Journal of Development Economics 99 (2012) 255–264

Contents lists available at SciVerse ScienceDirect

Journal of Development Economics

journal homepage: www.elsevier.com/locate/devec

Consumption versus asset smoothing: testing the implications of poverty trap theory in Burkina Faso

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ARTICLE INFO

Article history:
Received 1 July 2010
Revised 3 February 2012
Accepted 6 February 2012

JEL codes:
D91
O11
O16

Keywords:
Consumption smoothing
Risk
Poverty dynamics
Permanent income hypothesis
Africa
Threshold estimation

ABSTRACT

Despite solid theoretical foundations for the notion that poor, borrowing-constrained households will intertemporally manage assets to smooth consumption, the consumption-smoothing hypothesis has not always withstood empirical scrutiny. This paper reassesses the intertemporal asset management problem with a poverty trap model and shows that we would expect to see asset smoothing, not consumption smoothing, in the neighborhood of critical asset levels at which optimal accumulation behavior bifurcates. We then employ threshold estimation techniques to empirically confirm the co-existence of consumption and asset smoothing regimes using a household panel data set from West Africa. Households above the estimated threshold almost completely insulate their consumption from weather shocks, whereas those below the threshold do not. These results not only indirectly provide evidence of the existence of poverty traps but also speak to the level and incidence of the costs of uninsured risk.

1. Introduction

Rural households in many parts of the developing world face large, uninsured fluctuations in their income streams.[1] From a policy perspective, the critical economic question is whether households can effectively manage these fluctuations or whether the costs of uninsured risk are high enough to motivate interventions to bolster insurance markets or create other risk management instruments. Since the poor typically have limited access to financial markets from which to borrow in case of need, consumption smoothing in these contexts would presumably involve building up asset stocks in good times and drawing them down in bad times. In theory at least, such asset management strategies should at modest cost protect households from consumption fluctuations (Deaton 1991). Poor households in particular, which are more likely to face binding borrowing constraints, would in theory be expected to prudentially hold adequate asset stocks to smooth consumption (Lee and Sawada 2010).

Despite these theoretical expectations, empirical evidence of this behavior among the poor has been mixed, and often suggests limited consumption smoothing. For example, Fafchamps et al. (1998) test whether livestock holdings are used to buffer transitory income shocks due to drought in Burkina Faso. They find that most households that sell livestock indeed do so to offset consumption shortfalls due to negative income shocks. However, when they use data from all households to test whether transitory shocks induce livestock sales, they find almost no evidence of the sort of systematic dis-saving that would be needed to smooth consumption. At best, only 15% to 30% of consumption shocks are on average buffered by livestock sales. Adding to the puzzle, Kazianga and Udry (2006) find using the same data that it is the rich, not the poor, who smooth consumption.

Part of what makes these results so puzzling is that the standard theoretical framework does not specify any alternative to consumption smoothing behavior. Our contention in this paper is that we need to begin with a richer theoretical framework that allows for alternatives to consumption smoothing motives if we are to make sense out of empirical findings such as those in the Burkina literature. If indeed there are multiple behavioral regimes, empirical tests that pool together observations to test for global consumption smoothing will be muddled, data-weighted averages of the behavior in the multiple regimes. More importantly, without clarity on these points, it is difficult to speak to the larger welfare questions concerning the importance of uninsured risk.

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[1] The ICRISAT village level studies in India (Rosenzweig and Binswanger 1993) and Burkina Faso (Carter 1997) both reveal coefficients of variation in agricultural income well in excess of 100%.

0304-3878/$ – see front matter
doi:10.1016/j.jdeveco.2012.02.003

After reviewing the standard theory of consumption smoothing in Section 2, we show in Section 3 that the value functions for dynamic models with poverty traps are not globally concave and that the future value of assets become extraordinarily high in the neighborhood of the critical asset levels around which accumulation dynamics bifurcate. As would be expected, in these critical neighborhoods, individuals will optimally asset smooth, not consumption smooth, when hit by economic shocks.

Armed with this insight, Sections 4 and 5 use the Burkina household data to test for asset and consumption smoothing regimes. Our core results, based on Hansen's (2000) threshold estimator, show that there is indeed a critical asset level that splits the sample into asset and consumption smoothers. Those above the threshold almost completely insulate consumption from weather shocks, whereas those below the threshold do not. These results not only indirectly provide evidence of the existence of poverty traps but also speak to the level and incidence of the costs of uninsured risk. Section 6 concludes the paper with thoughts on what might be done to reduce these costs.

2. The elusive search for consumption smoothing

Risk has long been a central preoccupation of development economics — particularly in rural agricultural settings. The obvious absence of insurance and other financial markets in low income areas, coupled with the equally obvious riskiness of agricultural production, underwrote the suspicion that risk could result in major welfare losses and stand as a major impediment to economic development as individuals might understandably shy away from mean income-increasing but riskier technological and market opportunities.[2] In addition to an outpouring of work on the effectiveness of informal risk-sharing mechanisms (Besley 1995, Fafchamps and Gubert 2007, Fafchamps and Lund 2003), these observations led to efforts to understand the capacity of financial market-constrained households to autarchically manage risk by accumulating assets in good years and liquidating them to keep consumption up (smooth) in bad years. As prelude to a deeper look at the intertemporal asset management of households, this section briefly reviews the standard theory of consumption and reviews the puzzling empirical evidence to date on West Africa.

2.1. Theoretical foundations

Deaton (1991) put forward the canonical model of the intertemporal choice problem of a household that faces a stochastic income stream but has no access to financial markets:

$$\max_{\{c,L\}} E_0\left\{\sum_{t=0}^{\infty}\left(\frac{1}{1+\delta}\right)^t u(c_t)\right\} \tag{1}$$
$$\text{subject to:}$$
$$x_t(\theta,L)=F(\theta_t)+rL_t+L_t$$
$$c_t\le x_t\ \forall t$$
$$L_{t+1}=x_t-c_t$$
$$L_t\ge 0\ \forall t$$

where c_t is household consumption in period t and L_t is the household's asset holdings. Cash-on-hand, x_t, is defined as the sum of current income plus the value of asset stocks. In Deaton's model, current income is composed of the returns to a production or earnings function F, which depends on a random variable θ_t, plus earnings on the asset stock which pays a fixed, per-period rate of return, r. The first inequality constraint simply requires consumption in each period to be no more than total cash on hand. The next period's assets are simply the difference between cash on hand and consumption. Finally, the non-negativity restriction on assets captures the borrowing constraint implicit in missing financial markets. In his paper, Deaton analyzes the case of impatient agents ($\delta > r$), an assumption which eliminates all incentives for savings but for the precautionary motive.

