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Welfare Dynamics in Rural Kenya and Madagascar

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<u>Abstract:</u> This paper presents comparative qualitative and quantitative evidence from longitudinal studies in rural Kenya and Madagascar in an attempt to untangle the causality behind persistent poverty. We explore whether household-level welfare dynamics appear consistent with underlying hypotheses of convergence, conditional convergence or poverty traps familiar from empirical macroeconomics. Our findings suggest that much period-on-period welfare change is stochastic and transitory. Long-term persistent poverty thus depends mainly on the stock and productivity of household assets. We find evidence of highly nonlinear asset dynamics consistent with locally increasing returns and risk management to preserve a minimal stock of productive assets rather than just to smooth consumption. On balance, the empirical evidence supports the hypotheses of poverty traps based on multiple dynamic equilibria and of conditional convergence consistent with the notion of geographic poverty traps, while the evidence fails to support the convergence hypothesis that underpinned the design of market-oriented reform programs without ancillary interventions to build and protect the assets and productivity of the poor.

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1. Introduction

All development policy is based implicitly on a conceptualization of why people are poor and what interventions, if any, are needed to facilitate or accelerate their climb out of poverty. But the poor are a heterogeneous lot. Some people are poor from birth, others fall into poverty temporarily and are soon able to climb back out, and still others suffer a serious setback of some sort and stay poor for a long time thereafter. Policymakers and practitioners concerned about poverty reduction need to be clear as to which subpopulation of the poor interests them because appropriate interventions may differ fundamentally according to the nature of the target subpopulation's poverty and the causes of that poverty.

As Barrett and Carter (2004) explain in detail, different theories of economic growth suggest very different policy interventions to assist the poor. We can usefully summarize the various growth theories prevalent in contemporary macroeconomics into three different hypotheses: convergence, conditional convergence and poverty traps. In this paper, we use longitudinal data from several different sites in rural Kenya and Madagascar and a range of empirical methods to explore which of these three hypotheses appears most consistent with observed welfare dynamics at the microeconomic level of households. In order for a theory of economic growth to be credible at macro-level, it ought also to be consistent with the micro-level evidence. Yet there is a striking dearth of micro-level empirical studies that aim to test among the hypotheses posed by competing theories of economic growth.[1] This paper aims to start filling that void.

Under the convergence hypothesis that has long been the workhorse of macroeconomic growth theory, the poor enjoy higher marginal returns to productive assets than do the rich, so capital naturally flows disproportionately to the poor, enabling them to catch up economically. This flows logically from the standard simplifying assumption that there are diminishing marginal returns to assets in production. In this framework, shocks are merely temporary

[1] Several recent studies use an explicit growth model to study household-level dynamics (Ravallion and Jalan 1996, Gunning et al. 2000, Elbers et al. 2002, Jalan and Ravallion 2002, 2004, Deininger and Okidi 2003, Dercon 2004). Yet none seeks to test among competing hypotheses of the underlying growth mechanism. Most simply impose a variant of the classic Solow model.

setbacks and everyone enjoys the same latent opportunities. The key policy implication of the convergence hypothesis is to let markets allocate resources according to relative scarcity, i.e., to "get prices right," as the 1980s' liberalization mantra held.

Two decades after market-oriented reforms began to sweep sub-Saharan Africa, however, poverty rates have increased and the sense has spread throughout the policy, practitioner and research communities that getting macroeconomic and sectoral policies "right" does not suffice to stimulate broad-based growth and poverty reduction. There often seem to be structural obstacles that keep particular subpopulations from realizing economic opportunities, perhaps due to geographic factors such as climate, soils, disease incidence and distance to ports and markets that may cause lower productivity, sociocultural characteristics such as gender, religion or ethnicity that may underpin social exclusion, or some combination of these. When such constraints operate at meso-level, a "conditional" or "club" convergence hypothesis may apply, wherein individuals within identifiable groups each converge to group-specific standard of living, with variation across groups in those equilibria. Geographic or spatial poverty traps represent a specific kind of conditional convergence wherein some groups defined by physical location exhibit a dynamic equilibrium standard of living that falls below the poverty line. The practical policy implication of the conditional convergence hypothesis is that members of disadvantaged groups, those who converge to a low level of well-being, need targeted assistance to stimulate productivity growth. Asset accumulation and recovery from shocks occur naturally under conditional convergence. Even among the poorest, accumulation and recovery occur, albeit only to low levels. This hypothesis has long underpinned strategies based on technology improvements, marketing innovations and targeted interventions to train women and ethnic minorities.

Like the conditional convergence hypothesis, the poverty traps hypothesis holds that there exist multiple welfare equilibria in an economy, with some people clustering around low-level states. But unlike the conditional convergence hypothesis, which assumes individual households face a unique equilibrium specific to the group to which they belong, the poverty traps hypothesis posits that individual well-being depends fundamentally on initial conditions, that there exist multiple dynamic welfare equilibria accessible to each individual irrespective of group status. Two otherwise identical neighbors may have radically different experiences as one starts off with sufficient land, livestock and human capital to generate regular surpluses, save and invest, while the other lacks the minimum initial stocks necessary to accumulate wealth over time, or as one falls ill, loses livestock to disease or theft, or suffers some other shock that their otherwise-identical neighbor avoids. Under the poverty traps hypothesis, there exists a positive correlation – locally, albeit not necessarily globally – between wealth and rates of return on assets. This positive correlation is generated by (locally) increasing marginal returns to assets, meaning less wealthy people receive a lower marginal return on their assets than wealthier households, in direct contrast to the standard simplifying assumption of globally diminishing returns that generates the convergence hypothesis. Regions of locally increasing returns to assets can only exist in the presence of some mechanism that excludes some people with low initial conditions from accessing more remunerative livelihoods. Typically, exclusion occurs through restricted access to (formal or informal) credit or insurance necessary to build assets through investment and to protect them against loss or through socially exclusionary processes that limit certain groups' or individuals' access to preferred employment, credit or land.

The policy implications of the poverty trap hypothesis therefore differ markedly from those associated with convergence or conditional convergence. In the presence of poverty traps, asset transfers and protection against shocks to productive asset holdings may matter as much as or more than exogenous improvements in productivity or preferential treatment of historically disadvantaged groups due to the endogenous productivity growth that may result from changes in asset holdings. Furthermore, the poverty traps hypothesis suggests high returns to breaking down the social or commercial barriers that exclude some poor people from attractive investments and livelihoods.

The observation of persistent poverty is consistent with any of these three hypotheses. Slow but steady growth can leave people poor for long periods of time as they move toward a non-poor equilibrium under the convergence hypothesis, while poverty can be a long-term equilibrium under the conditional convergence and poverty traps hypotheses. Furthermore, the poverty traps and conditional convergence hypotheses are potentially complementary. There can be distinct growth patterns for different groups, with multiple equilibria within at least some groups' growth patterns such that group identity and initial conditions both matter. The primary objective of this study is to distinguish between these theories by considering empirical evidence on the nature of poverty dynamics, asset dynamics and the marginal returns to productive assets across settings distinguished by different agroecological and market access conditions.

The contest between the convergence hypothesis, conditional or club convergence and poverty traps has attracted much attention among macroeconomic researchers in recent years. Our approach differs from those macroeconomic studies in that we take the household, rather than the nation state, as the unit of analysis. This is an important step, given considerable variation in standards of living across households within any nation. Moreover, empirical studies relying on cross-sectional or macroeconomic data leave many analysts and development practitioners with the uncomfortable sense that unobserved heterogeneity, aggregation or both may bias reported results. Few micro-level studies have addressed the fundamental question as to whether economic growth processes at the micro-level of individual households are best described by unconditional convergence, conditional convergence or the poverty traps hypothesis. This paper aims to contribute new micro-level evidence to enrich the debate surrounding the nature of economic growth and poverty dynamics.

The remainder of the paper proceeds as follows. Section 2 provides a brief background on Kenya and Madagascar, then describes the data we use and the settings from whence they were collected in rural Kenya and Madagascar. The sampling strategy was designed to generate informative variation in agroecological and market access conditions so as to get at one form of the conditional convergence hypothesis: the possibility of geographic poverty traps. Section 3 then presents evidence on economic mobility and poverty dynamics in our survey villages based on a variety of different qualitative and quantitative data and methods. Section 4 explores the question of whether the observed patterns indeed seem consistent with the claim that conditional convergence and/or poverty traps exist and, if so why. Section 5 then draws out the policy implications of these findings.

2. The Settings and the Data

A) Poor Countries With Liberalized Markets

Kenya and Madagascar are both poor, rural African nations that underwent relatively dramatic market-oriented reforms beginning in the latter half of the 1980s. They had followed nearly-opposite post-independence trajectories for the 20-25 years prior to the onset of economic liberalization. Kenya had long been the most considered the most vibrant economy in east Africa, a former British colony that was home to the largest urban market (Nairobi) between Cairo and South Africa and to a wide range of modern agricultural and industrial producers who took advantage of the country's climate, soils and physical and social infrastructure that were well above sub-Saharan African norms. Madagascar, on the other hand, was a former French colony that became a Marxist dictatorship with a state-controlled, inward-looking economy modeled on the Democratic People's Republic of Korea and scant infrastructure outside of the capital city, Antananarivo.

The differences between the two countries mask, however, important similarities. Both countries encompass remarkable variation in agroecological conditions, from desert to humid rainforests to rugged highlands, from whence the ruling elites of both countries have hailed. Natural disasters – drought, floods and cyclones – ravage parts of both countries regularly and disease is widespread, confronting poor populations with considerable risk. Moreover, in spite of the stark differences in their early post-independence histories, both countries suffered serious balance of payments, external debt and fiscal deficit problems in the 1980s that necessitated reforms under the aegis of structural adjustment programs underwritten by the International Monetary Fund and the World Bank. In spite of 10-20 years of sometimes-halting reforms, the consensus among domestic and foreign observers is that getting the macro economy "right" has failed to stimulate broadly based, sustainable economic growth. Poverty has increased in both countries over the past decade. The variation in their histories and their shared recent experience of market-oriented policy reforms that appear not to have made an appreciable dent in poverty make Kenya and Madagascar as a pair a reasonable microcosm for much of sub-Saharan Africa.

B) Data Description

The data we use were collected through the "Rural Markets, Natural Capital and Dynamic Poverty Traps in East Africa" project of the USAID BASIS CRSP.[2] We opportunistically constructed household-level panel data sets in five different sites in rural Kenya and Madagascar, building on previous surveys conducted by our team. In order to control for the possibility of exogenous variation in welfare status and dynamics due to agricultural potential, access to commercial markets, or both, sites were selected to cover each cell of a matrix reflecting better or worse market access on one axis and a better/wetter or worse/drier agroecology on the other. Between-sites variation in observed welfare dynamics thus helps us address the conditional

[2] For more information, see the project web site at http://afsnrm.aem.cornell.edu/basis/ or the BASIS CRSP web site at http://www.basis.wisc.edu/ .

convergence hypothesis, especially the possibility of geographic poverty traps. Meanwhile, the within-site variation according to endogenous household attributes such as wealth enables us to explore the possibility of poverty traps associated with multiple equilibria at household level.

Our highest potential sites enjoy sufficient water to sustain sedentarized livestock and high-value horticulture and tree crops year-round and good enough access to markets to be able to engage in high frequency (daily or semi-weekly) commercial transactions. We have one such site in the central highlands of Madagascar: the Vakinankaratra region around Antsirabe and Betafo, about three hours' drive from Antananarivo on a macadam highway (Figure 1). There we resurveyed 94 households previously surveyed in 1997.

Our sites with greater agroecological potential but limited market access likewise have adequate rainfall to sustain multiple crops over the course of the year, but while access to secondary cities is adequate, it is a day or more's drive to the nation's principal commercial markets. In western Kenya, we resurveyed 89 households in Madzuu location in Vihiga District that had originally been surveyed in 1989. The "wetter-worse" site in Madagascar is in the southern highlands, in Fianarantsoa province, where we resurveyed 58 households previously visited in 1997.

