regions have a difficult time rising beyond such thresholds without assistance, and can unexpectedly

fall below them.[6] These thresholds reflect a bifurcation point in the expected dynamics of movement toward stable dynamic equilibria, with at least one equilibrium reflecting a poor standard of living. Absent such thresholds, all poverty would be transitory with everyone converging toward a single equilibrium income level, as posited by neoclassical economic growth theory (Solow 1956). Overwhelming empirical evidence against such unconditional convergence has motivated a flurry of research over the past twenty years on "new" or "nonergodic" theories of economic growth at the macroeconomic level and on the microfoundations of poverty traps.[7]

The causality behind the poverty trap phenomenon nonetheless remains murky. Different analysts from different disciplinary traditions, studying different regions, find different correlates of persistent poverty and posit different causal mechanisms. The gaps remain considerable between the theory and the empirics and between different disciplines' analyses of the phenomenon of chronic poverty. One reason (among many) is the difficulty of integrating findings from distinctly different scales of analysis. Most of the economics research on poverty is either at the very micro scale of individuals and households or at the macro scale of nation states and regions, while much of the corresponding literature in anthropology, geography, sociology, and political science concentrates on intermediate scales of villages, ethnic groups, ecoregions and political jurisdictions.

This leads directly to the second key aspect of the nature of poverty on which we focus: its multi-scalar nature. Our theory emphasizes the existence of a basic pattern that repeats itself at multiple scales of social-spatial aggregation. We therefore refer to this multi-scalar view of persistent poverty as a theory of *fractal poverty traps*, drawing on the fractal geometric concept of self-similarity with independence of scale.[8] The modifier "fractal" reflects our observation that there exists a pattern to poverty traps that repeats itself at all scales of aggregation, from the most micro-scale of individuals to macro-scale of nation states and multinational regions and through important intermediate, or "meso" scales. As we will explain in the remainder of the paper, the concept of fractal poverty traps implies a need (i) to

[6] The fall is necessarily unexpected – we will later refer to them as "shocks" – for if one could anticipate a shock severe enough to push one past such a threshold, one would avert it if at all possible.
[7] Easterly (2001) offers an especially accessible, even entertaining treatment of the evolution of growth theory and the empirical evidence on economic growth. After we began this paper, we discovered that he too uses the term "fractal poverty traps," although his use of the term is purely descriptive.
[8] See Mandelbrot (1977, 1983) for the seminal contributions to fractal geometry.

broaden poverty analysis beyond the familiar micro-macro dichotomy prevalent in economics so as to take intermediate scales of aggregation seriously, (ii) to address appropriate roles for subnational scale institutions in poverty reduction strategies,[9] and (iii) to consider how investments at any particular scale are shaped not only by the direct returns associated with asset accumulation or productivity growth at that scale, but also by prospective indirect effects resulting from how investment at one scale might affect thresholds, and patterns of asset accumulation or productivity growth at other scales. We begin by developing a model of poverty traps that centers on thresholds in the returns to assets and the dynamics of asset accumulation.

2. The causes of poverty traps: An informal theory

The theoretical economics literature on poverty traps works from the familiar microeconomic foundation of individual resource allocation to generate multiple equilibria through either (i) increasing returns to scale technologies, often due to externalities at the societal scale (Romer 1986, Lucas 1988, Azariadis and Drazen 1990, Durlauf 1996), (ii) spatial agglomeration economies and resulting market and technological effects at regional scale (Krugman 1991, Fujita et al. 1999), and financial markets failures combined with either (iii) indivisibilities in key investments, such as education or livestock (Loury 1981, Banerjee and Newman 1993, Galor and Zeira 1993, Dercon 1998, Mookherjee and Ray 2002) or (iv) irreversibilities due to subsistence thresholds (Zimmerman and Carter 2003). The parallel, multidisciplinary development literature on rural livelihoods and technology adoption emphasizes the role of social networks and collective action, and appropriately shifts attention away from the sectoral focus of most economic models to the multisectoral behaviours of individuals and groups (Reardon and Vosti 1995, Rogers 1995, Davies 1996, Bryceson and Jamal 1997, Scoones 1998, Ellis 2000, Barrett, Place and Aboud 2002). These two approaches remain largely unintegrated despite inherent complementarities on which we explicitly build in this paper. Both

[9] A focus on the distinct roles of meso-scale institutions distinguishes this paper from much of the U.S. based literature on fiscal federalism as well as the more recent literature on decentralized governance in transition and developing countries. The fiscal federalism literature concentrates on efficient production and allocation of public services to households and firms with different preferences (see Oates (1999) for an excellent recent review). By contrast, the newer literature on decentralized governance in developing countries focuses on issues such as accountability, regional disparities, leakage, and capture by elites (e.g., Bardhan 2002).

traditions seek to shed light on the etiology of persistent low productivity, investment, and standards of living, while emphasizing the role of assets and accumulation patterns. This section draws on key insights from each literature to advance a theory of fractal poverty traps.

a. The static model

The fundamental choices around which we construct the theory of fractal poverty traps are *strategies*. At the micro scale of individuals and households, and especially in the multidisciplinary literature on rural development, the current terminology refers to *livelihood strategies*, reflecting the diverse activities in which poor households typically engage (Scoones 1998, Ellis 2000, Hulme and Shepherd 2003). However, the modifier *livelihood* is less appropriate at more aggregate scales, where collective choice is reflected in *development strategies* that nest within them individual and household scale livelihood strategies. The more general, scale-independent concept, therefore, relates to *strategies*, defined as a set of activities undertaken by (individual or collective) decision-makers using available assets to shape current and future standards of living.

One of the weaknesses of most of the economic growth theory literature is the pervasive assumption of a unique production technology or uniform participation (or nonpartcipation) in markets, equivalent here to a single strategy. This assumed homogeneity defies the empirical regularity that within any collective unit, one tends to observe a range of different activities chosen by different constituent agents, with differing levels of productivity. Our conception of poverty traps explicitly seeks to incorporate and explain the multiplicity of strategies available and chosen at each scale of aggregation.

Choices among strategies depend on the opportunities available to and the constraints faced by decision-makers and the relative returns to each strategy.[10] Each strategy maps a stock of productive assets – roughly speaking, financial, human, natural, physical and social capital – into income and other flows of value via a transformation function. The shape of the transformation function depends on the underlying production and exchange mechanisms – production technologies, organizational forms, market and nonmarket resource allocation arrangements – that

[10] These returns may be multidimensional, reflecting income, risk, prestige, and other distinct factors of intrinsic value to individual decision-makers.

define each strategy and its productivity, given exogenous determinants of production and exchange (e.g., rainfall and other biophysical phenomena, local institutional history, exogenous market prices), as well as the risks associated with prices, yields, and assets. We take it as self-evident that decision-makers choose the strategy that best provides for their current and future needs and wants, given their individual circumstances. In economic terms, decision-makers opt for the strategy that maximizes their discounted stream of current and future utility. Strategy choice reveals agents' preferences among the feasible options they face.

Human welfare – including poverty – thereby turns on the strategic options available to people and on the productivity of those strategies. The set of feasible strategies depends, in turn, on the stock of productive assets they control: their endowments of financial, human, natural, physical and social capital. Some strategies are effectively open to any decision-maker. At the scales of households or individuals, for example, exclusive reliance on unskilled labor markets is almost universally feasible. Entry barriers commonly restrict access to other strategies that offer expected returns superior to those generated by such universally accessible strategies. Among desirable strategies, the higher the entry barrier, the higher the expected returns to the activity for those who can surmount the barrier, else the strategy would never be optimal and thus would never be chosen.