The first order necessary conditions to this intertemporal maximization problem imply consumption smoothing and behavior that tries to mimic that permanent income hypothesis:

$$u'(c_t)=\max\left\{u'(x_t),\beta E_t\left[u'(c_{t+1})\right]\right\} \tag{2}$$

where $\beta\equiv\frac{(1+\delta)}{(1+r)}<1$ under the assumption of impatience. As long as $u'(x_t)<\beta E_t[u'(c_{t+1})]$, this condition implies smooth consumption as assets will be managed to equate the marginal utility of current consumption to $\beta E_t[u'(c_{t+1})]$, which will be constant as long as shocks are independent and identically distributed (iid). When cash-on-hand is so scarce that $u'(x_t)>\beta E_t[u'(c_{t+1})]$, consumption will drop, though the household will get as close as possible to its long-term smooth consumption target by consuming all cash on hand ($c_{it}=x_{it}$.).

To facilitate comparison with later analysis, we can write the value function defined over the accumulable asset stock L as $J(L)$, and rewrite maximization problem (Eq. (1)) in Bellman equation form as:

$$J(L_{t+1})=\max_{c\le x}\left[u(c_t)+(1-\delta)^{-1}\int J[x_t-c_t]d\Phi(\theta)\right] \tag{3}$$

which yields the following interior first order condition:

$$u'=(1-\delta)^{-1}E\left[J'\right]. \tag{4}$$

Note that $E[J']$ captures expected value of assets carried forward to the stream of future well-being. As detailed by Deaton, under his assumptions, the value function J is monotonically increasing and concave in L and the expected marginal value of additional assets is strictly decreasing in L. As we shall see in the next section, poverty trap models break the monotonicity of J, implying sudden increases in the marginal value of assets and a shift from consumption smoothing to asset preservation or asset smoothing strategies.

2.2. Empirical dissonance on consumption smoothing

A number of studies have tried to test for consumption smoothing behavior. Two questions drive the structure of these tests: (1) how much of a positive income shock is consumed rather than saved? and (2) how much of a negative income shock is offset by liquidation of savings or assets? To address these questions, Paxson (1992a, 1992b) decomposes household income in Thailand into permanent, transitory and unexplained components using weather variability and then uses these to estimate the responsiveness of savings and consumption to these income components. Tests of consumption smoothing generally begin with similar income decompositions, and many use Paxson's original consumption function specification in these tests. Despite the theoretical expectation that the poor should be most damaged by consumption shortfalls and be more prudent in their savings behaviors, a number of studies show that poorer households fail to smooth consumption as well as richer households (e.g., Jalan and Ravallion 1999, Townsend 1994).

Recent empirical papers by Kurosaki (2006) and Verpoorten (2009) again find evidence that poor households fail to smooth consumption. Kurosaki's study of northern Pakistan reveals that structurally poor households exhibit excess sensitivity to income shocks. In an analysis of Rwanda, Verpoorten finds that while some households indeed seem to liquidate assets to offset income shocks and stabilize consumption, some households fail to sell assets, instead destabilizing

[2] Among other things, these observations have led agronomic researchers to search for 'pro-poor' seeds and technologies that reduce income fluctuation while still increasing the mean.

consumptions and preserving (smoothing) the assets they do have. Verpoorten suggests that the asset smoothing behavior of these households may reflect the vicissitudes of wartime Rwanda, in which Tutsi households were unable to safely market their cattle in order to smooth consumption.

While Verpoorten's observation could indeed explain asset smoothing in Rwanda, no such ready explanation exists to explain the reluctance of Burkina households to sell cattle in the face of income shocks in the data to be analyzed in this paper. In an important earlier paper that also examined this Burkina data, Fafchamps, et al. (1998) found that amongst those who chose to sell cattle in times of drought, most reported doing so in order to smooth consumption. While these descriptive data show precisely what would be expected from the canonical consumption-smoothing model, predictions of that model fail when they apply it to the full set of data, meaning both to households that chose to sell assets and those that did not. If anything, these results seem to suggest that there are multiple regimes in the data, with some households selling assets to smooth consumption, and others not.

In a follow-up, Kazianga and Udry (2006) follow the suggestion in some of the earlier empirical literature and try to identify multiple response regimes by splitting the data into rich and poor households. Similar to other empirical contributions to this literature, they do not offer a theoretical model that underwrites the idea that consumption smoothing is an unaffordable luxury for the poor. Nonetheless, Kazianga and Udry do find that this ad hoc division of the data around a poverty line indeed identifies two behavioral regimes: non-poor households who respond to shocks by selling assets, and poor households who do not (despite still having assets that could be liquidated). While an important addition to the empirical work on consumption smoothing, this work fails to provide a fully cogent explanation about what is going on and why the empirical search for consumption smoothing amongst poor households has proven so elusive.

3. Asset smoothing and poverty traps

While the intertemporal problem in Eq. (1) above implies that households will try to smooth consumption through savings, not all models of intertemporal utility maximization have this implication. Deaton extends the model above to consider the case in which the income generation process is not iid, but instead follows a first order autoregressive process. If the autocorrelation parameter is positive (a negative income shock this year predicts a negative income shock next year), then Deaton shows that dynamically rational households will depart from the unconditional consumption smoothing in expectation represented by expression (2). In particular, households in this context will engage in asset smoothing of sorts (and consumption destabilization), as they will hold on to and carry forward assets this year in anticipation of a continuing sequence of bad years in the future. Deaton's simulation analysis reveals that liquidity-constrained households suffer much more highly variable consumption in this AR(1) than in the iid case. To quantify this effect, we define the smoothing ratio to be $s=1-(cv_c/cv_f)$ where cv_c and cv_f are the coefficient of variation for consumption and income, respectively, and $s=1(0)$ indicates complete (no) consumption smoothing.[3] In Deaton's AR(1) simulations, this smoothing ratio falls from 50% to 22% as the first order autoregression coefficient rises from 0 (the iid case) to 0.7.