We had no Malagasy sites with poor agroecological potential for which we also had suitable baseline data on which to construct a panel. So our "drier" sites are all in northern Kenya. In lower Baringo District, a semi-arid region that nonetheless enjoys reasonable water access through Lake Baringo and the Pekerra River and the national irrigation scheme along the River before it empties into the Lake, we surveyed 30 households on a quarterly basis from March 2000 through June 2002, in Ng'ambo location. This site is less than two hours by all-season road from the secondary city of Nakuru and only half a day's drive from Nairobi. Our most remote, semi-arid site is Dirib Gombo, eight kilometers from Marsabit town in the eponymous dryland Marsabit District of northern Kenya, 540 kilometers from Nairobi, roughly half of that distance without a macadam road. The sample size and survey instruments and frequency were identical in Ng'ambo and Dirib Gombo, as they were part of a broader survey of six sites in northern Kenya (and five in southern Ethiopia) begun by the Pastoral Risk Management (PARIMA) project of the USAID Global Livestock CRSP. Agro-pastoralism predominates in both Ng'ambo and Dirib Gombo, with extensive grazing combined with rainfed crop cultivation (and limited irrigated agriculture in Ng'ambo) and some nonagricultural activities, especially for Ng'ambo with its superior market access.

Each site's baseline survey was designed for a different purpose and thus the data are imperfectly comparable across sites, although we took great care to ensure consistency across survey periods within each site. The Ng'ambo and Dirib Gombo sites are the only ones for which we have many periods' observations, so they are the only ones for which we can study high-frequency intertemporal variation. Because of these inconsistencies across data sets, the comparisons made in sections 3 and 4 are necessarily partial between sites. We use income data for comparative quantitative analysis because good expenditure data are not available for all five sites.[3] But we intentionally use multiple quantitative and qualitative methods as a check on robustness, as a way to tailor the measure to the question at hand, and to play to what we perceive as the relative strengths of different data sets.

The resurveying interval varies markedly across sites as well. As we discuss in the next section, this variation, from the high frequency, short 2000-2002 panel in northern Kenya, through the intermediate five year panels in Madagascar to the low frequency, 1989-2002 panel in western Kenya, enables a suggestive look at how time affects economic mobility and inference about the persistence of poverty. Each site's panel suffered attrition as households that were in an early round disappeared, were unwilling to be surveyed again or otherwise fell out of the sample by the later round(s). Such attrition could be systematically related to variables of interest, for example if poorer households were more likely to perish or migrate from a community. We therefore attempted to control for prospective attrition econometrically in each site's data, but could not establish any robust statistical pattern, suggesting that concerns about attrition bias do not seem serious in these data.[4]

Our meta-data set of 484 households also spans the full range of rural poverty rates in the two countries. The Vakinankaratra site lies in the highest potential region and has one of the lowest poverty rates in Madagascar. In contrast, the Dirib Gombo and Fianarantsoa sites are

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[3] It is important to note that different metrics – expenditure, income, anthropometric status, etc. – can yield different measures of chronic and transitory poverty. See Place et al. (2003) for a demonstration of this point using data from western Kenya.

[4] We used probit and logit models to estimate the probability of attrition from the survey conditional on households' initial characteristics. For a range of different explanatory variables, we could never come up with a regression specification that yielded a p-value of less than 0.09 on the test of the null hypothesis that the full set of regressors are uncorrelated with sample attrition. Alderman et al. (2001) and Falaris (2003) similarly found that attrition bias is not a serious concern in other developing country panel data sets.

located in resource scarce areas of the two countries, and have headcount poverty rates well above 80 percent. (Kenya Ministry of Planning 1998, Minten and Zeller 2000). The intermediate potential sites in Baringo and Vihiga Districts lie between these extremes. Consistent with the conditional convergence hypothesis, one might expect that poverty rates would decrease and rates of exit from (entry into) poverty would increase (decrease) as one moves from either drier to wetter agroecological zones or from poorer to better market access, signaling that physical geography matters to economic growth and mobility.

Finally, we followed up the panel survey data collection with qualitative poverty appraisals in each site. This involved both community-level focus group meetings and key informant interviews to establish local conceptualizations of poverty and community-level phenomena that have affected the observed trajectories of most households. We followed up these group meetings with in-depth case studies of selected households so as to construct social-historical profiles of distinct household types characterized by observed welfare transitions. We constructed household-level per capita income transition matrices – discussed in the next section – for each site in order to establish which households had been poor in each survey period, which had exited poverty from one round to the next, which had fallen into poverty between survey rounds, and which had consistently stayed non-poor. We then further broke down the subsamples in each site who remained poor in both periods and those who were nonpoor in both periods according to the direction of change in their income between periods: those with significant per capita income losses between periods, no significant change, and those who enjoyed significant per capita income gains from one survey round to the next. We did intensive household level oral histories for two sample households from each site in each of those eight transition matrix groups. In those interviews – and subsequent closing community meetings – we focused especially on understanding the historical context underpinning local households' strategies to improve their welfare and the pathways by which certain households collapse into or escape from poverty.

3. Income Mobility and Poverty Dynamics in Rural Kenya and Madagascar

We begin the empirical analysis by offering simple descriptions of intertemporal income mobility and poverty transitions by site. As we proceed through this section, we begin to move into (implicitly) asset-based measures before focusing more heavily on assets in section 4. In both sections we complement the quantitative analysis of survey data with qualitative analysis based on the participatory poverty analysis done in a subsample of the survey households.

A) Income Transitions and Poverty Exit Rates

Per capita income transition matrices offer perhaps the simplest way of depicting economic mobility, in that they summarize intertemporal movement relative to an income poverty line. In order to be able to compare households across periods and countries, we established a common poverty line. We opted for an ultra-poverty line of US$0.50 per capita per day in real 2002 US dollars, half the extreme poverty line of US$1.00/day per capita commonly used in international comparisons. This ultra-poverty line is reasonably close to (and roughly equidistant from) the relevant official poverty lines. Kenya's rural poverty line of KSh1,238/month per capita is equivalent to about US$0.53/day, while the official Malagasy poverty line of FMG988,600 equals about US$0.43/day per person.[5] We converted each period's local currency observations into U.S. dollars using the period-specific exchange rate and, lacking proper deflator series for these rural communities, used the U.S. GDP deflator to convert all nominal figures into real terms under the maintained hypothesis of constant real exchange rates. Table 1 presents the resulting real daily per capita income transition matrix.[6]

The sample proportions that were poor in each survey period are greatest in the "drier-worse" site of Dirib Gombo (northern Kenya), where every household's per capita daily income fell below $0.50 in each period, and least in the "wetter-better" site of Vakinankaratra (Madagascar's central highlands), where only 58.5 percent fell below the ultra-poverty line in each survey period. The population shares that were poor in both the initial and subsequent period also decrease as one moves in either the direction of better agroecology or better market access. Similarly, the population share that was non-poor in both the initial and subsequent survey periods increases as one improves agroecological conditions, market access, or both. Overall, more than 70 percent of our aggregate sample fell below the $0.50 daily per capita income ultra-poverty line in each survey period, and less than one-quarter crossed the poverty line between survey rounds, with overall ultra-poverty remarkably stable at 82 percent since 11.3

[5] Prevailing exchange rates in 2002-3 are roughly 75 Kenya shillings and 6200 Malagasy francs per U.S. dollar.
[6] Income measures were constructed the same way for each site. Income equals net cash income (wages, salary, earnings from farm and nonfarm enterprises, transfers, remittances, interest on savings, rental income from properties owned, etc.) plus the cash value of home-consumed food production (including milk and meat from slaughtered animals), valued at prevailing annual average, village-specific market prices for the goods in question.

percent fell into poverty while an almost-identical 11.2 percent climbed out. There is mobility around the poverty line, but it is essentially offsetting in that one household is replacing another.[7] The overwhelming majority of households in our sites are persistently ultra-poor.

This simple transition matrix suggests two key results, although one must be cautious about overinterpreting such figures since they are not statistically representative of either nation, much less of broader aggregates of low-income countries, and because the time periods of the surveys do not coincide perfectly. First, there is non-trivial entry into and exit from poverty in several of our sites. Even in very poor places, some people commonly escape while others fall into poverty, consistent with the mounting evidence on considerable transitory poverty (Baulch and Hoddinott 2000). Second, there seem to be distinct geographic patterns, with sites with poorer agroecological conditions and market access exhibiting greater and more persistent poverty than sites in more favorable settings. This is consistent with the idea of geographic poverty traps associated with the conditional convergence hypothesis.

Annual poverty exit rates provide another way to gauge the persistence of poverty. One can estimate the annualized poverty transition probability, m, or conversely the annual exit rate, 1-m, from

$$PR_t = m^t PR_0 \qquad (1)$$

where, PR_0 is the poverty rate in the baseline period and PR_t is the poverty rate in a future period t years hence. With just two data points, this computation becomes simply arithmetic; with multiple data points, one estimates m by regressing the logarithm of the PR_t series on the time index t (the natural logarithm of PR_0 becomes the regression constant). When PR_t reflects the sample proportion that was poor at time 0 and remained poor at time t, 1-m represents a gross exit rate. When PR_t includes households that have fallen into poverty since time 0, we have a net exit rate, i.e., those who became nonpoor less those who became poor.

Table 2 presents these estimates for our five sites. With the exception of the Ng'ambo site, where a small sample and a short panel period that began in the midst of an uncommonly severe drought likely inflate the estimated poverty exit rate, the net exit rates are no greater than 1.0 percent of the population per year and the gross exit rates are uniformly less than 2.5 percent per year. The negative estimated exit rate for the Vakinankaratra likely reflects the fact that the

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[7] Krishna et al. (2004) similarly find symmetry between entry into and exit from poverty (around 19% for each category) over a 25 year span in their study of western Kenya.

second round of panel data was collected immediately following a debilitating seven-month national crisis precipitated by a disputed presidential election that led to national strikes, fuel shortages and infrastructure damage. The poverty exit rate estimates, unlike the transition matrices, reveal no clear correspondence between agroecological potential or market access and household-level economic growth. Given that at least two-thirds of the sample in each site fell below the ultra-poverty line in each period of our surveys, these low estimated exit rates underscore the persistence of poverty in rural Africa. Graduation from ultra-poverty comes slowly at best.

B) Stochastic and Structural Income Dynamics

There are at least two major weaknesses of the poverty transition matrix or poverty exit rate approaches to studying economic mobility. First, they convey information only about whether or not households cross the poverty line. Because they rely purely on headcount measures of poverty with respect to an inherently arbitrary poverty line, transition matrices ignore the question of whether households experience growth *within* a category over time, as would be implied by the convergence hypotheses. In order to address this first weakness, one needs to look at the direction and magnitudes of welfare change, to which we turn momentarily. Second, this approach cannot distinguish whether a household exits poverty because they accumulate productive capital, because the productivity of their assets permanently improves – either of which would suggest they should remain non-poor thereafter – or if they merely enjoyed a transitory windfall – in which case they may well fall right back below the poverty line. Similarly, it matters whether someone entered poverty due to permanent asset loss (e.g., injury, death of prime-age worker, loss of land or livestock) or because of transitory events (e.g., a job change, temporary illness). In order to address this second shortcoming, one must look at the dynamics and potentially variable marginal productivity of assets, which we explore in section 4.

Figure 2 depicts the estimated empirical distribution of annualized percent change in household income for each site.[8] The income change distributions differ markedly across sites, both with respect to their central tendency and their dispersion. We hypothesize that this, at least

[8] We estimate over the annual average change in the natural logarithm of per capita income using a nonparametric Rosenblatt-Parzen density with a Gaussian kernel.

in part, reflects the timing of our surveys. As has already been mentioned, our 2002 Madagascar survey immediately followed the resolution of a national political crisis that plunged the country into a major recession during which rural incomes plunged.[9] Relative to 1997, median annualized percent change in real per capita household income was -10.8 percent in Fianarantsoa and -8.5 percent in Vakinankaratra.[10] On the other end of the spectrum, the northern Kenyan sites' figures reflect the fact that our initial March-June 2000 survey period coincided with the peak of the severe 2000 drought, which depressed initial incomes significantly. Median annualized percent change in real per capita household income was 9.1 percent in Dirib Gombo and 16.2 percent in Ng'ambo, 2000-2002. Median annualized per capita income growth, 1989-2002 in Madzuu was only 1.4 %, with no major covariate shocks occurring in either survey period in Madzuu. We are therefore inclined to interpret differences in median annualized real per capita income growth rates as reflecting major covariate events in our northern Kenya and Madagascar sites.