This basic conceptualization can be depicted in a simple diagram of strategic options that map one's initial stock of productive assets into resulting expected utility, productivity or income levels (i.e., the argument of the objective function one assumes the decision-maker to be optimizing). Each strategy offers a different transformation function (Figure 2). Strategy 1 (S1) yields the highest expected returns for those with asset stocks less than the T^2 threshold level at which it becomes preferable to practice strategy 2 (S2), which has an entry barrier, a minimum asset stock of E^2. Similarly, S2 is preferred up until the point T^3 where strategy 3 (S3, characterized by entry barrier E^3) begins to dominate, and beyond threshold T^4, strategy 4 (S4) is preferred. This is a very general framework that encompasses, for example, models of nonseparable consumption and production choice by households and multidimensional livelihood choice (DeJanvry et al. 1990, Baland and Platteau 1994, Ellis 2000).

Figure 2 reflects the role played by ex ante productive asset holdings in influencing strategy choice and resulting welfare outcomes. The larger one's stock of

assets ex ante – reflected in rightward movement along the x axis – the higher the returns one enjoys and the greater the likelihood that one chooses higher return strategies that, in the neighbourhood of the asset threshold at which the optimal strategy switches, generate increased marginal returns to assets. The local increase in marginal returns attributable to changing strategies, in spite of assumed diminishing returns to assets within each strategy, can be seen if one draws a ray connecting the origin and the transformation curves for each strategy. At the threshold points, such a ray increases in slope as decision-makers switch to the superior strategy. Such locally increasing returns are the hallmark of poverty traps (Barrett 2003a).

The slopes of the transformation functions depend on four key factors. First, production, processing and distribution technologies determine how assets map into expected physical output of primary or processed products. The more efficient and productive the technology, the steeper the slope of the transformation function since an extra unit of productive assets (e.g., an additional hectare of land) generates greater marginal output. This reflects the familiar production function approach in microeconomics, wherein land, labor, capital and other inputs combine to generate outputs.

Second, marketing arrangements and resulting (input and output) prices and transaction costs determine how physical output maps into expected money metric value. As the prices of purchased inputs or the transactions costs of commerce fall or the prices of goods and services rise, the transformation curve pivots in the same counterclockwise fashion as when production technologies become more efficient. At this level of generality, markets are analytically equivalent to technologies, where prices and transactions costs are the "production function" transforming things sold into things purchased.[11]

Third, the riskiness of the technologies and markets, as well as the risk preferences of the decision-maker(s), determine how expected monetary yield maps into risk-adjusted welfare. Increased variability in yield or prices or greater risk aversion flattens the transformation curve. Fourth, for all scales of aggregation

[11] This can be seen readily through a slightly more formal treatment. Describe a general production technology mapping productive assets (e.g., a stock of arable land or working age population), X, into output, Y, as $Y=f(X)$. Now, let there be another technology mapping X into another output, Z: $Z=g(X)$. A market provides a medium of converting Z into Y according to the relative price, P^Z/P^Y, and fixed transactions costs, T: $Y= (P^Z Z – T) /P^Y$. Of course, substitution implies $Y= (P^Z g(X) – T) /P^Y$ and $f(X)= (P^Z g(X) – T) /P^Y$ satisfies all the characteristics of a production function.

beyond the individual, the transformation function subsumes mechanisms for distributing aggregate net returns among units of the collective.

The location of the transformation curves in Figure 2 – i.e., the points at which they cross the x axis, holding slope constant – depend on the unrecoverable (i.e., sunk) costs required to access each strategy. The intercepts of the transformation functions along the Y-axis of Figure 2 (not shown) reflect the sunk costs to pursuing the strategy. Together with the slope of the resulting curve, which reflects the returns to the strategy, these generate both the minimum viable asset stock necessary for remunerative entry (the points marked E^2, E^3, and E^4) – the point at which there exist positive expected returns – and the threshold levels (the intersections of transformation curves at asset levels T^2, T^3, and T^4) at which agents naturally switch strategies. The greater the sunk cost, holding slope constant, the larger the minimum asset stock necessary to undertake the strategy.[12]

The shape of each transformation curve and the thresholds at which it becomes desirable to switch from one strategy to another necessarily vary among individuals or households. Some variation is individual- or household-specific. For example, more risk averse people will generally opt for lower return-lower risk strategies than otherwise identical people with lower risk aversion. Some variation will occur over space and time, reflecting spatial variation in prices and intertemporal variation in exogenous production conditions. This reflects the role of covariate factors on strategy choice and resulting welfare outcomes. For example, if strategies 1 and 2 in Figure 2 involve rainfed farming and the others do not, then the first two curves will move up and down over time as rainfall becomes more or less favorable, respectively. Those of moderate wealth may move between those two strategies and into and out of strategy 3 accordingly. Extending this example, if strategy 1 represents semi-subsistence farming while strategy 2 represents commercialized farming for market, then E2 and T2 may be very low for those living quite near good roads and urban terminal markets, but quite high for those living in more remote places.

As alluded to previously, the transformation curves reflect conditional expectations functions. One can envision a distribution of possible realizations of welfare outcomes around each point on the curve, reflecting idiosyncratic risk faced

[12] We intentionally avoid use of the term "scale" in referring to the stock of assets employed in a particular strategy or to the size of an operation (as implied by "economies of scale"). Rather, we only use "scale" in its measure theoretic sense, reflecting the metric used in measurement, particularly the degree of aggregation implicit in a particular unit of analysis.

by individual units at the relevant scale of analysis. Covariate shocks, by contrast, would be reflected in an unanticipated displacement of the transformation curve for all units uniformly affected by the shock. Realized output or income depends on both covariate and idiosyncratic risk.

b. The dynamic model

Thus far we have a purely static conceptualization of welfare outcomes, although our objective is to understand poverty traps, the inherently dynamic mechanism underpinning persistent poverty. As we now show, the static formulation of the preceding section lays the foundation for exploring the dynamics of asset accumulation and decumulation and thus of intertemporal welfare changes. The dynamic framework also helps us to address one of the key dimensions of poverty – vulnerability of livelihoods to shocks beyond the control of the individual decision-maker.

The key to understanding the dynamic implications of the foregoing framework lies in recognizing that each strategy individually exhibits the usual diminishing returns properties. Therefore, the well-known convergence implications of neoclassical growth theory apply within the domain of each strategy's dominance. Within any single strategy, low initial asset stocks imply high marginal productivity, which induces investment in asset accumulation up to the point where one converges on a dynamic equilibrium, a point at which a stable asset stock is optimal, given intertemporal preferences between current and future consumption. Conversely, if one begins a period above the dynamic equilibrium asset stock, one disinvests or decumulates assets back toward the equilibrium. An important implication is that asset and income growth are not inconsistent with the idea of a poverty trap, although growth rates and equilibrium asset or income levels are bounded from above in the presence of a poverty trap unless one switches strategies. In the empirical macroeconomic literature on growth, this pattern is sometimes known as "club convergence" (Baumol 1986, Quah 1996), wherein clusters of units each converge on a small number of equilibria, but they do not all move toward a single steady state growth rate or income level.

Different strategies therefore have different dynamic equilibria. Figure 3 depicts this graphically. The horizontal axis measures the productive asset stock in a particular period, just as in Figure 2, with the vertical axis now reflecting the

subsequent period's asset stock. The dashed, 45-degree line therefore reflects dynamic equilibria, points where the expected asset stock is constant across periods. The four recursion curves[13] reflect the path dynamics of optimal asset holdings conditional on the strategy chosen. Each recursion curve is associated with a different dynamic equilibrium, reflected on the vertical axis at A^{*1}, A^{*2}, A^{*3}, and A^{*4} for the four stylized strategies, respectively. These curves move in a fashion similar to those of Figure 2, moving up (down) as the underlying productivity of the asset stock – and thus discounted future returns to investment in the asset – increases (decreases) due to changes in market conditions, technologies or exogenous factors affecting a strategy's expected future productivity.[14]

The key to understanding the genesis of poverty traps lies in understanding the nature of transitions – or, more importantly, the absence of transitions – between strategies.[15] Where two strategies' recursion diagrams cross at an asset level below the dynamic equilibrium of the lower return strategy, decision makers will graduate endogenously from a lower return, *transition strategy* to the next higher return strategy until ultimately settling into the dynamic equilibrium of a *stable strategy*. Strategies are either stable or transition.