While the existence of an autoregressive process could explain asset smoothing behavior, it seems unlikely to explain the finding of Kazianga and Udry and others who have found that the rich smooth consumption, while the poor sometimes smooth assets. If the poor somehow imagined themselves in an AR(1) world, and the rich thought they lived in an iid world, then perhaps the augmented Deaton model could explain these empirical findings. However, such an explanation seems quite unlikely as the wealthy and less wealthy households occupy the same village space in the studies under consideration. We turn instead to an alternative class of intertemporal models to search for an explanation for the local coexistence of asset smoothing and consumption smoothing.

3.1. Theoretical foundations for the coexistence of consumption and asset smoothing

Consumption and asset smoothing can structurally coexist in multiple equilibria, poverty trap models (a poverty trap model is one that admits both a high-income equilibrium as well as a low-income, poverty trap, equilibrium). In such models, for some wealth levels, the future economic value of assets swamps their value current consumption smoothing value, leading optimizing agents to protect or smooth assets in the face of shocks and let their consumption fluctuate with the shock.[4] A key feature of these models is what Zimmerman and Carter label the Micawber Threshold, meaning the asset level around which dynamic behavior bifurcates. In the vicinity of this threshold, incremental assets are strategically valuable as they determine whether the household tends over time to the upper or lower equilibrium. Intuitively, one might expect to observe the asset smoothing behavior in the vicinity of these critical thresholds.

To more thoroughly explore this intuition, consider the following poverty trap model adapted from Barrett et al. (2011), hereafter denoted BCI:

$$\max_{\{\boldsymbol{c},\boldsymbol{L}\}} E_0\left\{\sum_{t=0}^{\infty}\left(\frac{1}{1+\delta}\right)^t u(c_t)\right\}$$
$$\begin{aligned} &\textit{subject to}: \\ &x_t(L,\theta)\equiv F(L_t)+(1-\tau)\theta_t L_t \\ &F(L_t)=\max\left[F^h(L_t),F^\ell(L_t)\right] \\ &c_t\le x_t \\ &L_{t+1}=x_t-c_t \\ &L_t\ge 0\ \forall t \end{aligned} \tag{5}$$

While fundamentally similar to the Deaton model discussed above, this model assumes that assets are not simply a buffer stock that generate a constant return r, but are instead productive assets that generate positive but diminishing returns. Under the usual assumptions that returns to assets approach infinity as the stock of assets drops to zero, agents in this model will be patient (up to a point), willingly accumulating assets for productive as well as for precautionary motives.

In addition, the model assumes that individuals have access to a high and a low productivity technology. Marginal returns to assets are always greater under the 'high' than in the 'low' technology: $\frac{\partial F^h}{\partial L}\ge\frac{\partial F^\ell}{\partial L}$. However, the high technology is subject to fixed costs such that total output is higher under the low technology until a minimum level of capital, $\tilde{L}$, is reached: $F^\ell(L)\ge F^h(L)\forall L\le\tilde{L}$. These assumptions create a discontinuous jump in the marginal returns to assets at the point $\tilde{L}$. In addition, as written the model assumes that assets depreciate at the rate τ and that shocks directly hit assets, rather than income. While this stochastic specification appears at odds with the Deaton and other classical formations, it is the realized sum of income

[3] Although we conventionally expect $0\le s\le 1$, it is of course theoretically possible for this smoothing ratio to be negative (e.g., if preserving assets in the wake of a negative income shock requires additional investments such that consumption is more volatile than income) or greater than one.

[4] Underlying these models is either a fixed cost or other non-convexity in the process that generates income from assets (Banerjee and Newman 1994, Barrett et al., 2011, Buera 2009), a non-convexity in the functional relationship between consumption and work capacity (Ray and Streufert 1993), or preference non-convexities that result from utility penalties that take place when consumption falls below a subsistence level (Zimmerman and Carter 2003).

and wealth, or cash-on-hand, $x_t(L,\theta)$, which constrains consumption choice. In both this and the Deaton model cash-on-hand depends on the stochastic factor, θ_t, asset stocks, and the earnings technology parameters.

The logic of this model, and its implication for consumption smoothing and stochastic asset management, can be most easily appreciated by examining it in Bellman equation form. The Bellman equation for the poverty trap maximization problem in Eq. (5) is identical to the expression (Eq. (3)) above, yielding the same first order condition (Eq. (4)) in which the marginal utility of current consumption is equated to the expected future value of holding assets. However, in contrast to the Deaton model, the value function J is no longer concave in assets. This feature and its analytic implications can be most easily appreciated by graphing this first order condition for a specific numerical specification of the BCI model.[5]

In Fig. 1, the (mostly) downward sloping line is the slope of the derivative of the value function ($E[J']$) with respect to assets carried over to the next time period. As can be seen, $E[J']$ suddenly increases at around 4 units of capital. This sudden increase in the marginal value of accumulation reflects the fact that beyond that point, it becomes dynamically rational for the individual to strive to attain the high-level steady state asset holding (i.e., this asset level defines the Micawber Threshold where dynamics bifurcate). At that point, marginal assets become extremely valuable as they determine the difference between a future at the low-level poverty trap equilibrium versus one at the high level equilibrium. Put differently, the incremental value of assets at this point reflects not only the additional immediate income that can be generated with the assets, but also the strategic value that attaches to the capacity to move forward over time to a higher standard of living. We would expect that individuals in this area would be willing to make substantial sacrifices of consumption to increase assets, and to pay a substantial penalty in terms of unsmooth consumption to protect assets and avoid falling below the critical asset threshold.

Fig. 1 also graphs the marginal utility of consumption for individuals with different wealth levels. The solid red curve shows this period's marginal utility of consumption (as a function of assets carried forward to next period) for an individual who begins with 11.5 units of the asset (at the steady state for the high income equilibrium). The solid green line shows the position of an individual who begins with 5.5 units of the asset (just above the Micawber threshold in this model). The intersection of these curves with value function curve identifies optimal behavior that fulfills first order condition (Eq. (4)). As can be seen, the initially wealthier individual will carry forward 11.5 units of the asset, reflecting the steady state position.

The broken lines show what happens to marginal utility curves when each household receives a shock that reduces its cash-on-hand by about 8%. The marginal utility curves shift to the northwest, as attaining the same level of capital stock next period requires a much greater level of savings (and reduced consumption) than what would have been needed prior to the negative shock. Intersections with the marginal value function curve again identify dynamically optimal behavior following the shock.