Perhaps the most striking feature of Figure 2, however, is the stark change in the dispersion of the household-specific income change distributions as the resurveying interval lengthens. The shortest panels, from Dirib Gombo and Ng'ambo, have the greatest variance, reflecting considerable short-term income volatility. But as the resurveying interval extends, the distributions become considerably more peaked, collapsing on their central tendencies. There is no meaningful difference between the distributions of sites with the same resurveying intervals (i.e., Dirib Gombo and Ng'ambo or Fianarantsoa and Vakinankaratra), but the differences between sites of different resurveying intervals is pronounced. This suggests that transitory income variation – for example, due to seasonality or short-lived shocks – and measurement error loom large in panel data sets where the intervals between survey rounds is short. In the short-run, there would seem to be considerable economic mobility, as reflected in the considerable dispersion observed in the shortest panels. The increase in the height of the peaks of income change distributions with the length of the survey interval suggests that this short-term

[9] Programme Ilo (2002, 2003) provides excellent analysis on the income and more general welfare effects of the 2001-2 political crisis on households throughout the island nation.

[10] The astute reader may note that the between site difference here points in the opposite direction from the estimated poverty exit rates reported in Table 2. Keep in mind that far more of the Fianarantsoa households started below the poverty line (see Table 1), thus the higher net and gross exit rates there reflect a few households on the upper tail of the income distribution enjoying modest income growth, thereby generating a positive net exit rate from poverty in spite of a sharp general downturn for the Fianarantsoa population as a whole. In the Vakinankaratra, the crisis pushed many people below the poverty line, yielding a negative net poverty exit rate.

volatility may reflect independent draws around a central tendency that cancel each other out over time. Extraordinary short-term gains or losses rarely continue. Risk management thus matters a great deal to households in these settings because they face extraordinary income volatility. In section 4, we return to the problem of risk management and the possibility that risk management behaviors differ significantly between richer and poorer households, helping create poverty traps.

For the moment, however, we maintain our focus on trying to understand patterns of income mobility in these ultra-poor rural African communities. As Figure 2 suggests, a considerable portion of any period's observed income is stochastic. That perhaps clouds inference about the structural patterns of welfare dynamics. This can perhaps be seen most easily by considering a simple decomposition of income for household i at time t,

$$Y_{it} = A_{it}`[r_{it}(A_{it}) + \varepsilon^{R}_{it}] + U_i + \varepsilon^{T}_{it} + \varepsilon^{M}_{it} \qquad (2)$$

where Y is measured income,[11] A is a vector of productive assets (labor, land, livestock, etc.) used to generate earned income, r is the corresponding vector of expected returns per unit asset held, which may depend systematically on the household's asset holdings, ε^R reflects period-and-household specific returns (i.e., yield and price) shocks, U captures household-specific but time invariant unearned income flows (e.g., the time invariant component of pensions or transfers), ε^T represents transitory unearned income (e.g., period-specific deviations from mean transfer volumes) , and ε^M is measurement error. Each of the stochastic components, ε^M, ε^R and ε^T is zero mean and independently and identically distributed over time. Expected period-specific income is therefore just

$$E\{Y_{it}\} = A_{it}`r_{it}(A_{it}) + U_i \qquad (3)$$

Assets vary in importance among households. In rural Africa, the poorest households typically rely heavily on unskilled agricultural labor markets; labor power comprises the vast majority of their productive asset stock (Barrett et al. 2001, Jayne et al. 2003). Wealthier households commonly rely more heavily on earnings from land, livestock and skilled employment (e.g., salaried labor or skill-or-capital-intensive nonfarm enterprises). Hence the importance of thinking about A in equation (2) above as a vector of assets.

Growth in observed income can then be represented by totally differentiating equation (2)

[11] One can substitute expenditures for income and repeat the analysis exactly, except that one then must account for endogenous savings. The income-based version is simpler and yields qualitatively identical results.

$$dY_{it} = dA_{it}`[r_{it}(A_{it}) + \varepsilon^{R}_{it}] + A_{it}`[dr_{it}/dA_{it} + d\varepsilon^{R}_{it}] + d\varepsilon^{T}_{it} + d\varepsilon^{M}_{it} \qquad (4)$$

Taking the expectation of equation (4) determines the expected change in income

$$E\{dY_{it}\} = E\{dA_{it}\}`r_{it} + A_{it}`E\{dr_{it}/dA_{it}\} \qquad (5)$$

revealing that income growth depends on changes in productive asset holdings and on induced changes in rates of return on assets. A household's assets evolve according to its savings behavior and asset shocks. Expected returns on assets evolve according to exogenous changes in prices and productivity and any changes associated with one's ex ante asset holdings.

The latter point is central to poverty traps based explanations. The existence of multiple equilibria implies nonlinear returns on assets. Multiple dynamic equilibria can only exist if there exist locally increasing returns at some point(s), i.e., $dr/dA_{|A=A*} > 0$ at some asset level(s) A*. This points us toward a natural empirical test for poverty traps that we undertake in section 4.

The preceding equations equip us to investigate the implications of the considerable stochasticity of income in these sites. If we simply regress the period-on-period change in income, dY_{it} on beginning period income, Y_{it}, then we necessarily incorporate intertemporal change in transitory unearned income, in the stochastic component of returns on assets, and in measurement error. Each of these will necessarily generate a regression-to-mean effect, a negative correlation between income change and beginning period income, controlling for the effects due to dA_{it} and dr_{it}/dA_{it}, which could be either negative or positive. In other words, if the stochastic components are serially independent, good draws in one period should typically be followed by poorer draws the next period and vice versa. Just as the stochastic component of income tends to exaggerate income inequality in cross-sectional analyses, so too does it generate spurious convergence in welfare measures because the stochastic component of measured income inextricably includes undesirable noise. In the abstract, one would like to include the $d\varepsilon^{R}_{it}$ and $d\varepsilon^{T}_{it}$ components, since these reflect real stochastic changes in households' incomes, but strip away the $d\varepsilon^{M}_{it}$ component that reflects only intertemporal change in measurement error because the change in measurement error necessarily generates negative bias in the regression of change in income on beginning period income.

We can, however, filter out the stochastic components ε^{M}, ε^{R} and ε^{T} by regressing the expected change in income, from equation (5), on expected income, as reflected in equation (3). This approach necessarily focuses on just the structural (i.e., nonstochastic) components of income and income dynamics.[12] As such, the structural income dynamics regression eliminates the ε^R and ε^T components of true (albeit transitory) income change that are negatively correlated with beginning period income. The resulting regressions will therefore exhibit some positive bias in the estimated regression of total income change on beginning period income but provide an unbiased estimate of the change in the structural (i.e., nonstochastic) component of income. If one is interested in the problem of persistent poverty, then these structural income dynamics are the portion of greatest interest, not total income dynamics that necessarily include measurement error and transitory shocks that one would expect to be reversed in time.

To demonstrate the effect of filtering out the stochastic components of income, we run both the (negatively biased) unfiltered income dynamics regression and the structural income dynamics regression. The convergence hypothesis on which market-oriented reform programs were based implies a negatively sloped relation between income change and base period income, with the curve crossing the zero change threshold just once, at the point toward which all households converge. In contrast, under the conditional convergence or poverty traps hypotheses, the regression relationship need not be monotonically negatively sloped. Rather, it will cross the zero income change line around each dynamic equilibrium toward which households converge, with the stable equilibria occurring where the regression line crosses the zero expected change point with negative slope.

Figure 3 presents these income change regressions for each site.[13] The dashed lines reflect the nonparametric regressions[14] of the unfiltered income change on beginning period income. For each of the five sites, the estimated slope is negative over most or all of the conditioning domain and the regression line intersects the (horizontal) zero change line from above at just a single point, consistent with the convergence hypothesis' implication of a unique point of

[12] Carter and May (2001) explain and demonstrate the importance to poverty analysis of this distinction between the stochastic and structural components of income.
[13] Note that the axes are not scaled identically across sites, given differences in ex ante income distributions.
[14] A locally-weighted scatter plot smoother (LOESS or LOWESS) regression generates a series of conditional means over a fine grid on the conditioning domain (i.e., the independent variables) by fitting a weighted linear regression, where the weights decrease with distance from the point of interest. We connect these predicted values to produce a (potentially highly nonlinear) curve. The key parameters affecting the estimated regression curve are the span or bandwidth, which determines how many nearby observations are used in predicting the dependent variable at a given point, and the degree of the regression, whether it is locally linear or quadratic. We use second degree (i.e., quadratic) LOESS estimators with optimal, variable span (based on cross-validation) on this and all subsequent nonparametric regressions.

convergence. As we show momentarily, however, when one filters out the stochastic component of income, these results change strikingly.

Given measurement error and the extraordinary income volatility evident in Figure 2 and a focus on understanding persistent poverty, one might prefer to look at the estimated structural income dynamics of these households. Toward this end, we estimated equation (3) via a simple ordinary least squares regression of income on a vector of assets appropriate to each site and period-specific dummy variables for each survey village, pooling observations across periods.[15] The coefficients on the individual assets reflect the expected rates of return, r, while the coefficients on the site-and-period-specific dummy variables summarize the change in expected rates of return holding asset stocks constant, dr, and the conjectured time-invariant level of unearned income, U. We study the resulting estimates in a bit more detail in the next section. For now, we are interested in comparing the nonparametric LOESS regression of the difference between period-specific income estimates on the baseline period income with the estimates yielded by the unfiltered regression analysis.

The solid lines in Figure 3 reflect the estimated structural income dynamics regressions. As is apparent, these lines are not monotonically negatively sloped. Except for Dirib Gombo – where no household graduated from poverty in our survey period (Table 1) – each of the site-specific structural income dynamics regressions exhibits multiple dynamic equilibria, as reflected by points where the regression line crosses the zero change line from above. In each site, one such equilibrium lies below the ultra-poverty line of \$0.50/day per capita, suggesting no expectation of a graduation out of poverty if one relies merely on the natural dynamics of the

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[15] With enough household-specific observations over time, one could properly estimate U_i, the time-invariant household-specific component of income from equations (2) and (3). In practice, we typically haven't enough longitudinal observations on single households to retain sufficient degrees of freedom in estimation if we include these household fixed effects. We therefore opt here for village-specific fixed effects. In Madzuu, the assets used as regressors are farm size, improved dairy cattle, unimproved dairy cattle, nondairy cattle, small ruminants (sheep and goats), poultry, farm and business equipment, household demographic composition (size, ages, gender), dummies for educational attainment categories for the household head and for the most educated member of the household, distance to nearest market, bicycles owned, and dummy variables for receipt of credit, being native to the village, and for 2002 (to capture period-specific shocks to aggregate returns). The equation fitting income on a linear function of these asset variables had an adjusted r^2=0.34. In the two Malagasy sites, we used the same regressors as in Madzuu, minus small ruminants and poultry, but adding number of hogs, bank savings and dummy variables for extension service access and villages, and breaking total farm land into lowland rice fields and all other agricultural lands. In Dirib Gombo and Ng'ambo, we used the Madzuu regressors, dropping improved dairy cattle (irrelevant in these sites) and whether the respondent was native to the village (the variable is absent from the northern Kenya data sets). The adjusted r^2 on the Fianarantsoa, Vakinankaratra, Baringo and Marsabit regressions were 0.43, 0.44, 0.37 and 0.28, respectively. The modest explanatory power of these regressions, given the small sample sizes, reinforces the point that much household-and-period-specific income appears stochastic rather than structural.

extant system. These regressions of expected income changes on base period income are inconsistent with the convergence hypothesis but consistent with the conditional convergence and poverty traps hypotheses. They suggest the existence of multiple dynamic equilibria. But by this method, we cannot distinguish between those two hypotheses.