The distinction arises because transition strategies such as Strategy 3 in Figure 3 have domains of accumulation – ranges over which one expects to observe further asset accumulation while the agent remains within the strategy – but no domains of decumulation, as shown in the Figure's bottom panel. Hence the "transition" label. Transition strategies merely provide pathways from lower productivity strategies to higher productivity ones. Rational agents would never intentionally reach a transition strategy's dynamic equilibrium, much less overshoot it and divest assets back toward the equilbrium. The concave production technologies that underpin neoclassical growth theory can be understood as an infinite sequence of transition technologies leading to the unique strategy exhibiting an optimal dynamic equilibrium.

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[13] We refer to these as recursion curves or recursion diagrams because they reflect the recursivity of the asset, i.e., they depict how the first-order Markov process describing the asset's law of motion varies with initial asset level.

[14] Life cycle effects may also shift these curves. If younger households tend to put greater value on accumulating assets that will pay dividends for a longer period, then the accumulation trajectory will tend to rise as households mature to middle years, then begin falling again as their remaining life expectancy grows shorter. Deaton (1992), however, finds life cycle savings relatively unimportant empirically in developing countries.

[15] The analytics of this choice among a family of individually concave strategies is developed formally in Barrett and Blume (2003).

The possibility of poverty traps therefore emerges when there exist lower productivity, stable strategies from which agents do not naturally graduate. Consider strategies 1 and 2 in Figure 3. Agents who start with asset holdings within the basin of attraction for each of these strategies follow an accumulation trajectory that leaves them at that same strategy's dynamic equilibrium. Those whose dynamic asset equilibrium leaves them below the poverty line – A^{*1} in Figure 3 – are chronically poor, as in the case of Strategy 1. Those whose asset accumulation trajectory spans the poverty line will routinely move into and out of poverty depending upon temporary or permanent changes to underlying asset productivity and shocks to their asset holdings. Those agents on the lower end of Strategy 2's basin of attraction may be transitorily poor. They are expected to grow out of poverty in time, but their accumulation trajectory spans the poverty line, leaving them vulnerable to temporary spells in poverty. Those whose asset endowments, given extant technologies, markets and exogenous institutional and biophysical conditions, permit them to pursue strategies 3 and 4 are the non-poor. Absent adverse shocks to their asset stock (e.g., due to permanently debilitating disease or injury, or theft or natural disaster that cause them to lose productive assets), they enjoy welfare and wealth accumulation that leaves them consistently above the poverty line.

Financial market failures are essential to the possibility of a poverty trap associated with low productivity stable strategies. If those with low asset stocks could borrow freely, they would do so in order to cross the thresholds and pursue Strategy 4, using the resulting productivity gains to repay the loan with interest. The absence of such moves provides prima facie evidence of the unavailability of financial contracts on terms sufficient to enable mobility. The same logic applies to those who suffer adverse asset shocks – e.g., disabling illness or injury, or loss of land, livestock or physical or financial capital – and haven't access to insurance contracts to recoup their losses. This financing constraint exists at all scales, from individuals and households unable to access credit because of insufficient collateral, to local governments unable to borrow on capital markets due to limited tax collection capacity, to national governments rationed out of global financial markets because of political risk or debt overhang. Hence the fractal nature of poverty traps.

This framework underscores the important distinction between income shocks – short-lived movements of or random draws around the transformation functions in Figure 2, as discussed in the previous section – and asset shocks, reflected in

movements along the x axis. Exogenous asset shocks – for example, valuable farm land or livestock washed away in floods, or cattle or cash stolen – immediately affect one's accumulation pattern. If the shock leaves one within the domain of accumulation of the ex ante strategy, the increased marginal value of assets induces fresh investment in accumulation toward the strategy's dynamic equilibrium. One gradually reconstitutes one's portfolio. But if the shock is severe enough to knock one down into the domain of a lower strategy, permanent change results, implying a new, lower dynamic equilibrium. Income shocks can affect asset stocks in so far as subsistence constraints force those suffering income shocks to decumulate assets endogenously as a coping strategy, moving them leftward along the x axis, potentially threatening their ability to continue their ex ante strategy. Hence the importance of safety nets to provide income transfers in response to income shocks. State-conditional transfers associated with safety nets can protect valuable productive assets, preventing endogenous asset decumulation off the equilibrium path depicted in Figure 3.

The importance of asset shocks to welfare dynamics underscores not only the centrality of vulnerability to the conceptualization of poverty but also the importance of different livelihood or development strategies to vulnerability. Some people, communities and nations systematically face greater objective exposure to adverse shocks. For example, IFRCRCS (2002) reports that more than 98 percent of the people affected by different types of environmental (e.g., droughts, earthquakes, floods, avalanches) and technological (e.g., industrial or transport accidents) disasters worldwide, 1992-2001, lived in low and medium human development nations. Airline crashes in the United States and heat wave fatalities in France may capture the headlines, but the overwhelming majority of shocks are experienced in the developing world. Beyond differences in objective risk exposure, identical biophysical or policy shocks can have markedly different dynamic welfare effects across strategies. For example, drought may devastate sedentarized agropastoralists but have little effect on migratory herders within the same rangeland communities (Smith et al. 2001). The end of state controls on commodity marketing and pricing may benefit producers in communities with good market access and have no effect on remote communities engaged in semi-subsistence production. In general, the emerging literature on vulnerability emphasizes cross-sectional differences in the ways in which nations, regions, communities and individuals respond to adverse shocks (Christiaensen and

Boisvert 1999, Pritchett et al. 2000, Christiansen and Subbarao, 2001, Chaudhuri 2001, Chaudhuri et al. 2002, Ligon and Schechter 2002). Within the fractal poverty traps formulation, these differences appear to correspond closely to pursuit of strategies with higher-level equilibria, with units following superior strategies proving more likely to maintain valuable productive assets in the face of asset or income shocks, and, even if they have to change strategies, they are less likely to fall beyond the poverty line.

Distinct classes, identifiable by the different strategies they pursue and the range of productivity levels they experience, thus emerge naturally from threshold effects created by the fixed or switching costs inherent to superior strategies and limited access to credit or insurance among the poor. Past disadvantage and adverse shocks can persist, even after the original source(s) of shock or disadvantage (e.g., ethnic or racial discrimination, political patronage) have passed. Conversely, positive asset shocks due to transfers or windfall gains or transitory policy interventions that increase the returns or reduce the entry costs to higher return strategies, even if only temporarily, can have permanent effects. Hence the value of initial (but short-lived) subsidies to new technology adoption or to the creation of new organizations to address collective action problems, of educational loans and land reform, of safety nets to prevent asset decumulation in response to income shocks, etc.

Short-term interventions will be successful, however, only if they affect the transformation functions, and thus the accumulation trajectories, of populations trapped in low productivity stable strategies. General economic growth stimulus will tend to leave the chronically poor behind unless particular efforts are made to facilitate their transition to more remunerative livelihood strategies. The challenge of reducing chronic poverty revolves around finding ways to remove or transcend the thresholds and financial constraints that limit accumulation and access to remunerative strategies.