As is visually apparent from the diagram, the marginal utility of consumption for the initially wealthier individual optimally increases very little following the shock. More specifically, in response to the 8% cash-on-hand shock, the initially wealthier household will carry forward 10% less livestock than they began with. In contrast, the marginal utility of consumption jumps more sharply for the initially poorer household that will optimally respond to the 8% shock by carrying forward only 5% fewer assets than the pre-shock level. In short, the initially poorer household responds to the shock by protecting its

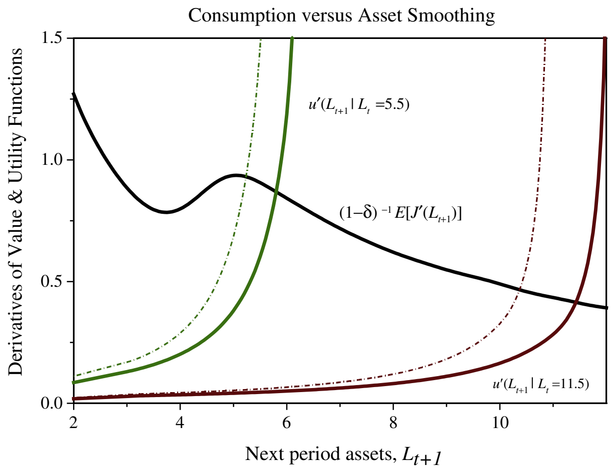

Fig. 1. Marginal intertemporal value and utility curves as a function of next period asset stock. The wiggle in the marginal value function with asset dynamics (solid downward sloping line) indicates the increased value of assets at the dynamic threshold. Marginal utility curves are drawn for high and low current asset levels. Dashed marginal utility curves indicate marginal utility after 10% reduction in assets.

assets, whereas the wealthier household draws its stocks down more liberally.

The operational logic driving this asset protection behavior is that the initially poorer household is highly vulnerable to further asset losses that would push the household below the Micawber Threshold and towards a long-run equilibrium of low living standards. In contrast to the Deaton model (which exhibits a monotonic value function), savings and assets become extraordinarily valuable in some portions of the asset space, allowing asset protection or smoothing behaviors to coexist with consumption smoothing, even when all individuals have the same expectations about the stochastic process (iid, in this case).

In the BCI model, asset smoothing characterizes the behavior of agents whose asset stocks are substantially below the steady state level associated with the high-returning technology. These agents have strong incentives to accumulate assets rapidly lest they suffer further shocks and fall below the critical Micawber threshold where they collapse to the low-level equilibrium. As a result, they are willing to pay a high price in terms of low consumption levels to hold on to the assets they have.[6] While this model implies that asset-smoothing is an out of equilibrium behavior, asset smoothing as an equilibrium behavior emerges in the somewhat more complex poverty trap model of Zimmerman and Carter (2003). The Zimmerman and Carter (ZC) model allows households to accumulate a productive asset as well as the directly consumable buffer asset of the sort considered by Deaton. The ZC model also allows shocks to contain a covariant component, as well as the utility penalty mentioned above.

Leaving expositional details to the ZC paper, their key result for the analysis here is that two distinctive portfolio and portfolio management strategies emerge in the ZC model: An entrepreneurial portfolio characterized by consumption smoothing and a defensive portfolio characterized by asset smoothing. Productive assets predominate in the former portfolio, which is pursued by individuals who begin above a minimum wealth level. Despite the fact that ZC calibrate a stochastic simulation based on the extreme risk levels of rural Burkina Faso, the long-term smoothing ratio for these initially richer individuals is 66%. In contrast, those individuals who gravitate toward the defensive portfolio largely

[5] See Barrett et al. (2011) for details.

[6] Note that by the same logic, asset protection would be observed in a single technology, stochastic Ramsey model for individuals who are far from their desired steady state.

hold their wealth in the form of buffer assets (implying that they smooth income) and they never sell their modest productive assets in response to a shock. To the extent that these households do consumption smooth, they do so by selling units of the buffer asset. The net result is a smoothing ratio of only 33% in the ZC simulations for households that manage the defensive portfolio. In contrast to the one asset BCI model which suggests a continuum of asset to consumption smoothers, the ZC model suggests the emergence of two distinctive strategy groups. In the empirical analysis to follow, we will look for evidence of both types of asset smoothing.

3.2. Empirical evidence on poverty traps

Before turning to a more complete test of asset smoothing, we review briefly the empirical literature that has tested for poverty traps. To date, there have been few empirical tests of asset smoothing, in part because much of the literature on consumption smoothing has not had in mind any well-formed alternative to the canonical consumption smoothing model discussed in Section 2. As one exception, McPeak (2004) analyzes consumption smoothing among Kenyan pastoralists and formulates an explanation for limited smoothing based on the dynamic management of livestock as a productive asset that produces future income. We aim to build on this study, which empirically characterizes income and asset shocks in this setting and assess their impact on household consumption behavior, by using a more explicit theoretical framework to contrast consumption and asset smoothing.

There is a somewhat larger empirical literature that looks for evidence of poverty traps. One such approach has directly examined asset dynamics in an effort to identify the Micawber threshold around which accumulation strategies bifurcate (e.g., Adato et al., 2006, Barrett, et al. 2006, Carter, et al. 2007, Lybbert, et al. 2004). The search for a repelling threshold may seem like an empirical long shot since one might think that the area around the threshold would necessarily be sparsely populated. Yet, a sufficiently stochastic system will be constantly repopulating the area around the threshold, making it detectable, at least in principle.

As an alternative to a direct empirical approach to detecting a Micawber threshold, the ZC model suggests that its existence can be inferred from observing coping strategies. Moreover, when it comes to smoothing strategies shaped by poverty traps, a deeper insight arises from a comparison of models: whereas single asset models allow for asset smoothing as a disequilibrium response, the two asset ZC model turns asset smoothing into an equilibrium coping strategy. In this vein, Barrett et al. (2006) find descriptive evidence that is consistent with asset smoothing and poverty traps. Among the very poor in northern Kenya, these authors find that the coefficient of variation of income is less than the coefficient of variation of expenditure, but for the rest of their sample income is more variable than expenditure. Taking an approach that infers the presence of thresholds from preference estimates rather than coping strategies, Lybbert and McPeak (2012) estimate relative risk aversion and the elasticity of intertemporal substitution directly using an Epstein and Zin (1991) recursive utility function and find that the poor (also in northern Kenya) are simultaneously more risk averse and more willing to destabilize consumption than the relatively rich. Similarly, in an analysis of a long-term panel data from Zimbabwe, Hoddinott (2006) finds consumption smoothing by households that have sufficient animals to insure that they can plow their fields the next year, whereas those who are at that threshold asset smooth, destabilizing consumption, in the face of rainfall shocks. Finally, in an analysis that is complementary to that presented here, Santos and Barrett (2011) find that sampled households in southern Ethiopia are reluctant to informally lend to neighbors whose assets have been driven too low, presumably because they recognize that those neighbors are collapsing to a low-level equilibrium and will be unable in the future to reciprocate in future times of need.