Our qualitative studies among these households echo this general impression that there exist multiple equilibria. Throughout the Kenya sites, community focus groups told us repeatedly that poverty has increased in our survey communities and that the time it takes for a household to recover from an adverse shock or to exit poverty has increased over the past ten to twenty years. Although local definitions of poverty vary across the sites, in both community focus group interviews and in depth oral histories of individual households, respondents in Dirib Gombo, Madzuu and Ng'ambo all explained increased poverty and reduced economic mobility as arising due to greater environmental variability and lower average rainfall, poorer quality soils due to less frequent fallowing and reduced manure application, decreasing per capita holdings of land and livestock, increasing difficulty in finding remunerative employment for educated adults, and the decline of informal support networks to help in response to temporary health and income shocks (Mango et al. 2004).

Interestingly, those who are continuously nonpoor or who were poor but exited poverty in our samples commonly offer stories consistent with the hypothesis of conditional convergence. Meanwhile, the current poor – whether they became poor during the survey period or had always been poor – describe poverty dynamics in a fashion far more consistent with the hypothesis of poverty traps. Inference from above the poverty line plainly differs from the perspective from below. This reinforces our perception that both conditional convergence and poverty traps may be at play in these sites, with distinct groups facing different growth trajectories, some of which exhibit multiple stable dynamic equilibria.

The currently nonpoor frequently emphasize individual attributes – most notably work ethic and drunkenness – as leading to fundamentally different stations in life. By their view, those without the discipline to refrain from excessive alcohol consumption and to work hard stay poor, while their more self-disciplined neighbors exit poverty and then remain nonpoor. This is essentially a story of convergence to a group-specific equilibrium, with little hope of people changing groups.

By contrast, the currently poor emphasize the difficulty of asset accumulation and the central role of asset losses in explaining patterns of mobility. Every one of the households we interviewed who were poor in the most recent period could trace their poverty ultimately to some asset shock, whether before or after the first round of our surveys. Serious human health shocks – permanent injury or illness (e.g., HIV/AIDS, cancer) – and death were the most frequently cited reasons for households falling into poverty (Mango et al. 2004, Randrianjatovo 2004).[16] Some adverse effects are direct, when economically active household members fell ill and subsequently had to stop working or even died and their earnings were lost or their absence came at a critical time in the cropping cycle, causing them significant seasonal losses from which they have been unable to recover. Other effects respondents mentioned frequently are indirect, as when children had to be pulled out of school for want of school fees due to the high costs of treating illness or funeral expenses, or when the family lost productive draught power and milk production when it had to undertake ritual slaughter of livestock for a funeral.

The poor routinely point to certain activities – e.g., zero-grazing dairy production with improved (cross-bred) cows, commercial tea cultivation, salaried employment based on above-average educational attainment and social connections – as higher-return activities that lie beyond their reach for want of start-up capital to buy improved cattle or tea bushes, or due to a lack of education or the connections to land a good job. Several people mentioned the importance of migration as an escape route. Young, educated people who can move to better land or to cities where they can find a good job enjoy some prospect of escaping the persistent rural poverty toward which they otherwise seem headed. Parents frequently invest heavily in educating their children in the hope that they can indeed win the skilled employment lottery in a city and eventually provide financial support back home. But the personal connections necessary to land a good job and the capital necessary to start small businesses are perceived as major obstacles to be overcome by poorer families. The poor's perception is that barriers to entry into more remunerative activities dampen their labor, land and livestock productivity relative to their nonpoor neighbors. Meanwhile, their considerable exposure to risk of asset loss – due to human or livestock disease, theft or natural disasters – leaves them concerned about undertaking activities that might further increase those risks.

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[16] This echoes other qualitative work on poverty dynamics undertaken in the eastern escarpment of Madagascar (Freudenberger 1998), western Kenya (Krishna et al. 2004, Kristjanson et al. 2004) and India (Krishna 2004).

The qualitative descriptions offered by our respondents to explain their own welfare dynamics mirror the quantitative evidence previously presented. Between site variation in ultra-poverty rates and rates of exit from poverty suggest that poverty is lower and exit faster where market access and the basic agroecology are more favorable. This creates significant migration incentives. There nonetheless remains considerable intra-community variability in welfare status.[17] One needs to guard against geographic determinism in explaining patterns of persistent poverty.

Within sites, there exists significant short-term variation in incomes or other measures of well being, but over the longer term, there seems relatively little income mobility. Furthermore, there appear to be multiple equilibria toward which household incomes converge. Neither the qualitative nor the quantitative evidence support the unconditional convergence hypothesis that implicitly underpinned the design of macroeconomic and sectoral reforms under structural adjustment programs.

4. Does Income Immobility Signal Poverty Traps?

So why do there appear to be multiple structural dynamic equilibria in these rural Kenya and Madagascar sites? In this section we explore this question further. We look in turn at whether there might exist measurable differences in risk management strategies by ex ante household wealth, and whether there might be locally increasing returns on assets due to discrete shifts in livelihood strategies or production technologies, both phenomena suggested by the qualitative evidence. Then we explore whether these features of the rural economies of Kenya and Madagascar – and, we suspect, of much of rural sub-Saharan Africa more broadly – might lead to S-shaped asset dynamics associated with multiple dynamic equilibria.

A) Wealth-Differentiated Risk Management

The considerable short-term income volatility manifest in the data series from each of our sites raises important questions about poor households' capacity to undertake consumption smoothing. This is of interest for its own sake, as consumption smoothing is intrinsically valuable for households exhibiting risk aversion. But understanding more about households'

[17] Jayne et al. (2003) find similar patterns using nationally representative survey data from several eastern and southern African countries. Mistiaen et al. (2002) have similar findings in their poverty mapping study of Madagascar.

management of income volatility also offers us a window into prospective sources of differential expected returns on assets, as is implied by a poverty traps explanation of persistent poverty.

A small literature in development economics demonstrates that in the presence of highly stochastic income, risk preferences, subsistence constraints or both can induce poorer households to trade off expected income growth for reduced income volatility, relative to wealthier households (Rosenzweig and Binswanger 1993, Carter 1997, Bardhan et al. 2000, Zimmerman and Carter 2003). Of course, if this means that poor households eschew the risks inherent to investment, this can lead households to precisely the sort of low-level equilibrium posited by the poverty traps hypothesis. If this wealth-differentiated portfolio choice phenomenon is true, then we should see a lower coefficient of variation (CV)[18] of income among poorer households than among wealthier households, corresponding to the risk-return tradeoffs predicted by standard economic assumptions about preferences characterized by decreasing absolute risk aversion. Poor households should have lower expected returns on assets and a disproportionately lower variability in those returns.

Furthermore, poor households may be more likely to destabilize consumption as part of their strategy to cope ex post with uninsured and unmitigated income risk, precisely so as to avoid having to divest scarce productive assets on which future well-being – or even survival – depends. This implies that poorer households may have higher coefficients of variation in consumption than do richer households. Richer households will have more savings (in cash and in kind, including in the form of productive assets) and more access to credit, so they will have more opportunity to smooth consumption ex post of stochastic income realizations than do poorer households.

The combination of these two hypotheses raises an interesting possibility. If income variability increases with wealth but consumption variability decreases with wealth, that implies that consumption smoothing increases in expected income. If consumption smoothing increases welfare due to risk aversion, and if poorer households indeed smooth consumption less than wealthier households – i.e., if consumption smoothing is a normal good, increasing in income or wealth – then standard, static expenditure measures will tend to understate welfare differences because they omit the positive value of smoother consumption.

[18] Coefficient of variation equals the standard deviation divided by the mean. It yields a unitless measure of risk that lends itself to comparison across groups.

To the best of our knowledge, the hypothesis that wealth has opposing effects on the volatility of consumption and of income has not yet been empirically tested. One reason, surely, is that this requires sufficiently high frequency data to establish the volatility of both income and expenditures. Fortunately, with ten quarterly observations per household, our northern Kenya data are suitable for this task. The data cannot support testing this hypothesis in our other sites. Using data from all six of the PARIMA sites in northern Kenya,[19] we computed 177 household-specific coefficients of variation (i.e., standard deviation divided by mean) for quarterly income and expenditure series.[20]

Figure 4 plots the nonparametric regression of these CVs on initial period household herd size, expressed in tropical livestock units (TLU)[21] per capita, a useful scalar measure of wealth in pastoralist communities. The positive correlation between wealth and income risk is apparent in the upward slope of the thinner solid line depicting income CV. Bootstrapped confidence bands (not shown) indicate that the positive slope to this regression line is indeed statistically significant over most of the conditioning domain. Poorer households indeed appear to systematically suppress income variability. One would expect this to come at a cost of lower expected marginal returns on assets. As we show in the next sub-section, these data support that hypothesis as well.

The thicker solid regression line reflects the relationship between the CV of expenditure and household wealth. This slopes modestly downward, although bootstrapped confidence bands (not shown) indicate that the differences are only statistically significantly different between the tails of the wealth distribution. The gap in Figure 4 between the income and expenditures CV regression lines reflects consumption smoothing behavior. While richer households take on greater income risk than poorer households do, they nonetheless enjoy lower intertemporal variability in expenditures. Consumption smoothing indeed appears to be a normal good among these households, increasing in wealth in spite of prospectively greater absolute risk aversion among the poor.

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[19] The full data set and details on the other four pastoralist communities in northern Kenya are described in Barrett et al. (2004).

[20] Because we have to compute household-specific estimates of income and expenditure coefficients of variation, we lose the time series variation on which site-specific regression estimation depends in our northern Kenya locations of Dirib Gombo and Ng'ambo. So for this analysis we pool the data with those from households in the four other PARIMA sites.

[21] The TLU represents a standardized measure of metabolic liveweight in animals, enabling aggregation across species according to the formula 1 TLU = 1 cattle = 0.7 camels = 10 goats = 11 sheep.

The dashed curve, which should be read against the righthand vertical axis, depicts the empirical wealth density depicting the asset distribution among surveyed households. Among the poorest households – up to roughly the median of the wealth distribution – mean intertemporal income variability is actually less than mean expenditure volatility, signaling that the most vulnerable households indeed seem not to smooth consumption as the standard neoclassical growth model predicts, but to destabilize consumption in order to protect crucial productive assets on which their future survival depends. This underscores the dynamic welfare cost of uninsured risk borne by vulnerable households. Consumption smoothing appears to increase relatively rapidly as one moves above the median of the wealth distribution among these northern Kenya pastoralists.

B) Locally Increasing Returns on Assets

If poorer households trade lower risk for lower returns, this should appear as well when we plot expected income against assets. Figure 5 presents the nonparametric kernel regression of per capita daily income per capita herd size using the same 177 northern Kenya households from the preceding analysis so as to ensure direct comparability. The increasing slope of the income function over most of the wealth distribution signals increasing returns per unit wealth, as would be expected if households are indeed taking on higher risk – higher reward portfolios of activities and assets as their wealth increases. Of course, this creates multiple dynamic equilibria based on initial wealth, possibly including equilibria below the poverty line. The marginal rate of increase in expected income (the slope of the income function) does not begin to decrease until about the 96th percentile of the wealth distribution. Over most of the wealth distribution, there appear to be increasing returns to asset holdings.

This raises the obvious question: if expected returns are increasing in livestock holdings over most of the wealth distribution in the northern Kenya pastoralist sites we study, why don't poorer households accumulate assets so as to increase expected income? It would seem that there must be some barrier(s) to accumulation. The explanation already discussed concerns portfolio choice based on risk preferences that differ across the wealth distribution. The data appear consistent with that claim. But there may be alternative or supplementary explanations.

One candidate explanation would be subsistence constraints that limit households' ability to reduce current consumption in order to increase savings and thus asset accumulation.