3. The fractal nature of poverty traps

This informal theory of poverty traps applies to any social or spatial unit that controls productive assets, uses them to generate outputs of value, and accumulates or decumulates them over time in response to shocks and shifting returns to asset building. Most macroeconomists take the nation state as the unit of analysis and

attempt to explain the large persistent differences observed in economic growth and welfare across countries. The data presented in Figure 1 and the broader empirical literature on chronic poverty demonstrate the relevance of the concept at the household scale as well. The limited available empirical evidence also suggests persistent differences in poverty between types of individuals within households, between families in communities, between communities in regions, and between regions in countries.

We thus propose that poverty traps can best be conceived as multi-scalar, interlinked across scales of aggregation, and fractal. They are multi-scalar in that significant and persistent differences in poverty appear at multiple scales from individual to national and beyond. They are interlinked across scales in that phenomena at one scale have important spillover effects on higher and, especially, lower scales. For example, low farm-level productivity in cultivation technologies may have community-scale origins in coordination failures due to social cleavages that result, for example, in failures to coordinate weed, water or pest control, or they may be rooted in the failure of national-scale agricultural research systems to develop and adapt new technologies or regional markets for distribution of mineral fertilizer, improved seed or other key variable inputs. Poverty traps are ultimately fractal in that the underlying patterns of thresholds, bounded patterns of accumulation and decumulation, and multiple dynamic equilibria are reproduced at all scales in strikingly similar patterns.

Variation in outcomes and poverty dynamics *within* units at collective scales – from household up through multinational region – result primarily from (i) differences in initial asset holdings, which are often the product of past shocks, (ii) inter-unit differences in available production technologies, market prices and participation costs, and exogenous conditions (e.g., rainfall) that cause transformation functions to vary up and down across different units, (iii) the sunk costs to technology acquisition, market participation and institution building (e.g., financing costs) that move the transformation functions left and right for different units within the collective, and (iv) internal and external social organizational factors – e.g., likelihood of coordination, cooperation and conflict – that affect the transformation of endowments into products and the efficiency with which savings from one period can be translated into greater productive assets in subsequent periods.

Variation in outcomes *between* collective units commonly arise from organizational and institutional characteristics that create inter-scale linkages. For example, communities within which households cooperate actively in the resolution of various coordination and externality problems tend to suffer less poverty and enjoy greater economic mobility as compared to communities plagued by ongoing collective action problems. Nations subject to internal civil strife suffer higher poverty and lower growth than those that maintain political stability. Regions in which firms work out effective vertical contracting arrangements tend to enjoy stronger employment growth and technological change than those in which volatile spot markets continue to mediate most transactions (Porter 1990, Fujitsa et al .1999). Districts with good informational and marketing linkages to metropolitan centers – where through infrastructure or through social linkages such as those due to ethnic trader networks – commonly acquire new production and processing technologies sooner and grow faster than regions with poorer physical and social connections to other units.

The remainder of this section therefore illustrates the applicability of the fractal poverty traps concept to macro, meso and micro scales of analysis. One could structure this discussion from micro-to-macro, aggregating and endogenizing phenomena as the discussion proceeds. We opt, however, to reverse the order, working from macro scale poverty traps down to the micro scale, steadily peeling away layers of between-units variation in poverty to focus on within-units variation as we work from the macro scale of nation states and multinational regions, through the meso scale of subnational jurisdictions, cultural and geographic communities, down to the micro scale of households and individuals.

a. Macro scale

At a certain level, the very existence of development studies as an area of research reflects the fractal nature of poverty traps at macro scale. Whole regions of the globe – Sub-Saharan Africa, South Asia, Southeast Asia, Latin America and the Caribbean, North Africa, Central Asia, and Central and Eastern Europe – have been mired in widespread, acute poverty for prolonged periods of time. The idea of macro scale poverty traps is perhaps most baldly reflected in the regional dummy variable phenomena common to much of the empirical growth literature in economics, wherein a dummy variable for "Africa", "Latin America" or other such broad populations is included and commonly found to be associated with statistically

significantly negative effects on economic performance (Barro and Sala-i-Martin 1995, Collier and Gunning 1999).

A variety of explanations exist for broad geographic clustering of poverty in the world at the scale of nation states and groups of countries, turning largely on exogenous conditions. Many of the classical development theories fit the fractal poverty traps model exceedingly well, as they arise from positive technological spillovers due to internal or external economies of scale. For example, Rosenstein-Rodan's (1943) theory of the "big push" emphasized the need for coordinated investment and expansion between industries in order to reach the critical minimum efficient scale of production necessary to emerge and sustain their growth. Nurkse (1952) and Myrdal (1957) developed this further in their discussions of "circular causation" among industries. They recognized the existence of positive pecuniary externalities associated with industrialization such that one industry's growth depended on the existence of a market for its products, a market most likely to develop in cities among the labor force of other industries. This creates fundamental interdependence among industries due to inherent coordination problems. Failure to coordinate, these authors cautioned, would lead economies into a "low-level equilibrium trap." Even Hirschman's (1958) focus on backward (and to a lesser extent, forward) linkages between industries, although cast in contrast to Nurkse as an argument for "unbalanced" growth, likewise rested on the idea that investments in sectors with the strongest linkages would endogenously generate broad-based growth propagated through those linkages. These "high development" theories emphasized strategic complementarity among sectors due to coordination effects and inherent nonconvexities due to positive externalities and increasing returns to scale technologies.[16]

Some more contemporary explanations of macro scale poverty traps turn on the biophysical characteristics of regions, especially how humidity and temperature affect agriculture and health and how distance to ocean ports and the mass of global economic activity affect trade (Sachs and Warner 1995, 1997, Gallup and Sachs 1998, Bloom and Sachs 1998). Other explanations turn on history-dependent social phenomena, whether the ethnic divisions that permeate countries and regions (Easterly and Levine 1997, Collier and Gunning 1999), histories of political violence

[16] For a modern, formal development of the classical models, see Murphy et al. (1989).

(Barro 1990, Easterly and Levine 1997, Collier and Gunning 1999), the complex effects of subjugation by different colonial powers on internal and external organization (Acemoglu et al. 2001, 2002), the historical accidents of urbanization (Fujita et al. 1999), or wealthy country policies that distort global market prices, such as European Union and United States beef, cotton and sugar producer subsidies that substantially lower the terms of trade African and Caribbean exporters earn from these products.

Each of these explanations fits the theoretical framework developed in the preceding section. All involve exogenous factors that affect asset accumulation and the development strategies chosen by governments. Some explanations turn on lower returns to specific strategies (e.g., agriculture or manual labor in hot and diseased settings) in particular world regions as compared to others, effectively shifting down the transformation curves in Figure 2, as well as their associated accumulation paths in Figure 3, potentially generating poverty traps. Other effects add to nations' or regions' fixed costs of accessing state-of-the-art technologies or high value-added markets, shifting higher strategies' transformation curves rightward and again potentially leading lower level strategies to become stable rather than transition strategies.

b. Meso scale

A rapidly growing body of literature points to the existence of poverty traps at scales that are intermediate between household and nation. Many studies have found evidence of significant and sustained income disparities between regions and administrative areas within countries, between villages within larger administrative areas or regions, and between population cohorts that cut across geographic units. In this paper we group all of those phenomena under the heading of meso scale poverty traps.