Table 1
Means of key household variables by region with standard deviations in parentheses (1982–84).

	Region					
	Sahelian		Sudanian		Guinean	
Annual Rainfall (mm)	350.4	(59.8)	502.5	(66.0)	695.7	(77.5)
Cultivated area (ha)	6.6	(4.1)	5.9	(4.1)	7.3	(5.1)
Adult equivalents	7.8	(4.5)	9.3	(5.6)	10.5	(7.4)
Crop income (000 CFA)	16.2	(12.0)	15.1	(7.8)	26.0	(22.3)
Herd size (TLU)	12.7	(20.5)	8.3	(29.5)	13.2	(34.2)
Net livestock sales (000 CFA)	2.3	(8.1)	0.47	(4.7)	3.1	(23.0)
N =	126		108		147	

4. Data and income decomposition

To estimate the consumption and livestock sales equations specified above and the associated smoothing threshold, we use data from rural Burkina Faso collected from 1981 to 1985 by the International Crop Research Institute for the Semi-Arid Tropics (ICRISAT). This panel dataset was constructed using household surveys across three distinct agro-climatic zones (Sahelian, Sudanian, Guinean), which vary in rainfall patterns, soil types and population densities. In each of these zones, two villages were included in the sampling frame, each with roughly 25 households selected into the survey. This panel dataset spans the drought of 1984, which makes it an excellent dataset for studying risk.

Carter (1997) extensively studies the extent of production risk in this system, but does not explore the degree to which individuals are able to buffer such shocks with asset management strategies. Subsequent studies explicitly study the extent which households use assets to smooth consumption in response to stochastic shocks (e.g., Fafchamps et al., 1998, Kazianga and Udry 2006). For a detailed description of the survey, sample, and data, we refer interested readers to Malton (1988) and Malton and Fafchamps (1989). Given these complete descriptions of the data, we present descriptive statistics for only a small set of key variables (Table 1).

We begin our analysis by decomposing observed household income into permanent, transitory and unexplained income components. The basis of this decomposition is a computed measure of crop profit that values plot-level crop production at prevailing market prices, aggregates this value across plots and crops for each household and season, and then deducts the total cost inputs purchased by the household that season.[7] Building on Paxson (1992a, 1992b) and following the approach of Kazianga and Udry (2006), we decompose income by estimating a quasi-crop profit function specified as follows:

$$\pi_{ivt} = \boldsymbol{\alpha_1}'\mathbf{z_{ivt}} + \boldsymbol{\alpha_2}'\mathbf{F_{vt}X_{ivt}} + \alpha_v F_{vt} + \gamma_i + \gamma_{vt} + \varepsilon_{ivt} \tag{6}$$

where π_{ivt} is crop profit for household i in village v in year t, $\mathbf{z_{ivt}}$ is a vector of household demographic variables, $\mathbf{X_{ivt}}$ is a vector of variables indicating the amount of land cultivated by household i by slope and soil type, F_{vt} is a rainfall variable measured as the deviation of rainfall from its long-run village average, γ_i is a household fixed effect, γ_{vt} is a village-year fixed effect, and ε_{ivt} is the error term. The fixed effects included in this specification play important roles. The household fixed effect controls for a variety of fixed factors that shape its crop profit, including permanent features of the structure of its productive activities (e.g., crop-livestock mix, livestock mix) and any time–invariant interactions between household labor composition and its productive assets. Instead of including prices as arguments, the typical practice with profit functions, this quasi-profit specification uses village-year fixed effects to control for prices.

[7] This crop profit measure does not account for family or hired labor costs and is therefore denoted as 'crop' profit instead of 'farm' profit.

Table 2
Crop income regression used to extract household income components.

Transitory income components				Permanent income components		
		Coefficient	(Std. error)		Coefficient	(Std. error)
Rainfall (deviation from long run average)		0.10***	(0.02)	Age HH head	−0.3	(0.53)
Rainfall interactions	*Seno* soil area	0.17***	(0.04)	Age	0.006	(0.01)
	Zinka soil area	0.09	(0.06)	HH size	−0.29	(0.57)
	Bissiga soil area	0.04	(0.04)	Adult males	−1.17	(1.41)
	Raspuiga soil area	0.14**	(0.09)	Adult females	−0.72	(1.71)
	Ziniare soil area	0.05	(0.05)	Boys (age 7–14)	−0.41	(1.41)
	Other soil area	0.01	(0.02)	Girls (age 7–14)	−1.01	(1.57)
	Low land area	−0.16***	(0.02)	Constant	20.9**	(12.80)
	Near low land area	−0.13***	(0.02)	*HH fixed effects included*		
	Midslope area	−0.07***	(0.02)			
	Near upland area	−0.04	(0.07)			
	Near home area	−0.005	(0.02)	R-squared	0.59	
	Distance to home	−0.02	(0.03)	Observations	464	
Village-year fixed effects included				Number of HHs	126	

*** p<0.05.
** p<0.1.
* p<0.15.

After estimating the coefficients in this farm profit model, we can decompose income as follows:

$$\begin{aligned} \textit{Permanent Income}_{ivt} &= y^P_{ivt} = \boldsymbol{\alpha_1}'\mathbf{z_{ivt}} + \gamma_i \\ \textit{Transitory Income}_{ivt} &= y^T_{ivt} = \boldsymbol{\alpha_2}'\mathbf{F_{vt}X_{ivt}} + \alpha_v F_{vt} + \gamma_{vt} \\ \textit{Unexplained Income}_{ivt} &= y^U_{ivt} = \varepsilon_{ivt}. \end{aligned} \tag{7}$$

Table 2 displays the results from estimating the quasi-farm profit function in Eq. (6), a few of which are worth highlighting. The importance of rainfall in determining crop income is apparent. The R squared is 0.59, suggesting that a substantial share of household crop income is unexplained in this risky environment. Most of the income variability that is picked up by the permanent components is attributed to household fixed effects (not shown).