Unfortunately, we have no good way to test directly for subsistence constraints in our data. The data do show, however, that all of these households received food aid in at least some period and that many suffer acute food insecurity manifest in coping behaviors such as reduced frequency of meals, in many households to just one a day.

Another plausible, complementary explanation arises from the lack of liquid savings and credit. Although there is a Kenya Commercial Bank (KCB) branch in Marsabit town and there have been efforts at promoting microfinance institutions in several of the survey communities, fixed fees at KCB make real rates of return negative on small accounts and loan limits at existing microcredit institutions preclude purchasing fertile large ruminants for herd building (Osterloh 2004). Less than 15 percent of the survey households hold bank accounts and access to credit is negligible. Given scant cash holdings or credit, very few households purchase animals; herd accumulation involves almost exclusively biological reproduction (Osterloh et al. 2003). To a certain extent, then, households' asset holdings may be constrained to follow the natural population dynamics of their livestock. We study asset dynamics in the paper's next subsection.

The phenomenon of locally increasing returns on assets appears in all of our sites for at least some assets, but with variation in degree across years and locations. To get at the hypothesis in a different way, we ran the ordinary least squares regression of household income on a range of household assets for each location and year separately using a generalized quadratic, second-order flexible functional form to allow for nonlinearities and interaction effects among assets,[22] then computed the estimated marginal returns on assets and ran the nonparametric LOESS regression of those estimated marginal effects on the asset stock. The results underscore a pattern of locally increasing returns to several key assets in many of our sites.

Consider, for example, Figure 6, which depicts the nonparametric regression of estimated marginal returns to labor force (measured as working age adults in the household) and to the amount of rice land area a household owns on household stock of labor and rice land, respectively.[23] These regressions depict the potentially endogenous returns on assets, as

[22] Detailed regression results and diagnostics are available from the authors by request.

[23] In Madagascar, "rice land" (*bas fond* or *tanimbary*) is lowland that is irrigable and thus suitable for cultivation of rice. It is distinct from the upland (*tanety*) that is purely rainfed. The underlying regression coefficients for the variables discussed are statistically significantly different from zero at the five percent level. Marginal returns were then estimated for each household using the point estimates from the second order generalized quadratic specification – normalized to produce an exact second-order approximation at the sample means – and the household-specific asset stock values. Here we report only the results for 1997, but the 2002 data yield qualitatively identical patterns.

permitted in equation (2). The upper left panel of Figure 6 shows that the estimated marginal returns on household labor stock are increasing significantly around the middle of the labor distribution in Fianarantsoa, the poorer of our Malagasy sites, where illness and migration limit labor availability for many poor households, commonly impeding expansion into higher return, labor-intensive activities such as dairy production or SRI rice production.[24] Few households in Fianarantsoa have cash savings, access to credit or steady cash income from salaried employment to use to hire unskilled workers when they (perhaps temporarily) suffer labor shortages that might impede adoption of an improved technology or that might cause agricultural yield losses due to mistiming of field operations (e.g., due to a spell of malaria). Liquidity constraints make labor availability a critical determinant of household livelihood strategies. Those households that lose an adult to death or migration (without compensating remittances) thus lose not only a productive worker but also suffer average productivity losses among the remaining adults, reflecting the endogenous asset returns characteristic of poverty traps. Interestingly, this effect is not present in the wealthier Vakinankaratra site, where widespread off-season cropping and salaried employment and better access to markets and credit enable households to hire labor more freely in response to latent demand. The result is diminishing returns to labor, as shown in the upper right panel of Figure 6.

The marginal returns to rice land likewise exhibit locally increasing returns in Fianarantsoa. It is almost exclusively the households with the largest lowland rice area who adopt SRI, apply fertilizer or manure or use animal traction. Estimated marginal income per unit area of rice land owned is thus sharply increasing in the upper third of the land distribution as the largest farms enjoy the highest rice yields. Once again, the locally increasing returns evident in the poorer Fianarantsoa site are absent in the better-off Vakinankaratra region, where even small farmers are commonly able to secure off-season contract farming that provides fertilizer inputs and where water management is relatively reliable, maintaining reasonable yields even on smaller farms.

[24] The system of rice intensification (SRI) was developed in Madagascar in the late 1980s and has demonstrated tremendous potential for yield growth without requiring any new seed, chemical fertilizer or other purchased inputs. SRI generates these effects through a suite of changes in agronomic practices in plant spacing, timing of seedling transplanting and soil moisture management. However, SRI requires additional initial labor investment that typically puts it out of reach of the poorest and smallest households. Moser and Barrett (2003) document these effects, while Barrett, Moser, McHugh and Barison (2004) document that SRI increases yields on average by more than 80 percent, holding farmer and plot characteristics and other inputs constant, while also increasing yield risk, providing a link to the preceding sub-section on wealth-differentiated risk management strategies.

The argument we advance here is subtle. We do not claim that there exist globally increasing returns to any particular asset, nor even that locally increasing returns exist everywhere, as implied by most macroeconomic models of endogenous growth. Rather, our point is that there exist places where market failures – perhaps especially in the finance necessary to undertake investment or to cope with shocks without liquidating productive assets – can lead to sharp differences in productivity among reasonably similar households and thus to poverty traps. In less-favored areas such as the rangelands of northern Kenya and the southern highlands of Madagascar, such phenomena seem to exist, while we do not find evidence of similar patterns in the more favored area of Madgascar's central highlands.

C) Asset Dynamics

Because assets generate income, asset dynamics underpin income dynamics. We therefore also study asset dynamics in order to understand income dynamics better in these rural Kenyan and Malagasy communities. If the return on assets increases with ex ante wealth over at least some portions of the wealth distribution, then one would naturally expect this to lead to asset accumulation. Then, as the returns on asset diminish, accumulation slows, leading to a stable dynamic equilibrium where asset stocks remain stable over time. When returns on assets are increasing only locally, however, there may be multiple stable dynamic equilibria, consistent with the notion of a poverty trap.

We also know that pastoralists' mobility depends on herd size (Lybbert et al. 2004, McPeak and Barrett 2001). Because food and potable water availability on the open range is limited, pastoralists who migrate their herds in order to take advantage of spatiotemporal availability of forage and water must be able to sustain themselves off of their herds' milk, meat and blood. But these pastoralists rarely move their whole households, typically splitting herds and leaving most of the "wet" (i.e., lactating) herd in a base camp nearer to town with women, children and the elderly, while able-bodied men migrate to mobile satellite camps with the "dry" (i.e., non-lactating) herd and enough wet animals to sustain the herders. This herd splitting strategy introduces a minimum efficient scale below which herders effectively become sedentarized. Sedentarized grazing is inherently less productive, however, and leads to greater localized resource degradation which could potentially lead to slower herd growth (McPeak 2003).

The net result of these factors may be highly nonlinear asset dynamics leading to multiple equilibria. Lybbert et al. (2004) found such patterns in southern Ethiopian pastoralist communities very similar to the northern Kenya sites in our study. There seem to be multiple stable dynamic herd size equilibria in our northern Kenya sites, as well. Figure 7 depicts the nonparametric regression of herd size (the solid line without markers), measured in per capita TLU, on the previous quarter's herd size, pooling the Dirib Gombo and Ng'ambo observations together to improve precision.[25] The dashed diagonal line depicts dynamic equilibria. The expected asset dynamics exhibit stable equilibria – points at which the regression line crosses the dashed diagonal line from above – at approximately 0.2 and 10 TLU per capita. Translated into somewhat more concrete units, a median household of six persons faces both a low-level equilibrium herd size of about one cow or 10-12 goats or sheep (small ruminants), or a higher stable equilibrium herd size on the order of 50-60 cattle. The higher stable dynamic equilibrium in Figure 7 falls within the region of diminishing returns to herd size reflected in Figure 5, reflecting the link between returns on assets and dynamic asset equilibria.

There exists one unstable dynamic equilibrium between these two stable dynamic equilibria. This nonparametric regression suggests that household-level herd dynamics bifurcate at 5-6 TLU per capita. Above that level, the herd size naturally grows toward the higher equilibrium of 10 TLU per capita. But below the unstable equilibrium, household herd sizes tend to collapse toward the low-level equilibrium of less than one TLU per capita. This suggests that 5-6 TLU per capita demarcates a critical threshold that northern Kenyan pastoralist households and those interested in their welfare need to defend that threshold vigorously.[26]

We need to be careful, however, about investing too much in the estimates that result from the simple bivariate autoregression depicted in Figure 7. This necessarily assumes away statistically significant differences in other characteristics, thereby raising the real possibility of omitted relevant variables bias. On the other hand, parametric methods of estimating these recursion diagrams must use high order polynomials of the lagged asset holdings, along with proper controls for life cycle effects that naturally influence observed asset dynamics – people accumulate assets during their working adult lives and then begin divesting assets in their latter

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[25] We also ran these regressions separately for each site and found no statistically significant difference between the two sites in herd dynamics, thus justifying combing the data from the two sites.

[26] Previous research similarly suggests 4.5 TLU per capita as a threshold for the minimum amount of livestock necessary to provide adequate nutrition for an individual surviving on livestock in arid lands, based on productivity estimates and approximate caloric needs (Pratt and Gwynne 1977; Fratkin and Roth 1990).

years – and for community-and-period-specific effects, in order to allow for multiple equilibria.[27] Such estimation is simply not feasible in most panel data sets. And even when it is, it can still be very difficult to fit complex nonlinear dynamics parametrically, as we show momentarily.

As a check on the robustness of the basic pattern, we therefore also estimated herd dynamics in Dirib Gombo and Ng'ambo parametrically. More precisely, we regressed the year-on-year change in household i's per capita herd size on a fourth-order polynomial in one-year lagged herd size,

$$A_{it} = \alpha_1 Y_{it} + \alpha_2 Y^2_{it} + \beta_1 A_{it-1} + \beta_2 A^2_{it-1} + \beta_3 A^3_{it-1} + \beta_4 A^4_{it-1} + \boldsymbol{\delta_t} + \boldsymbol{\lambda_i} + \varepsilon_{it} \qquad (6)$$

where Y is the household head's age in years, entering quadratically to control for life cycle effects, and the bold-faced vectors $\boldsymbol{\delta}$ and $\boldsymbol{\lambda}$ represent period- and household-specific effects, respectively. The regression results (available from the authors by request) imply a modest, statistically significant steady increase in herd size as a household head ages, peaking at age 53 before declining again. Of more immediate interest to the present analysis, the regression point estimates suggest stable dynamic equilibria at 0.35 and 7.83 TLU per capita and an unstable equilibrium at 6.08 TLU per capita. The lower estimated equilibrium herd size is strikingly similar to that derived through the simpler, bivariate nonparametric regression shown in Figure 7. The unstable is statistically significantly higher and higher-level stable equilibrium is statistically significantly lower than the counterpart estimates from the nonparametric regression. But as the plot of the parametrically fitted expected herd dynamics in Figure 7 (depicted by the line with + markers) shows, even a fourth-order polynomial seems to oversmooth the estimated asset dynamics in the upper tail of the wealth distribution, underscoring the value of nonparametric statistical methods in studying potentially complex nonlinear asset dynamics. Clearly, more work needs to be done to identify such thresholds with confidence and an appropriate balance between flexibility of functional form and control for other covariates. Nonetheless, the hypothesis of multiple herd size equilibria among these pastoralists, consistent with the poverty traps hypothesis, appears robust.

One advantage of studying such patterns among pastoralists is that one can reduce wealth to herd size without having done tremendous violence to the underlying reality.[28] In order to

[27] A third order polynomial (i.e., cubic) in the lagged asset stock is an absolute minimum to allow for the possibility of multiple stable equilibria; and that only permits two stable equilibria on the tails of the sample data.

replicate this analysis in our other sites, where more favorable agroecology leads to more diversified crop and animal agriculture and where higher population densities lead to greater propensity to own nonagricultural assets and businesses, we need an alternative method for summarizing assets.