Economic geographers have long noted the existence of geographic pockets where poverty is particularly deep and persistent. Areas noted in the economics literature include the north and west of China (Jalan and Ravallion 2002), northern Uganda (Okidi and Mugambe, 2002), the "poverty square" in the east and central region of India, northeast Thailand, isolated areas of the Himalayas (Bird et al., 2003; Prakash, 1997), and more remote areas of Madagascar (Stifel et al. 2003). Advances in the collection and analysis of spatial economic data has increased the possibility of

using objective and measurable criteria to target development assistance to particular areas of acute need. Poverty mapping studies have recently been completed or are underway across the developing world under the World Bank's leadership.[17]

A parallel body of research has emerged around efforts to establish the determinants of spatial inequality within nations.[18] That research suggests that poverty is particularly prevalent and persistent in "less favored lands" that are far removed from market and political centers, experience persistent conflicts, and attract low levels of government investment and services. The core of this argument is that these areas have been less favored by both nature, in the form of lower and more erratic rainfall and poorer soils, and people, through infrastructural and institutional deficiencies and high levels of market price volatility and political disturbance. Poor communications and transport infrastructure so inflate the costs of market participation that households rationally opt out of commercial agriculture and settle for low-return semi-subsistence production with few improved, purchased inputs (Omamo 1998a, 1998b). Spatial patterns of grain storage lead to greater intra-annual price variability in rural areas, with adverse welfare consequences for the rural poor, especially those who are seasonal net food buyers (Barrett 1996). National policies routinely impose costs on poorer regions for the benefit of other, richer regions, such as quarantine-based methods of animal disease control in Kenya (Barrett et al. 2003), taxation and general public services provision (Bates 1993), and agricultural pricing and distribution policies (Lipton 1977). Fafchamps and Moser (2002), studying commune scale data from Madagascar, find that more remote rural communities systematically suffer higher rates of violent crime and property crime per capita, all else equal, because governments largely ignore rural areas, leading to a certain level of lawlessness and underprovision of police protection services relative to need. Smith et al. (2001) find that inter-district differences in agroecological conditions, physical and social services endowment and recent experience of health (especially HIV-AIDS) shocks have considerable power in explaining differences in the patterns of livelihoods pursued and the welfare trajectories of peoples in rural Uganda.

[17] See Elbers et al. (2001 and 2002) for an explanation of the small area estimation technique that underpins contemporary poverty mapping.

[18] See especially the papers presented at a series of conferences organized by Ravi Kanbur, Tony Venables and various collaborators under the auspices of the United Nations University's World Institute for Development Economics Research (WIDER) Project on Spatial Disparities in Human Development (http://people.cornell.edu/pages/sk145/links.htm or http://www.wider.unu.edu/research/).

A smaller number of studies have focused on the magnitude and determinants of differences in poverty between communities within particular geographic areas. Krishna (2002) has studied differences in welfare between villages in the Indian state of Rajastan and found internal social cohesion and the strength of linkages to external sources of power and finance to be the most important determinants of village development performance. Dercon (2002) used panel household data from Ethiopia to assess the determinants of inter-village differences in the dynamics of poverty, finding that inter-village differences were related to initial differences in key assets: the size of land holdings, educational achievement, and road infrastructure. In an analysis of household data from 808 non-pastoralist communities in Kenya that were surveyed in 1994 and again in 1997, Christiaensen and Subbarao (2001) found income diversification, market access, adult literacy, and access to electricity reduced vulnerability, while the incidence of malaria increased vulnerability.

Some sub-populations that stretch across geographic areas also experience significantly higher levels of poverty than the general population. This includes ethnic minorities such as the African American population in the United States or indigenous upland ethnic groups in southeast Asia. Bias against the hill tribes of Thailand is strong and formalized; many millions of people aredenied citizenship and officials hold them responsible for many of the country's problems. Levels of welfare and economic development are much lower than for lowland Thai living nearby. Such differences may stem from systematic biases in the provision of public services, lower access to labour markets, and / or insecure property rights. Such market failures and social rigidities may induce adaptations of local organizations that help in some respect, but also create other problems (Hoff et al. 1993). For example, social networks that provide for mutual insurance in the absence of effective financial markets can create obstacles to the adoption of new technologies (Hogset 2002, Moser and Barrett 2002), to expanding employment in small businesses (Fafchamps and Minten 2002), and to investment in business enterprises (Platteau 2000). Social networks and group identity have multiple effects, some of which can foster asset accumulation and welfare improvements, others of which retard economic advance in poor communities, leading to precisely the sort of multiple equilibria that underpin poverty traps (Durlauf 2001, Barrett 2002a, 2003b).

The theory of fractal poverty traps fits these meso-scale patterns well. At the meso-scale, the relevant assets tend to be those held by collectives or public sector

institutions. Groups that can cooperate and coordinate effectively between units are better able to produce public goods (e.g., roads, water management infrastructure, schools, health clinics) and services (e.g., security, reliable communications, sanitation) that crowd in private investment, leading to higher tax revenues and ultimately higher level equilibria. High rates of public investment typically accompany high private investment, and low public with low private, in cycles of mutual causation. Evidence of this mutual causation between public and private investment is provided, for example, by Escobal et al. (2000) for the case of Peru.

At meso scales of analysis, coordination, cooperation and conflict are especially important determinants of asset accumulation, the transformation of assets into goods and services of value, and distribution of those goods and services among units within the aggregate. Thus the institutional arrangements that shape interactions among units and between scales weigh especially heavily in establishing the equilibrium into which an economy settles. In game theoretic terms, a coordination problem exists when the returns to an activity increase as others undertake the same activity, with multiple equilibria emerging naturally. A low-level equilibrium might involve, for example, disrespect for individual property rights, which may be individually optimal behavior conditional on everyone else not honoring property rights, but collectively irrational in that everyone could be made better off if property rights were made secure and honored costlessly by all parties. Similarly, cooperative equilibria lead to high-level equilibria, while noncooperative equilibria tend to lead to lower-level equilibria (e.g., cooperative equilibria are Pareto efficient while noncooperative ones are not).

Institutional arrangements that foster greater cooperation within aggregates of individuals, like those that promote communication and coordination, thereby tend to lead to dynamic equilibria that are less likely to be associated with a poverty trap. Institutional arrangements that coordinate behavior within and between scales are also directly associated with another key dimension of poverty, the ability of individuals or groups to exert influence over phenomena that directly or indirectly affect their lives – in other words, the degree of voicelessness they suffer. The performance of meso-scale institutions may be judged on the basis of their responsiveness to the needs of all of their members, their ability to mobilize resources from internal and external (sometimes higher scale) sources, and the efficiency with which they transform assets into goods and services of value to their members.

The accumulation of physical assets can occur in any of at least four ways. First, individuals and households in an area may mobilize resources, through voluntary contributions or taxes, to obtain additional assets for use by a public agency. Consider, for example, a group that raises funds for the construction of a clinic in the local area. In that case, resources move from the micro to the meso scale. Second, a public agency can accumulate assets by reinvesting profits obtained from selling their services. For example, a clinic may levy a surcharge on its services to build up an investment account for expansion. Third, a public agency may be allocated funds from a local government that taxes citizens or economic activity in their area of jurisdiction.. For example, local governments may levy taxes on sales or property or sell concessions to forest resources (essentially converting one type of asset into another). In such cases, resources are mobilized from within the meso scale. Fourth, the public agency or organization may implement programmes on behalf of, or with support from more aggregate scales of government or from external sources such as development agencies or non-governmental organizations, establishing a macro-to-meso link. Regardless of the accumulation mechanism, however, non-linearities in coordination, transaction or agency costs may generate thresholds in asset accumulation. Shifting from one strategy to another may be associated with a shift in the mechanisms of asset accumulation.