On the basis of these estimates, we decompose farm profit for each household and each year using the equations in Eq. (7) and display these components graphically in Fig. 2. This figure clearly depicts both the poverty and vulnerability of the households included in this sample. The absolute poverty level of the households is evident in the position of the permanent income distribution relative to the dollar-a-day poverty line. Specifically, the mass of permanent income (across households and years) clearly lies below this poverty line. The vulnerability of these households is evident in the substantial variance of the distribution of transitory income, which can be negative and substantial during especially bad years. The tri-modal distribution of transitory income indicates important regional differences in income shocks, which are largely driven by regional rainfall differences. The aggregate distributions in Fig. 2 suggest that the households are exposed to significant livelihood risks, which makes their intertermporal coping strategies particularly important.

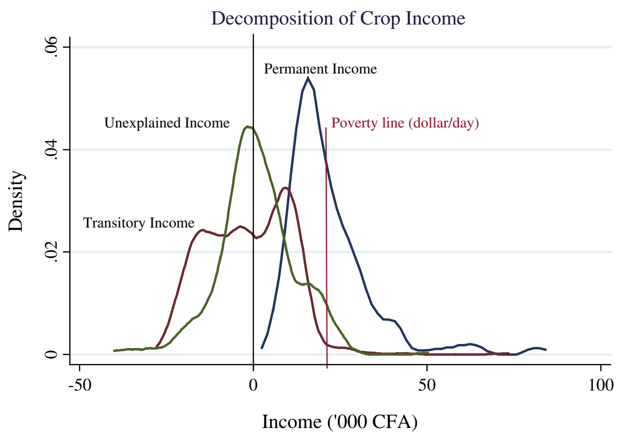

Fig. 2. Kernel densities of crop income components.

5. Discerning asset smoothing from consumption smoothing

Following the work by Paxson (1992a, 1992b), income components as constructed in the previous section are often used to test for consumption smoothing. Kazianga and Udry (2006) use these components to estimate a consumption function and conclude that roughly half of transitory income shocks are passed on to consumption changes. We take this standard incomplete consumption smoothing result as our point of departure and test for patterns of smoothing that are consistent with asset smoothing as outlined above.

We begin with a descriptive test of these smoothing patterns. Specifically, we non-parametrically regress net livestock sales ('000 CFA) on crop income shocks ('000 CFA) by herd size quartile (excluding households without livestock). In such a regression, a slope of −1 indicates complete smoothing from livestock sales and purchases. The results, shown in Fig. 3, provide a striking consumption smoothing pattern. Although the regressions for the first, second and third herd size quartiles do show a livestock sales response to negative income shocks, these responses are swamped by the magnitude of the fourth quartile reaction, which is indistinguishable from complete smoothing over much of the negative income shock range. Relatively low total herd values (i.e., stock-out values) among the lower herd quartiles do not appear to drive this pattern: the stock-out value is over 10,000 CFA and 30,000 CFA for the 10th and 25th percentiles, respectively, suggesting that even livestock poor households could offset a negative income shock entirely if they wanted to.

While the pattern in Fig. 3 clearly suggests the presence of two distinct behavioral regimes, this is only descriptive evidence. As the first step in a more rigorous test, we compare smoothing patterns that treat drawing down a productive asset such as livestock differently than consuming a non-productive asset such as grain stocks (a la Zimmerman and Carter). Ultimately, we wish to estimate a parallel specification for both net livestock sales and net consumption of grain stocks as follows:

$$\begin{aligned} \textit{Net Livestock Sales}_{ivt} &= \beta_1 y^P_{ivt} + \beta_2 y^T_{ivt} + \beta_3 y^U_{ivt} + \gamma_i + \varepsilon_{ivt} \\ \textit{Net Consumption of Grain Stocks}_{ivt} &= \beta^g_1 y^P_{ivt} + \beta^g_2 y^T_{ivt} + \beta^g_3 y^U_{ivt} + \gamma^g_i + \varepsilon^g_{ivt}. \end{aligned} \tag{8}$$

Tests of consumption smoothing hinge on the estimated coefficients on transitory income. Specifically, testing the hypotheses

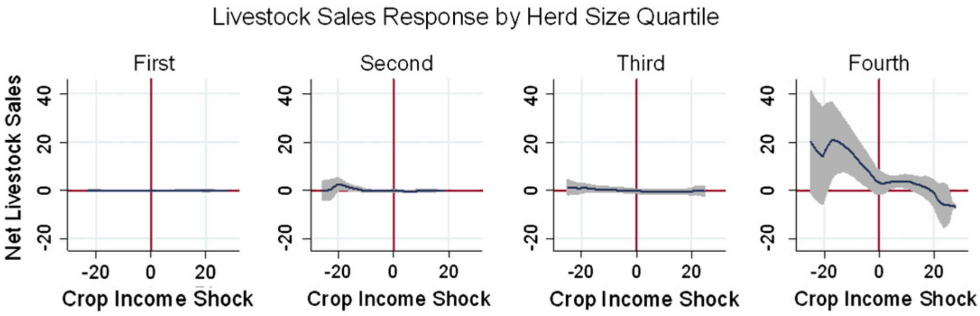

Fig. 3. Nonparametric regression of net livestock sales ('000 CFA) on transitory plus unexplained crop income shock ('000 CFA) by beginning period herd size quartile with 90% confidence interval.

$H_0: \beta_2 = 0, H_A: \beta_2 < 0$ is a test that households use livestock as a buffer stock to smooth consumption during transitorily bad production years. Since livestock sales and transitory income are both measured in 1000 CFA, testing the hypotheses $H_0: \beta_2 = -1, H_A: \beta_2 > -1$ is a test of the null of complete consumption smoothing using livestock. Since the same interpretation applies to grain stocks consumption, the ratio β_2/β_2^g indicates the importance of livestock sales relative to grain stocks consumption as a smoothing strategy.