The asset index introduced by Sahn & Stifel (2000) provides one method for doing precisely this.[29] This approach has three significant advantages. First, the asset index reflects latent "wealth" variable common to most assets, providing a summary statistic of general wealth, i.e., wealth manifest in a range of assets. In trying to explain income as a function of assets – as in equation (3) – we can combine the asset index with a subset[30] of specific asset measures that may have their own, idiosyncratic effects on welfare separate from their reflection of general wealth. This permits us to capture the distinct effects of potential complementarities between productive assets (e.g., land and herd size where crop-livestock integration generates yield gains due to more efficient use of the waste byproducts of crop and animal agriculture) distinct from that of general wealth status (which may reflect individual traits, credit access, etc.). Second, the asset index method conserves degrees of freedom relative to including a long laundry list of assets. Third, it lends itself to graphical presentation in a way multi-dimensional asset measures do not.

We computed asset indices separately for each site, pooling data across sample periods so as to be able to apply a consistent set of weights across periods, but adding period-specific dummy variables so as to account for temporal changes that might otherwise influence asset weights. We can then use the resulting factor weights to compute household-specific asset indices. These are unitless measures with unconditional site-specific means equal to zero due to the normalized weights of the asset index. So we cannot compare levels across sites, since the weighting schemes and normalizations are not comparable. We can, however, study household-specific asset dynamics using these asset index measures just as we did herd dynamics in the northern Kenya pastoralist households previously.

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[28] Nonetheless, with increasing voluntary sedentarization of educated and employed pastoralists (McPeak and Little forthcoming), using herd size as a proxy for overall wealth is becoming increasingly suspect even in pastoral areas with little crop agriculture or nonagricultural industry.

[29] The Sahn-Stifel method uses factor analysis to find a single common factor that explains the covariance of a vector of assets under the assumption that these assets reflect a common, latent wealth variable that we cannot directly measure. The resulting factor loadings then represent data-driven weights on the assets. The product of these weights and a given household's asset holdings yields an intuitive, unitless asset index.

[30] Since the asset index is a linear combination of a set of assets, identification requires omission of some assets used to construct the asset index.

Figure 8 presents the nonparametric autoregressions of latter period household-specific asset indices on their initial period asset index for the three other sites. The two Malagasy sites do not appear to exhibit multiple equilibria in asset index dynamics.[31] But in Madzuu, multiple dynamic equilibria appear to exist, with one at the upper reaches of the current wealth distribution and another around the mean of the current wealth distribution. If we run the simple ordinary least squares regression of real per capita daily income on the asset index and then calculate the predicted value at the dynamic asset equilibria, we find that these dynamic asset equilibria correspond to expected real per capita daily incomes of $0.51 in the lower equilibrium, just beneath Kenya's rural poverty line, and $1.48 in the upper equilibrium, hardly wealthy but nonetheless nearly three times higher than the lower equilibrium and the relevant poverty line. Again, the data appear consistent with the poverty traps hypothesis.

This matches up reasonably well against a nonparametric density plot of the cross-sectional income distribution in Madzuu (Figure 8). If multiple dynamic equilibria exist, households should converge toward these equilibria, leading to a mode in the cross-sectional distribution around the stable dynamic equilibria (Barrett forthcoming). Because households should not remain long at or near unstable equilibria, observed density at those points should be less than at the nearest stable equilibria. If there are multiple equilibria – potentially including a few distinct points of conditional convergence, what Baumol (1986) and Quah (1996) refer to in empirical macroeconomic analysis as "club convergence" – there should therefore appear more than one mode in the cross-sectional income distribution.[32] We see precisely this pattern of multi-peaked income distributions in Figure 9. It certainly appears that multiple equilibria exist in Madzuu, with less than one-quarter of the population clustered around the higher dynamic equilibrium and the rest distributed around, and presumably converging toward, the lower level equilibrium beneath the poverty line.

As suggested in Figure 8, the chronically poor in Madzuu hold limited assets. Table 3 shows household mean asset holdings by categories from the poverty transition matrix (Table 1). Those who were poor in both two survey rounds, on average, had smaller asset bases – land,

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[31] Since the weights are site-specific, one cannot meaningfully compare the curves across sites. So although the Vakinankaratra curve crosses the diagonal at a spot above the Fianarantsoa curve, one cannot conclude that equilibrium asset levels are greater in the Vakinankaratra, although casual observation and survey data suggest that is indeed the case.

[32] Quah (1996) first remarked on this in the context of empirical macroeconomics, referring to the phenomenon of "twin peaks" reflecting two distinct dynamic equilibria. More generally, "multi-peakedness" provides prima facie evidence of multiple dynamic equilibria inconsistent with the hypothesis of unconditional convergence.

improved or cross-bred dairy cattle or access to off-farm employment earnings — than either the transitorily poor or, especially those households who were consistently non-poor, although the differences are only statistically significant between the chronically poor and the consistently non-poor. This reinforces the impression that initial asset conditions affect poverty dynamics, consistent with the poverty traps hypothesis. [33]

This quantitative evidence corresponds with the qualitative evidence from our in-depth interviews with a subsample of farmers and participatory focus group discussions about local definitions, dynamics and responses to poverty. The prevailing view within the community is that those who manage to complete their secondary education and secure salaried employment through social connections or good fortune – education is merely a necessary condition to finding a decent job, but by no means is it sufficient – can then build and sustain a reasonable livelihood, with improved dairy cattle and tea bushes on several acres of land in addition to – and in large measure because of – steady non-farm cash income. Each of the households we interviewed who were nonpoor in both 1989 and 2002 emphasized nonfarm employment as playing a crucial role in their achievement and maintenance of an adequate standard of living.

Equally important, an adequate livelihood is vulnerable to shocks in Madzuu. Overwhelmingly, health shocks were the most frequent reason given for households falling into poverty, cited by nearly every Madzuu household we spoke with that was poor in 2002.[34] Health and mortality shocks may cause a loss of permanent salaried employment or self-employment, ending a household's steady cash flow and often necessitating distress sale of productive agricultural and household assets to pay for medical expenses. Even transient health shocks – most commonly malaria in this area – can lead to significant yield losses because they prevent the application of labor at crucial periods during the rainy, growing season, when illnesses are most common. These yield losses can reduce consumption over the subsequent year, leaving the household more vulnerable to further disease, thereby igniting a vicious cycle of disease and destitution.[35] In other cases, the death of a close family member – a father, brother or spouse –

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[33] Gamba et al. (2004), in a probit analysis of chronic poverty among rural Kenyan households, likewise find that initial assets, particularly land holdings and educational attainment, are negatively related to the likelihood of being poor in multiple periods in their panel data.

[34] Krishna et al. (2004) and Kristjanson et al. (2004) similarly find health shocks to be overwhelmingly the most common explanation for households falling into poverty in their study of a broader cross-section of western Kenya.

[35] Tegemeo/MSU (2001) study on health shocks and productivity and income find qualitatively identical patterns using a far larger panel data set from 24 rural districts in Kenya.

imposed funeral expenses on a household that wiped out its assets, causing it to pull children from school and thus breaking the household's long term access to remunerative employment.[36]

Retrenchment in Kenya's off-farm labor market, due in considerable measure to reduced public sector employment and to infrastructure decline that has hurt rural non-farm industry throughout the country, has affected the accessibility of the higher-level equilibrium. Madzuu residents repeatedly told us that fifteen or twenty years ago, secondary school leavers could almost always find remunerative employment. That is no longer true. The result of lower off-farm skilled labor demand relative to supply has had multiple adverse effects in communities such as Madzuu. First, there are the obvious, direct labor market effects: greater unemployment and lower real wages, both skilled and unskilled (the latter because skilled workers who fail to find salaried employment commonly join the unskilled labor market, expanding supply there as well). The indirect impacts have likewise proved important, according to the households we interviewed. Less off-farm employment has reduced outmigration from Madzuu, leading to increased on-farm population density. The result has been farm partitioning, manifest in sharp declines in average farm sizes, reduced fallowing and as a direct consequence, accelerated soil nutrient depletion. Uniformly, respondents report that farms in Madzuu are now smaller and less fertile than they were a generation ago. Perhaps more remarkably, Madzuu residents routinely make the sophisticated connection between land and labor markets, observing that adverse changes in local land quality follows in large measure from the lack of growth in off-farm labor demand for a growing rural population.

5. Conclusions and Policy Implications

In order to make progress in combating persistent poverty, policymakers must have a clear and accurate conceptualization of the causal mechanism that keeps people poor indefinitely. The macroeconomic literature lays out three candidate theories of economic growth, each consistent with the observation that people remain poor for an extended time, but each making a distinct, empirically testable prediction. This paper offers a first attempt at trying to establish which of those theories appears more consistent with observed household-level income and asset

[36] Freudenberger (1999) offers a hauntingly similar narrative of a vicious cycle wrought by local custom regarding funeral expenses. Based on participatory poverty assessments in forest communities in Fianarantsoa, she found that ritual slaughter of livestock in Bestileo culture had driven many families from stable livelihoods into destitution, as the loss of cattle reduced draught power and manure, both essential inputs to the intensive terraced rice cultivation practiced in these communities.

dynamics: (i) the canonical neoclassical growth model that implies convergence towards a unique dynamic equilibrium welfare level, (ii) the "club" or conditional convergence model that implies all units within a particular sub-population converge on a unique dynamic equilibrium, with variation across subpopulations in the standard-of-living associated with their equilibria, or (iii) a poverty traps model that implies that households face multiple dynamic equilibria and naturally grow towards the one associated with their initial wealth unless perturbed by a shock to the stock or productivity of their assets.

The results are striking. Our data from rural Kenya and Madagascar offer no support for the convergence hypothesis, on which most economic liberalization programs in the developing world were implicitly based in the 1980s and 1990s. Rather, there seems strong evidence in favor both of geographic poverty traps in less-favored areas, consistent with the conditional convergence hypothesis, and of poverty traps associated with low initial asset holdings, especially in lower potential and remoter regions. Both quantitative and qualitative evidence support these inferences.

Why might poverty traps exist? We offer a few tentative results in the direction of explaining this phenomenon, but we cannot confidently establish the causality behind these phenomena. We find evidence that considerable risk exposure leads to wealth-differentiated risk management, with the relatively wealthy able to smooth consumption and take on higher risk-higher return livelihoods. Meanwhile, poorer households have to destabilize consumption so as to protect scarce, crucial productive assets and they choose lower risk-lower return livelihoods. This predictably leads to observable divergence in growth trajectories.

We likewise find evidence that marginal returns on assets are positively correlated with initial wealth in some places and over some ranges of asset holdings. Such locally increasing returns also lead to divergent growth patterns and to poverty traps for those facing locally diminishing marginal returns on their meager asset stocks. This seems to occur because households with fewer productive assets tend to be excluded from higher-return livelihood strategies due to cash liquidity constraints, social exclusion, or both.

So what are the key policy implications of these findings? First, macroeconomic and sectoral reforms alone are likely insufficient to put poorer populations on sustainable growth trajectory. Less-favored areas and the poorest households need more direct intervention to build and protect assets and to improve the productivity of households' existing asset stocks, or to remove the barriers (e.g., access to credit, insurance and savings products) that exclude the poorest households and regions from accumulation processes. Such interventions can induce natural asset accumulation and income growth. The most appropriate assets to build will depend on local context. In the northern Kenyan rangelands, livestock are (not surprisingly) they key asset and our evidence suggests a critical threshold at 5-6 TLU per capita. In that context, it seems critical to build herds to that size, perhaps most cost-effectively by lowering the critical threshold through, for example, improved veterinary care, physical security of herds and herders, and dry season water availability. In the southern Madagascar highlands, it would appear the persistently poor could be helped considerably by improving preventive and curative health care so as to prevent households from losing precious adult workers, relieving seasonal liquidity constraints that impede uptake of improved rice production methods, and facilitating adoption and marketing of higher-value fruits, vegetables and dairy products.