Besides mobilizing investment in physical assets, meso-scale groups may also augment private returns by regulating the use of collective natural resources, such as forests, rangelands and waterways. The theories of open access and common property, which date back to Gordon (1954), stress the importance of meso-scale coordination of micro-scale decision making in order for resource use to be efficient. Both theoretical and empirical studies of natural resource management from around the developing world stress the tradeoffs between the effectiveness of the governance structures that make and enforce rules and the associated transaction costs (Ostrom 1990, Baland and Platteau 1996). One example of a threshold effect would arise from the sunk transaction costs of hiring forest guards to enforce rules on extraction of products from a community forestry. Communities that can afford to make the sunk investment in hiring and equipping guards can achieve a higher-level equilibrium based on effective rules enforcement than can otherwise identical communities unable to make such investments.

At meso scales, it is clear that asset thresholds have economic, collective action and political dimensions that are inter-related. Many public goods and services exhibit increasing returns to scale and scope at subnational level.[19] Equally, the demand for public services depends upon the structure and efficiency of markets for substitute services. For example, the lack of private insurance or credit markets increases people's willingness to participate in collective risk pooling and the potential benefits of public sector options for credit or risk buffering.

The political dimension of asset accumulation thresholds refers to the governance of meso scale government agencies and organizations. Since the 1980s there has been a strong trend toward decentralized provision of public services and devolved authority for natural resource management.[20] Governments in developing countries have implemented decentralization and devolution to various extents, so that countries such as Mali, Bolivia, Uganda and the Philippines now have fairly autonomous local governments that exercise significant responsibility for providing services to local residents. The performance of these local agencies is decidedly mixed. On the positive side, Dreze and Sen (1995 referenced in Prakash 1997) hypothesize that differences in the degree of decentralization of political power influenced variation in poverty prevalence in the Indian Himalayas. Himachel Pradesh had decentralization and high success in reducing infant mortality, while Utar Pradesh has been overly centralized and has failed to reduce infant mortality. On the other hand, reports from supposed success stories such as Uganda find local governments plagued by technical inefficiency and corruption. Bardhan (2002) argues that the relative performance of centralized versus decentralized administrative arrangements ultimately depends upon the extent to which they are captured by elites. Andersson (2002) shows that decentralization in Bolivia has been associated with

[19] Economies of scope relate to the variety of goods and services provided, while economies of scale relate to the volume of any single good or service provided. In both cases, per unit costs decrease over some range of output due to fixed costs of provision and complementarities in provision.

[20] The impetus for decentralization comes from several directions: external push, democratization, competition among government agencies, and internal financial crisis (Knox and Meinzen-Dick, 2001). Multilateral organizations and multinational NGOs have pushed for decentralization because of their perception that more local agencies are more accountable to local residents and less prone to corruption and capture by elites. At least three United Nations agencies – the World Bank, the UN Development Programme, and the UN Capital Development Fund – now have explicit programmes for supporting decentralization. Democratic changes have hastened decentralization in some countries, for example in the Philippines and Indonesia. However, Agrawal and Ostrom (2001) emphasize that decentralization is most often motivated by financial exigencies and competition among government agencies. Over-stretched central governments see decentralization as a face-saving way of conserving funds and local offices see it as a way of gaining power.

large variation in the way that municipal governments have implementation forestry laws, with variation caused by differences in values, incentives and degree of accountability.

Meso scale phenomena are not restricted to institutions of collective action. Of particular importance, markets are socially constructed institutions. Once one gets to aggregate scales of communities and regions, the terms on which individuals can buy or sell goods and services – terms that are effectively exogenous at the individual or household scale – begin to turn in part on how communities of households organize themselves. Producer organizations such as cooperatives and periodic markets organized by local jurisdictions, as well as local contracting conventions, physical security and road and marketing infrastructure maintenance all have a pronounced effect on market conditions. The Asian experience underscores the importance of the emergence of a rich set of agricultural producer organizations to facilitate bulk purchases of inputs and sales of outputs, access to extension services and political voice. Some organizations have been set up by government, some by private firms and some have emerged spontaneously from within communities. We understand relatively little about how efficacy varies with group origins, but we do know that some marketing organizations can prove extremely effective in achieving economies of scale or scope, in securing access to higher-return markets, and in stabilizing input and output prices faced by even small producers (World Bank 2003).

c. Micro scale

While the macroeconomic and meso scale evidence point to poverty traps, evidence at these aggregate scales fails to explain the extraordinary amount of poverty that exists within even relatively affluent communities. Jayne et al. (2003) present evidence from extensive household surveys in five African countries (Ethiopia, Kenya, Mozambique, Rwanda and Zambia) showing that income poverty among smallholder households is not primarily a geographic phenomenon. They argue that most variation in household incomes is attributable to within-village differences rather than between-village differences, emphasizing in particular the meagre land endowments of most of the rural poor in Africa.

The essence of dynamic poverty traps at micro scale is that households and individuals remain in chronic poverty because they are unable to self-finance

investments needed to generate high returns because of the lumpy nature of or the risk inherent to those investments and because they are unable to obtain external finance because of weak credit and insurance markets. This manifests itself in discrete strategies exhibiting markedly different welfare distributions, where the ex ante poor choose strategies offering less attractive stochastic returns than the ex ante rich choose, simply because the more attractive strategies lie beyond their means.

For example, Figure 4 (adapted from Barrett et al. 2001a) depicts the cumulative frequency distributions of total income among 1079 households in Rwanda, organized into four distinct livelihood strategies. The farm and farm worker (FFW) strategy includes households that only work as unskilled agricultural laborers or farm their own land. The full-time farmer (FTF) strategy represents households that farmed their own land and livestock and had no off-farm employment. The mixed strategy includes non-farm employment with farming and unskilled agricultural labor. Finally, the mixed-skilled only (MSO) strategy involves only farming or skilled non-farm labor for a salary or as an entrepreneur. As displayed in Figure 4, full time farming (FTF) and especially farm and farm worker (FFW) livelihood strategies are stochastically dominated by mixed strategies, especially those involving only skilled labor and farming (MSO). No one would choose the FFW strategy if they had access to the Mixed or MSO strategies. Barriers to entry into higher return strategies become evident by revealed preference.

Such welfare orderings among distinct strategies appear strongly related to barriers to entry that impede access to more remunerative livelihoods by those lacking the necessary financial, human or natural capital to undertake these activities (Dercon and Krishnan 1996, Ellis 2000, Barrett, Reardon and Webb 2001). In the Rwandan example, full-time farming is only an option for those endowed with enough land or livestock to absorb all the adult labor in the household. Skilled non-farm employment is only available to those with education, particular skills (e.g., blacksmiths, lorry drivers), or the necessary financial capital to start a business.

As a consequence, a growing mass of empirical evidence underscores the importance of initial asset holdings in determining households' income growth and the likelihood of exit from poverty. For example, Ravallion and Datt (2002) find that the elasticity of the poverty rate to non-farm output depended significantly on the initial percentage of landlessness among households in India. Barrett et al. (2001b) similarly found that among rice farming households in Côte d'Ivoire, households with

poor initial asset endowments were unable to access superior livelihood strategies that bestowed considerable income gains following the massive CFA franc exchange rate devaluation of January 1994. Those with poor endowments were less able to respond to attractive emerging on-farm and non-farm opportunities, while the ex ante rich reaped considerable gains from devaluation that was promoted as benefiting small farmers. Dercon (1998) likewise finds that initial assets condition Tanzanian agro-pastoralists' ability to accumulate wealth and move out of poverty. Simply put, initial conditions matter.