While the focus in the literature is squarely on transitory income in specifications such as these, unexplained income – which contains real permanent and transitory components as well as statistical errors – may also merit attention (see Paxson, 1992a, 1992b p.27 for some discussion). Focusing exclusively on transitory income and ignoring unexplained income may be well justified if unexplained income, which is simply the residual from the income decomposition in Eq. (7), can be largely attributed to measurement or other data errors. If, however, unexplained income includes realized household income that we do not capture because of omitted transitory variables in the income decomposition, this income component may represent a realized income shock to the household that is indistinguishable from our transitory income construct from the perspective of the household. For example, the specification in Eq. (6) cannot capture crop losses due to weed infestations that may be idiosyncratic due to differential access to weeding labor during critical periods of the growing season. We use these two opposing interpretations of unexplained income to place bounds on households' responsiveness to income shocks. Thus, we estimate the equations in Eq. (8) with transitory and unexplained income components *combined* to provide a second bound on their responsiveness.

The theory of asset smoothing predicts that productive assets drive smoothing tendencies, so we aim to discern different smoothing regimes in net livestock sales. We use Hansen's (2000) threshold estimation technique to test for the presence of a threshold that splits our sample into two meaningfully different livestock sales regimes and to estimate the location of such a threshold. We search for the presence and location of such a threshold using beginning of season herd size measured in Tropical Livestock Units[8] (TLU). Conditional on finding a threshold and estimating its location in herd size space as L^*, we are then able to estimate a more flexible version of Eq. (8):

$$Net\,Livestock\,Sales_{ivt} = \begin{cases} \beta_1^h y_{ivt}^P + \beta_2^h y_{ivt}^T + \beta_3^h y_{ivt}^U (+\gamma_i) + \varepsilon_{ivt} \text{ if } L_i \geq L^* \\ \beta_1^\ell y_{ivt}^P + \beta_2^\ell y_{ivt}^T + \beta_3^\ell y_{ivt}^U (+\gamma_i) + \varepsilon_{ivt} \text{ if } L_i < L^* \end{cases} \quad (9)$$

where h and ℓ superscripts denote coefficients for the subset of households above and below the estimated threshold, respectively. Compared to the arbitrary quartiles used to split our sample in Fig. 3, this threshold estimation approach allows us to more precisely identify and to statistically test for distinct behavioral regimes. We estimate Eq. (9) with and without household fixed effects (γ_i) since both between and within household variation may be important to identifying the consumption smoothing response. In this specification, testing the hypotheses $H_0: \beta_2^h = \beta_2^\ell = 0, H_A: \beta_2^h < \beta_2^\ell \leq 0$ is a test for a consumption smoothing pattern that is consistent with dynamic asset smoothing. Such a result may further suggest that L^* represents a dynamic asset threshold as perceived by households.

There is evidence that dynamic livestock thresholds may exist (e.g., Barrett, et al. 2006, Lybbert, et al. 2004), but there is no similar evidence that dynamic grain stock thresholds exist. Thus, our empirical approach allows dynamic thresholds to directly influence livestock sales in response to income shocks, but disallows a direct dynamic threshold effect on consumption from grain stocks. Instead, a dynamic livestock threshold may indirectly influence grain stocks consumption by changing how much of an income shortfall is offset by livestock sales — and, hence, the size of the residual shortfall that can be offset by compensating grain stocks consumption. To reflect this structure, we implement a sequential estimation strategy in which we first estimate Eq. (9) and then use the estimated livestock threshold L^* to test for a compensating grain stocks consumption response for the lower and upper livestock regime.

Hansen's threshold estimator applied to Eq. (9) with and without fixed effects yields a livestock threshold L^* of 24.1 (85th percentile herd size) and 15.5 (80th percentile herd size), respectively. Since both of these threshold estimates are significant at the 1% level, we are confident that the net livestock sales responses of households below and above these thresholds are statistically distinct.[9] To test whether the presence of these significant thresholds is consistent with our theoretical framework, we now check for evidence of asset smoothing below this threshold and consumption smoothing above it.

Table 3 contains the estimation results from Eq. (9). The two-tailed p-values reported in this table are based on standard errors that are robust to heteroskedasticity and have been bootstrapped since the equation includes generated variables (income components) as explanatory variables.[10] Consider first the pooled results in models 1a and 1b. These results suggest that households offset 12–25% of crop income shocks with livestock sales. These pooled results tell the same story as in Fafchamps et al. (1998) and Kazianga and Udry (2006): livestock appear to be used in only a very limited

[8] Computed with standard weights of 0.1 for sheep and goats and 1 for cattle.

[9] Furthermore, estimating this threshold based on total herd value or herd size per adult equivalent yields consistent results and separates households into nearly (if not exactly) identical sub-groups.

[10] We estimated all the models we report in Tables 2 and 3 with cluster robust standard errors (retaining the heteroskedastic assumption and bootstrapping). While the standard errors are slightly bigger with clustered standard errors, the results are qualitatively unchanged. We report the unclustered standard errors simply because the number of clusters in our data (six) is small enough that clustered standard errors may be misleading.

Table 3
Livestock sales response to income components on either side of the estimated herd value threshold L^* with two-tailed p-values in (.).

	Net Livestock Sales ('000 CFA)					
	Pooled		Below L*		Above L*	
	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)
	Without Household Fixed Effects (L^*=15.5 TLU)					
Permanent income	-0.11	-0.08	-0.038	-0.032	-0.57	-0.6
('000 CFA)	(0.002)	(0.004)	(0.029)	(0.019)	(0.017)	(0.014)
Transitory income	-0.12		-0.026		-0.89	
	(0.063)		(0.22)		(0.005)	
Transitory + Unexplained		-0.16		-0.033		-0.94
		(0.027)		(0.11)		(0.009)
Unexplained income	-0.21		-0.041		-1.03	
	(0.024)		(0.081)		(0.11)	
Constant	4.3	3.48	0.54	0.38	23.5	24.2
	(0.000)	(0.001)	(0.21)	(0.22)	(0.000)	(0.001)
Observations	371	371	313	313	58	58
R^2	0.03	0.02	0.04	0.03	0.11	0.11
	With Household Fixed Effects (L^*=24.1 TLU)					
Permanent income	3.1	3.1	0.092	0.094	7.2	7.24
	(0.19)	(0.19)	(0.65)	(0.61)	(0.13)	(0.13)
Transitory income	-0.25		-0.036		-0.64	
	(0.014)		(0.19)		(0.13)	
Transitory + Unexplained		-0.19		-0.038		-0.53
		(0.018)		(0.095)		(0.16)
Unexplained income	-0.13		-0.041		-0.21	
	(0.17)		(0.25)		(0.77)	
Constant	-64.9	-64.7	-1.7	-1.74	-127	-127
	(0.20)	(0.20)	(0.70)	(0.66)	(0.17)	(0.17)
Observations	371	371	331	331	40	40
Number of HHs	126	126	117	117	16	16
R^2	0.21	0.21	0.02	0.02	0.57	0.57

Two-tailed p-values (in parentheses) are based on bootstrapped, robust standard errors.

manner as a buffer stock. Table 3 results for below and above the threshold L^* suggest that this story is muddled by the presence of two distinct smoothing regimes whose responsiveness to income shocks is markedly different. Lower regime households offset a mere 2–4% of income shocks with livestock sales, while upper regime households offset 53–94% of shocks with livestock sales.