Second, bifurcation in accumulation and risk management patterns must originate in one or more exclusionary process that prevents poorer households from choosing more remunerative livelihood strategies. Some of this exclusion may be geographic, as certain production strategies are infeasible in particular areas due to soil and hydrological conditions, available infrastructure, access to markets, and demand for skilled labor. In other cases, the exclusion may result from household-level barriers to entry associated with limited access to credit or insurance, educational attainment or other critical assets. We cannot probe these issues adequately here. Our objective, rather, is to call attention to the emerging evidence that poverty traps indeed seem to exist and we must redouble efforts to understand and combat them where they exist.

Third, effective safety nets to protect the assets households accumulate can prevent inadvertent back-sliding. Such safety nets need to be located strategically just above the critical asset thresholds at which expected income dynamics birfurcate. This calls for a somewhat broader conceptualization of safety nets than simply the nutrition-focused, food aid-based safety nets prevalent in policy discussions today. Protecting human health through adequate nutrition and ensuring children stay in school (e.g., through food-for-education projects) is indisputably important and may suffice where one need only maintain access to labor markets in order to grow out of poverty. But in most rural areas, health shocks largely unrelated to nutrition – e.g., HIV/AIDS, malaria, tuberculosis – are the most common reason households become and stay poor, underscoring the importance of preventive and curative health care quite apart from support for adequate access to food. Moreover, labor is not the only critical productive asset. A number of recent studies have pointed, in particular, to the importance of losses of livestock in explaining households' decline into poverty (Freudenberger 1998, Krishna et al. 2004, Kristjanson et al. 2004), results echoed in our own qualitative and quantitative results. This underscores the importance of developing insurance and other means to help poor households manage risk due to theft, climate and civil strife.

Much remains to be learned. Our results are by no means definitive. But they offer some innovative ways to investigate the causal mechanism underpinning chronic poverty in Africa and how communities, governments and donors can most effectively combat persistent poverty.

Figure 1: Survey Sites in Rural Kenya and Madagascar

Kenya | Madagascar

1 = Madzuu (Vihiga)

2 = Ng'ambo (Baringo)

3 = Dirib Gombo (Marsabit)

4 = Fianarantsoa

5 = Vakinankaratra

Figure 2: Annual average percent change in income, by site and resurveying interval

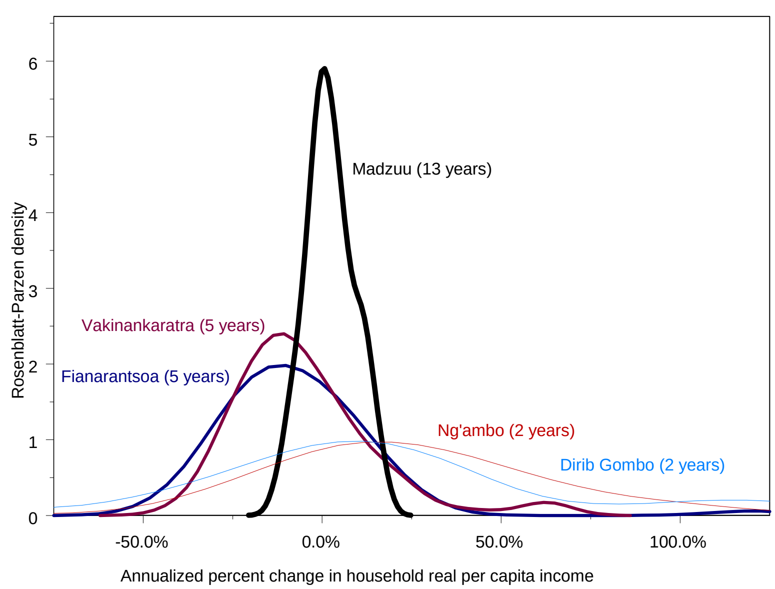
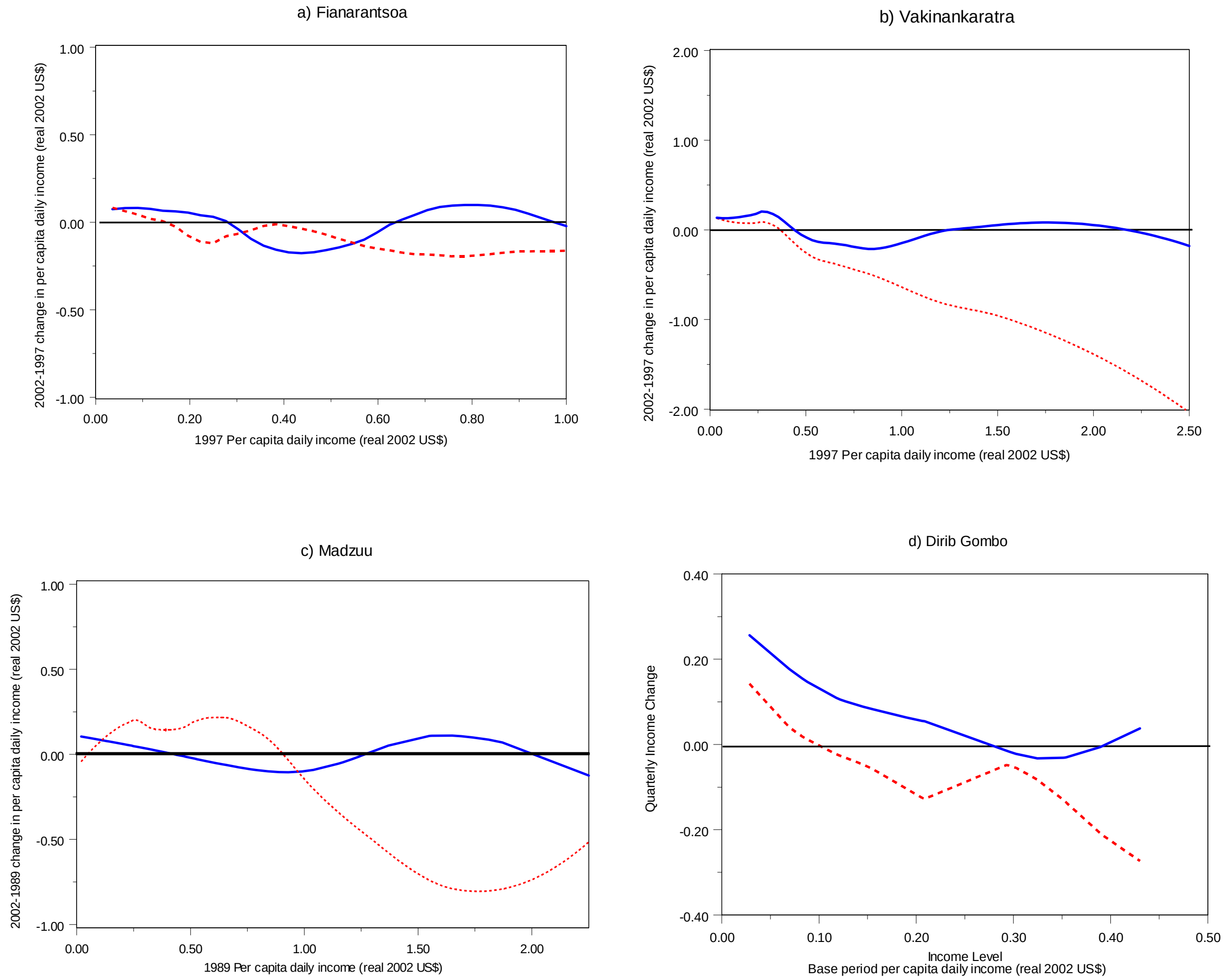
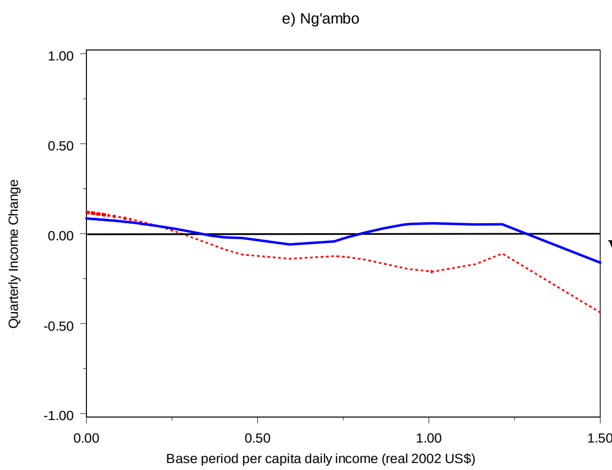


Figure 3: Site-specific filtered and structural income change regressions





In each panel, the red, dashed lines represent the unfiltered nonparametric regression of income change on beginning period income, while the blue, solid line represents the structural income dynamics regression of income change predicted econometrically from the regression of income on assets on beginning period income.

Figure 4: Wealth-dependent risk management in northern Kenya

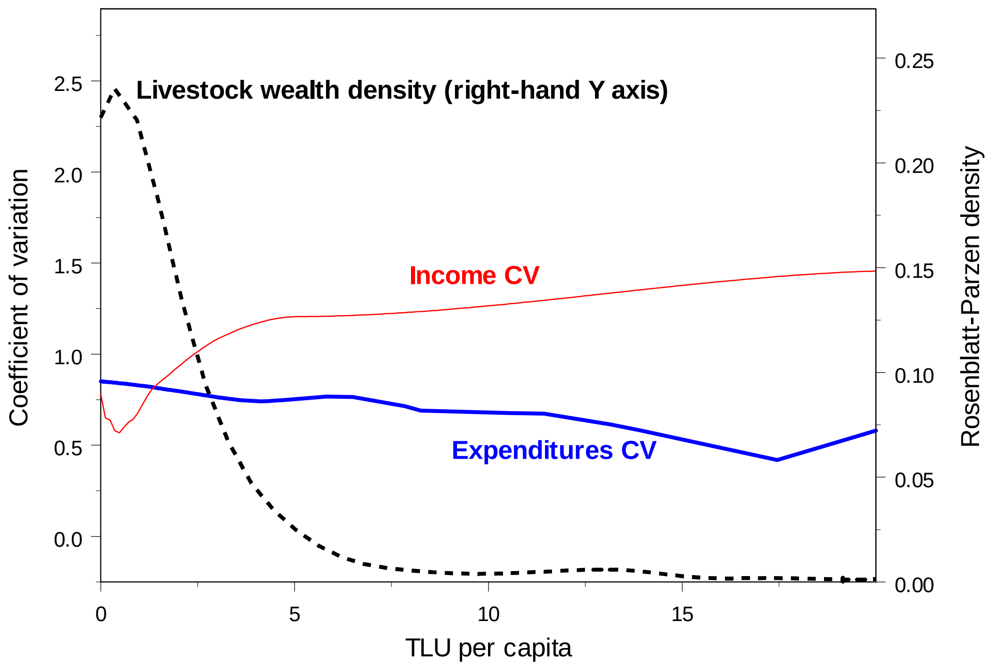


Figure 5: Welfare – Herd Size Relation in northern Kenya

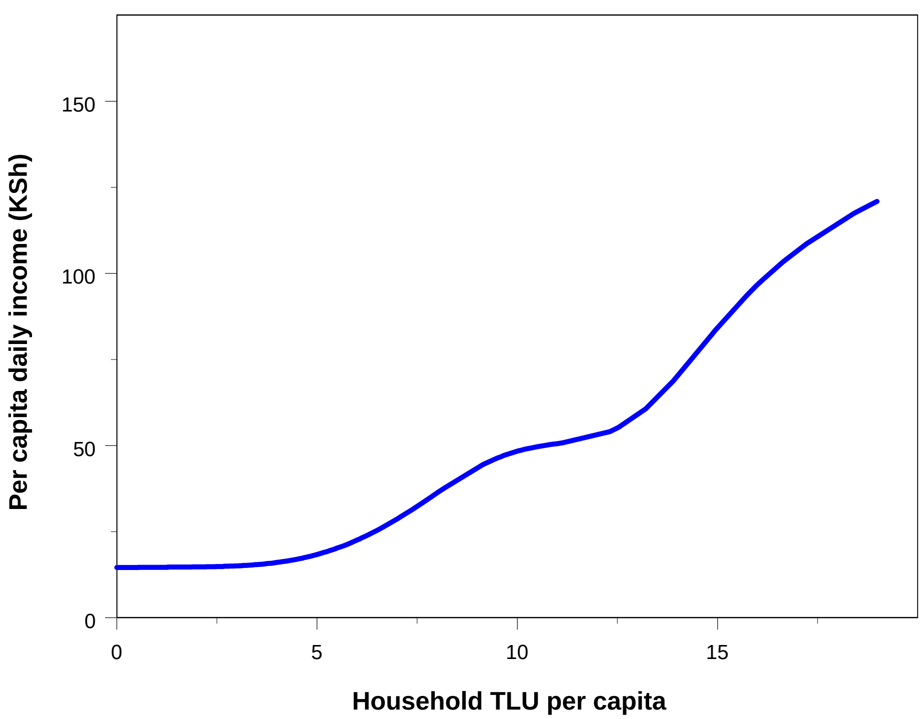
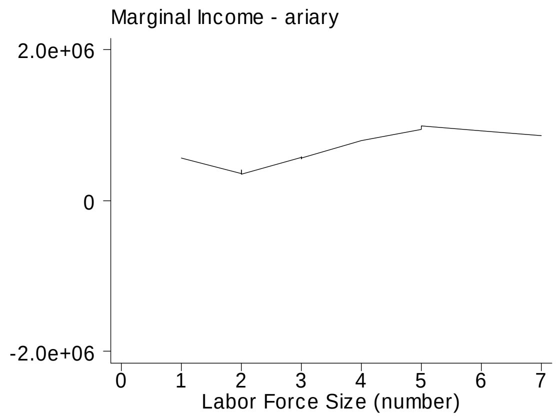