As suggested by the Rwandan example illustrated in Figure 4, those with little or no assets are far less likely to acquire scarce skills or capital necessary to enter into remunerative nonfarm activities that lead to higher income and consumption (Dercon and Krishnan 1996, Barrett, Reardon and Webb 2001). In Ethiopia, pastoralists whose livestock herds fall below a threshold of 12-15 head of cattle tend to become involuntarily sedentarized because of a minimum necessary scale for transhumant migration. As a consequence, multiple equilibria emerge, with traditional pastoralists able to sustain large, mobile herds while others languish with one or two animals, trapped in grim rangeland towns with few employment prospects (Lybbert et al. 2002). Patterns of fallow, commodity production and land holding dynamics in the Peruvian Amazon similarly depend heavily on ex ante land and labor endowments (Coomes and Burt 1997, Coomes et al. 2000).

Households caught on the wrong end of such traps often end up in a pattern of persistent poverty and steady degradation of the natural resource base on which they depend (Shepherd and Soule 1998, Coomes and Burt 1997, Coomes et al. 2000, Barrett et al., 2002b). Sufficient conditions for the existence of dynamic poverty traps at the household scale are that they have incomplete access to financial services (credit or insurance) along with (i) high return production or marketing strategies exhibit a minimum efficient scale of production that is beyond the means of the credit-constrained poor (Barrett and Blume 2003); or (ii) risk and subsistence constraints discourage long-term investment in high-return assets among poorer, more credit-constrained households (Zimmerman and Carter 2003).

The most extreme cases of micro scale poverty traps involve essentially irreversible human capital accumulation failures due to childhood undernutrition, illness and lack of education. Perhaps the most compelling models of poverty traps emerge at this micro scale, where undernutrition and morbidity early in life can lead

to permanent reductions in physical stature and health status associated with sharply increased risk of involuntary employment and lower incomes in adulthood (Dasgupta 1993, 1997, Strauss and Thomas 1998), and where household-scale financial constraints can cause underinvestment in the education of children – even those with manifestly high natural ability – thereby propagating poverty across generations (Loury 1981).

4. Implications for Finding Pathways Out of Chronic Poverty

We opened this paper by emphasizing the need for strategic focus and the imperative of igniting sustained growth among the poor if poverty reduction objectives, such as those reflected in the Millenium Development Goals, are to be achieved. The model of fractal poverty traps introduced and illustrated in the preceding sections highlights the multi-scalar nature of the problem and the centrality of threshold effects and coordination problems to chronic poverty as it appears at all scales of analysis. So what are the key implications of fractal poverty traps for policy and research? How can the fractal poverty traps concept provide an analytical foundation to make pathways out of poverty accessible to the 1.2 billion people presently suffering extreme poverty?

Five interrelated strategic emphases emerge directly from the fractal poverty traps formulation First, it is possible that short-term transfers to individuals, households, communities, and nations caught in low-level equilibria can enable them to approach and cross crucial thresholds presently inaccessible to them and thereby to alight on endogenously sustainable accumulation trajectories that can carry them out of chronic poverty. Threshold effects and poverty traps imply a potentially large role for transitory policy interventions to enable people to overcome constraints that keep them from reaching the nearest relevant threshold and subsequently embarking on an endogenous growth path to a higher equilibrium. In Asia, short-term state investment in rural roads, electrification, water, marketing systems for improved seeds and inorganic fertilizers, in institutions to support small industry and services, etc. ignited private investment. The possibility of "crowding in" investments reflects the possibility of higher level equilibrium. These policies do not have to be fiscally sustainable in the long-run since the crucial positive effects come in the short-term. Such interventions nonetheless do need explicit sunset provisions so as to ensure that they do not become permanent drains on scarce fiscal resources.

Second, governments and donors need to work for the creation and extension of transition strategies that are accessible to the chronically poor and that can lead to accumulation that will carry them past thresholds and into other strategies with still-better equilibria. In Kenya, for example, the most successful transition strategies at the micro scale are small-scale irrigation of vegetables or tree seedlings using small-scale water management technologies such as treadle pumps and water harvesting structures and smallholder tea produced under outgrower arrangements. In Madagascar, we have observed that low-cost initial promotion of off-season cultivation of barley or potatoes induces increased uptake of modern rice varieties, mineral fertilizer and improved cultivation practices, yielding sustainable increases in yields and small farmer welfare.

Third, public agencies need to assess the possibilities for eliminating or moving thresholds through interventions at aggregate scales that make previously inaccessible strategies feasible at more disaggregated scales, thereby inducing individual behavioural change by individuals, households or communities that leads to endogenous growth and exit from chronic poverty. Examples include investments in potable water and small-scale irrigation structures that reduce both time lost to illness and to drawing and transporting water as well as variability in crop yields, sustainable microfinance institutions that increase access to credit and insurance, producer groups that reduce unit costs for purchased inputs and increase unit revenues for product sales, and transport infrastructure improvements to reduce the costs of market participation.

Fourth, there is a critical need for effective safety nets set just above critical thresholds so as to prevent people from falling unexpectedly into chronic poverty. Especially where adverse asset shocks due to manmade or natural disasters are commonplace, safety nets to insure consumption and to prevent coping through asset decumulation can be valuable instruments for ensuring subsequent recovery with minimal need for further assistance. This can induce endogenous improvement in productivity and income growth as poor people choose asset portfolios and activity patterns with greater expected returns that also exhibit greater uninsured risk in the absence of safety nets.[21]

[21] The importance of safety nets also implies a need for researchers to identify reasonably precisely the thresholds that define poverty traps: which assets are crucial? And what are the critical levels that induce endogenous change in strategies? Vulnerability analysis needs to begin to move away from

Perhaps the most essential safety nets are those that protect human health and education, keeping children adequately nourished and in school regardless of what is happening to their family's income and insuring that adult workers enjoy sufficient, balanced nutrient intake to maintain physical productivity during temporary downturns in order that transitory shocks do not have permanent adverse consequences. Safety nets to prevent the non-poor from falling into poverty in response to uninsured shocks are a fundamental component of any sensible poverty reduction strategy. Otherwise, it is rather like draining the bathtub with the spigot still on. As soon as some leave the basin of poverty, others enter, thereby maintaining the overall level and at great cost.

Finally, fractal poverty traps carry important implications for decentralization. Following the principle of scale-sensitive subsidiarity, it typically makes sense to devolve authority over a resource or issue area to the lowest possible scale within which the associated externalities can be fully internalized and at which provision of the good or service can be done efficiently (i.e., realizing available economies of scale or scope). The scale-sensitivity criterion to the subsidiarity principle is too often lost in contemporary discussions of public services provision, resource conservation design, and related arenas in which the principle of subsidiarity is commonly invoked. The default position appears to have become decentralization, although this may not always be appropriate. Applied researchers and policymakers need to identify the scale(s) at which (i) market and coordination failures are most limiting and it appears feasible and cost-effective to provide temporary assistance to surmount thresholds, (ii) spillover effects that will shift thresholds at lower scales, indirectly igniting accumulation and opening up pathways out of poverty for some presently trapped. Toward that end, prioritization exercises must take place at multiple scales and there must be serious attempts to integrate these, not just cursory exercises as has too often been the case in recent PRSP processes (Swallow 2003).

Because many key factors behind persistent rural poverty – for example, water and health care availability, soil fertility degradation – are the result of a multi-scalar process involving policies at multiple scales of government and linkages among those scales, some povetry traps originate at multiple scales simultaneously. For example, soil fertility degradation – one of the most pressing problems confronting much of

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measures relative to arbitrary poverty lines and toward establishing which units face the greatest risk of falling below such thresholds.

rural east Africa – has its origins in individual and household scale phenomena associated with meager land holdings and liquidity constraints to the purchase of mineral fertilizer or livestock, in community scale phenomena associated with tenurial regimes that limit investment incentives and impede effective organization of producer marketing groups to improve smallholders' terms of trade, in regional scale thresholds associated with transport infrastructure and fertilizer distribution, and in national and multinational scale traps related to fertilizer production capacity and agricultural and natural resources management research. Overcoming soil fertility problems – or other limiting factors with multi-scalar etiology – requires some combination of public action (e.g., a revolving fund for fertilizer), collective action (e.g., multi-purpose commodity clubs that can tax on delivery), and private action (e.g., investment in fertilizers or integrated crop-livestock systems). This necessarily requires multi-scalar approaches to develop, adapt and apply improved transition strategies so as to facilitate asset accumulation and productivity growth among the chronically poor and thereby enable them to escape the fractal poverty traps that appear to ensnare so many today.

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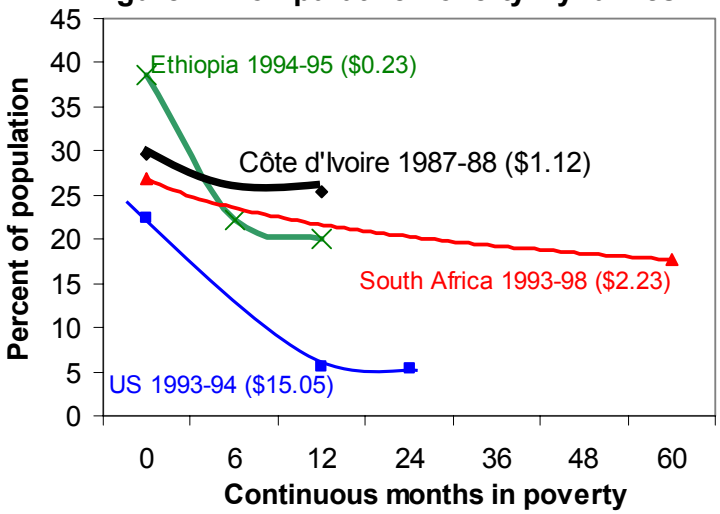
Figure 1: Comparative Poverty Dynamics



Sources: Côte d'Ivoire: Grootaert and Kanbur (1993), , Ethiopia: Dercon and Krishnan (2000), South Africa: Carter and May (1999), USA: Naifeh (1998)

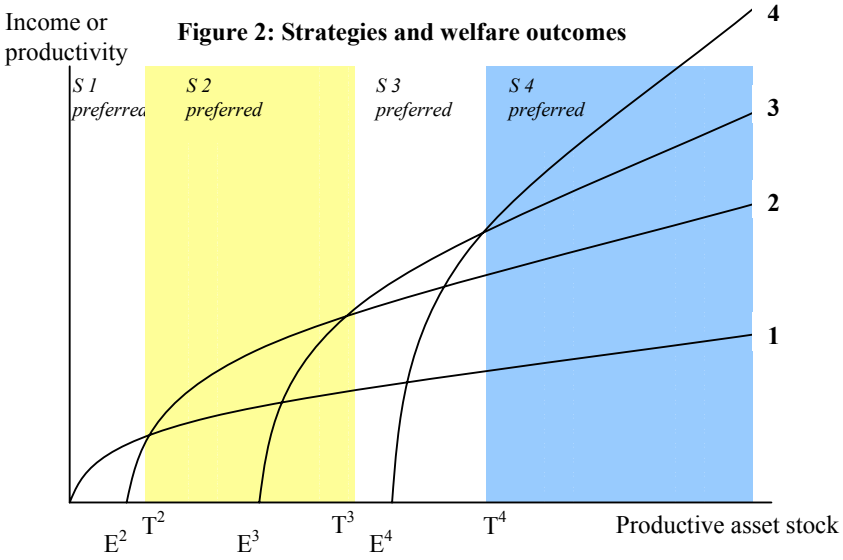

Income or productivity
Figure 2: Strategies and welfare outcomes
S 1 preferred
S 2 preferred
S 3 preferred
S 4 preferred
4
3
2
1
E2
T2
E3
T3
E4
T4
Productive asset stock

Figure 3: Asset dynamics and poverty traps

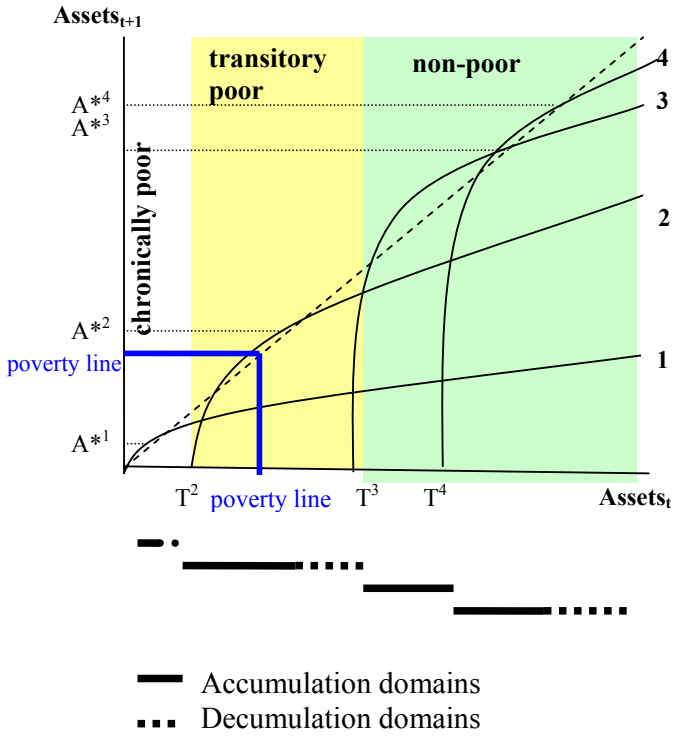
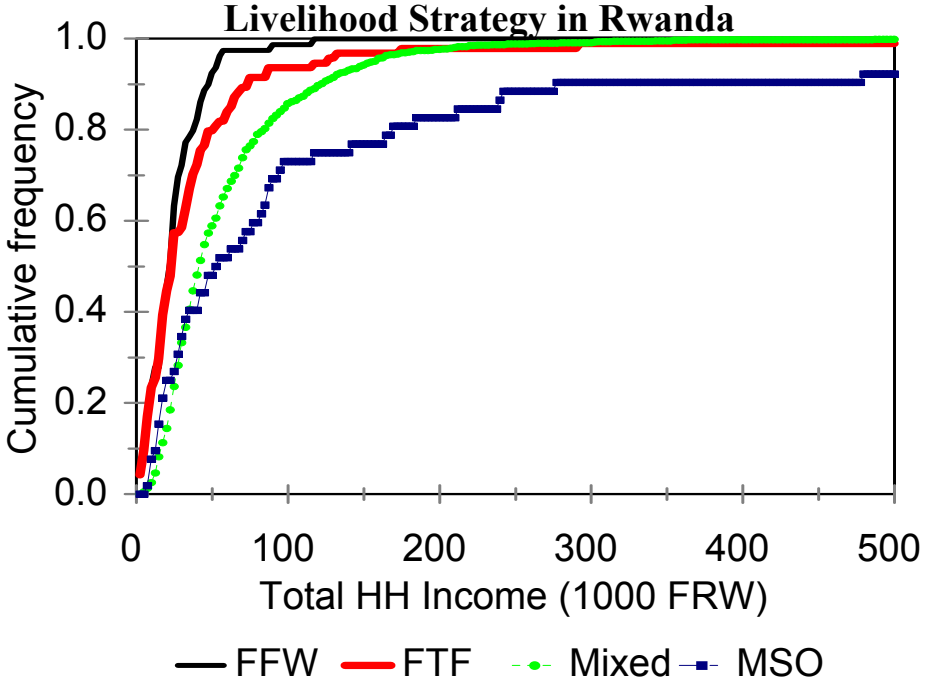


Figure 4: Income Orderings by Livelihood Strategy in Rwanda



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