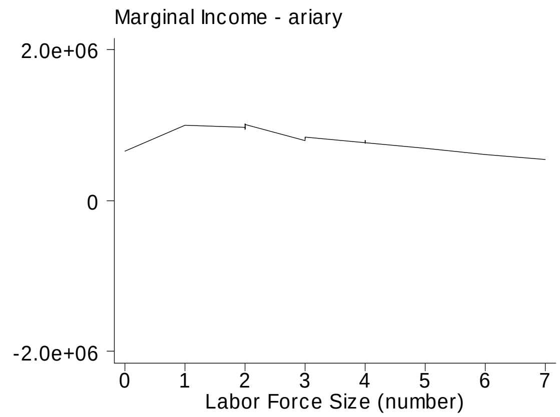
Figure 6: Estimated Site-and-Year-Specific Returns on Assets, Madagascar

Marginal Returns to Labor Force Size, 1997

Fianarantsoa

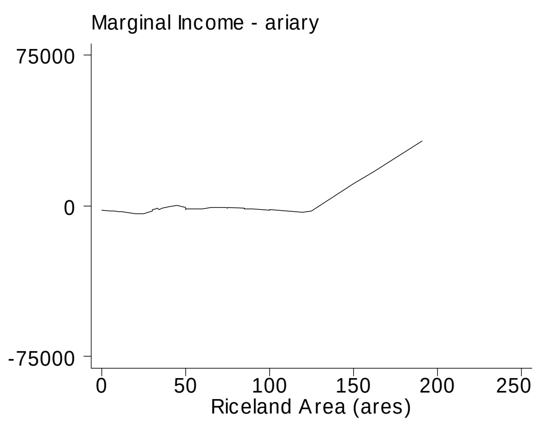


Vakinankaratra



Marginal Returns to Rice Land Area, 2002

Fianarantsoa



Vakinankaratra

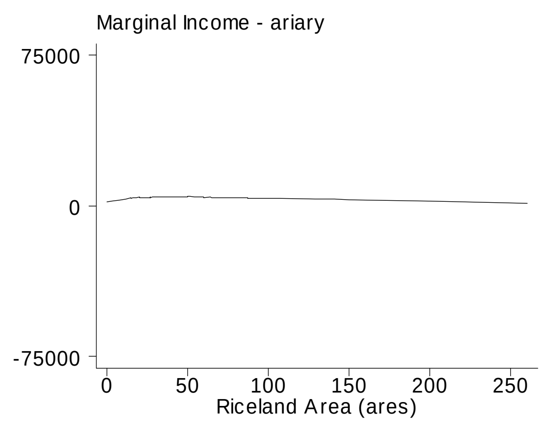


Figure 7: Herd Dynamics in Northern Kenya

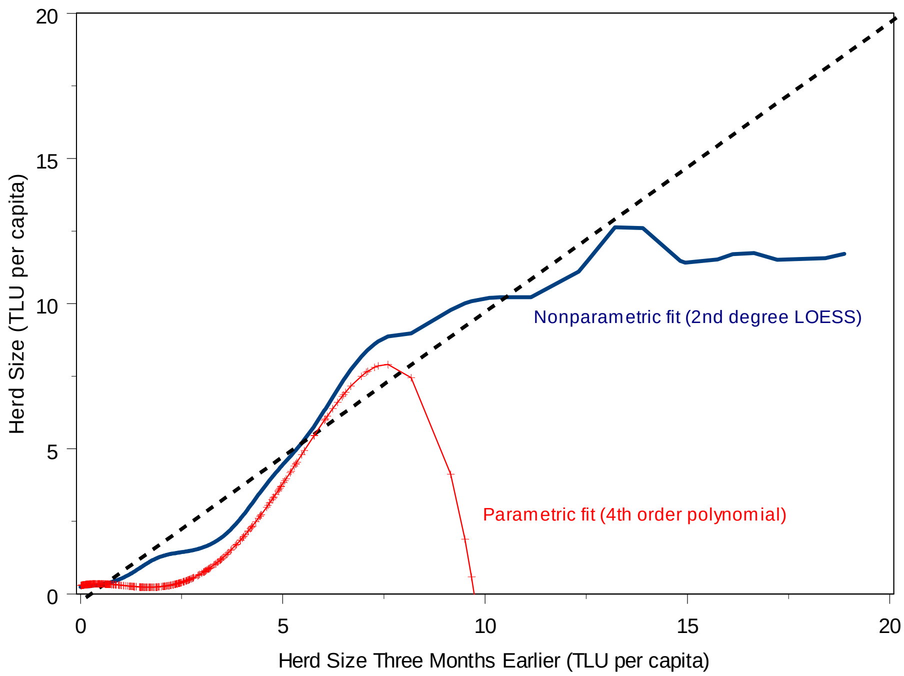


Figure 8: Asset Index Dynamics

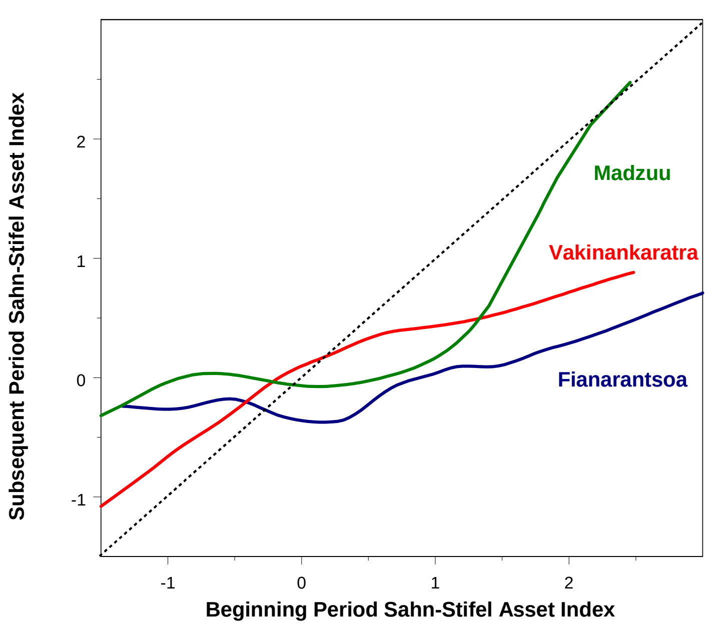


Figure 9: 2002 Income Distribution in Madzuu

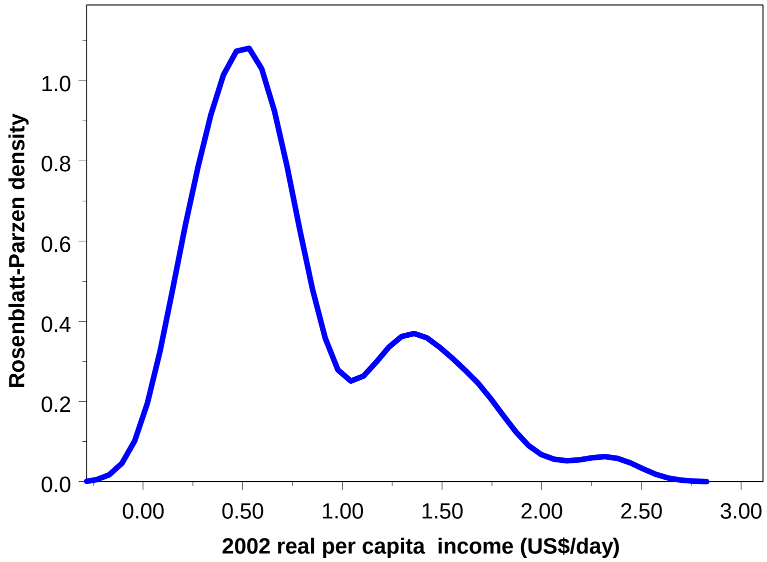


Table 1: Ultra-Poverty Transition Matrices
As measured against $0.50/day per capita income poverty line

	Poor in Subsequent Period		**Non-Poor in Subsequent Period**	
Poor in Initial Period	2000-2002 Dirib Gombo 100.0% **70.8%**	1989-2002 Madzuu 60.7% 1997-2002 Fianarantsoa 82.8%	2000-2002 Dirib Gombo 0.0% **11.2%**	1989-2002 Madzuu 20.2% 1997-2002 Fianarantsoa 10.3%
	2000-2002 Ng'ambo 86.5%	1997-2002 Vakinankaratra 58.5%	2000-2002 Ng'ambo 9.0%	1997-2002 Vakinankaratra 7.4%
Non-Poor in Initial Period	2000-2002 Dirib Gombo 0.0% **11.3%**	1989-2002 Madzuu 10.1% 1997-2002 Fianarantsoa 6.9%	2000-2002 Dirib Gombo 0.0% **6.8%**	1989-2002 Madzuu 9.0% 1997-2002 Fianarantsoa 0.0%
	2000-2002 Ng'ambo 0.0%	1997-2002 Vakinankaratra 22.3%	2000-2002 Ng'ambo 4.5%	1997-2002 Vakinankaratra 11.7%

Within each transition matrix cell, the sites are presented in a two-by-two matrix, with the upper left reflecting sites with poor agroecological conditions and market access (Dirib Gombo), those on the upper right having poor market access but favorable agroecological conditions (Fianarantsoa, Madzuu), that on the lower left having favorable market access but poor agroecological conditions (Ng'ambo), and those on the lower right having favorable agroecological conditions and market access both (Vakinankaratra).

Bold red underlined number is the weighted average across all sites.

Table 2: Estimated annual gross (net) poverty exit rates

Dirib Gombo:	0.0% (0.0%)
Madzuu:	2.2% (1.0%)
Fianarantsoa:	2.3% (0.7%)
Vakinankaratra:	2.4% (-4.2%)
Ng'ambo:	5.2% (4.1%)

Table 3: 1989 Mean Asset Holdings, Madzuu

	Chronically Poor	*Transient: Poor to Non-poor*	*Transient: Non-poor to poor*	*Non-Poor*
Farm size (acres)	*0.81*	*1.00*	*0.97*	*2.41**
Head of improved, cross-bred dairy cattle	*0.06*	*0.11*	*0.11*	*0.25**
Household includes secondary school graduate (1=yes, 0=no)	*0.44*	*0.44*	*0.44*	*0.88**
Family has off-farm employment earnings at least 10 months/year (1=yes, 0 =no)	*0.26*	*0.22*	*0.33*	*0.38*

* statistically significant differences at five percent level.

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