A few additional observations regarding Table 3 results are worth making. First, the upper regime includes a relatively small sample, which implies a likely loss of statistical precision and provides additional motivation for the bootstrapped standard errors. Second, while the results with and without fixed effects similarly suggest the presence of two distinct smoothing regimes, there are some differences. When both between and within variation is used as the basis of estimating the income coefficients (without fixed effects), we reject the null in favor of the alternative of complete income smoothing. While the within estimates (with fixed effects) are statistically less precise, we reject the null in favor of the one-tailed alternative $H_A:\beta_2^h<0$ at the 10% level. We see complementarities in the estimation with and without fixed effects. On the one hand, between household variation may provide useful information in this case since differences between household land holdings and herd sizes are likely to affect the magnitude of crop income shocks and potential livestock sales responses. Moreover, the absence of fixed effects does not imply that households' productive structure is missing from the specification — indeed, the estimated permanent income component captures a portion of this structure (recall Eq. (7)). On the other, however, including household fixed effects captures unobserved differences in productive portfolios that more lead to structural differences in households' smoothing responses.

We subject these results to a variety of robustness checks. First, adding other household controls (e.g., adult equivalents, age of household head, etc.) does not change the key results. We therefore opt to present the most parsimonious specification in Table 3. Second, much of the consumption smoothing literature and much of our discussion thus far implicitly focuses on households' response to negative shocks. In order to ensure that the estimated coefficients above are not reflecting aggressive livestock purchasing in the wake of positive income shocks, we run these specifications excluding positive income shocks and find that the point estimates increase in magnitude and that the gap between the lower and upper regime actually increases.[11] Combined with the non-parametric regressions in Fig. 3, this suggests that Table 3 results are, if anything, conservative estimates of households' response to negative income shocks. Third, the relatively strong results above L^* may be due to influential outliers. This is a potential concern not only because of the small sub-sample, but also because this sub-sample includes households with the biggest 15% of herds. We use robust regression with iteratively reweighted least squares to test whether outliers may be driving these results. The estimated coefficients fall slightly in magnitude (42–44%), but remain significant and an order of magnitude larger than comparable below L^* estimates.

As two final robustness checks, we test whether the relatively muted response among households in the lower regime is attributable to households with no livestock at the beginning of a season. After all, such households may purchase livestock, but cannot have positive net livestock sales over the subsequent year and therefore would appear as completely unresponsive to negative shocks. Lastly, we test whether the results are robust to the inclusion of village-year fixed effects, which effectively control for the livestock market conditions that prevail for households in a given village and year. In order to include these additional fixed effects, however, we must pool the lower and upper regimes into a single specification and use intercept and slope shifters to test for response differences between below and above L^* households. Table 4 displays the results of these two final tests. All the models in this table include household fixed effects and exclude the 38 observations that begin the year with no livestock.[12] Models (5a) and (5b) include village-year fixed effects. The disparity in smoothing responses between these two regimes is clear in these results and becomes statistically clearer when we control for local livestock market conditions (and other village-year unobservables) with fixed effects.

As described above, we next estimate a grain stocks consumption version of Eq. (9) using our estimated livestock thresholds to distinguish the lower and upper regimes (Table 5). These results suggest that Burkinabe households offset 20–25% of income shortfalls by consuming grain stocks.[13] While the lower regime estimates are more precise than the upper regime estimates, they are nearly identical in magnitude. We depict the key estimates graphically in conjunction with comparable results from Table 3 in an 'iso-smoothing' space in Fig. 4. To be conservative, we use estimates from models with fixed effects for both livestock sales and grain consumption. The axes in this figure measure the percent of an income shock that is offset by livestock sales (x-axis) and by drawing down grain stocks (y-axis). Thus, parallel lines of slope −1 represent iso-smoothing curves and

[11] We consider this more of a qualitative test than a rigorous econometric test because the sample size becomes worryingly small for the upper regime after positive transitory income shocks are excluded. The non-parametric regressions in Fig. 3, although not conditioned on other variables, similarly suggest that our results are not driven by buying livestock with positive transitory income shocks.

[12] Note that 36 of these observations are from 13 households who never hold any livestock over the 3 years included in the data. Note further that the non-parametric regressions in Fig. 3 similarly exclude these 38 households and compute herd size quartiles accordingly.

[13] We recognize that valuing grain stocks on hand at market prices may introduce measurement error for households not engaged in grain markets. For such households, the shadow value of grain stocks may provide a better measure of the value of stocks. While we lack the data required to estimate household- (and year-) specific shadow values, we expect the shadow value to exceed the market value of grain stocks when there is a divergence between the two and note that such a relationship would imply that we underestimate how much of a transitory income shortfall is offset by drawing down grain stocks.

Table 4
Pooled livestock sales response with different income coefficients for households below and above L^* and with/without village-year fixed effects. Households with no beginning period livestock are excluded.

	Net Livestock Sales ('000 CFA)			
	Pooled		Pooled	
	(4a)	(4b)	(5a)	(5b)
	With Household Fixed Effects		(L^*=24.1 TLU)	
Village-year fixed effects:	-	-	YES	YES
Below L^*{0,1} Interactions				
Permanent income	1.99	1.98	2.17	2.1
	(0.22)	(0.22)	(0.28)	(0.27)
Transitory income	-0.087		-0.15	
	(0.140)		(0.41)	
Transitory + Unexplained		-0.075		-0.083
		(0.063)		(0.180)
Unexplained income	-0.062		-0.065	
	(0.32)		(0.33)	
Above L^*{0,1}	-61.7	-61.9	-53.8	-54.7
	(0.33)	(0.19)	(0.27)	(0.39)
Above L^* {0,1} Interactions				
Permanent income	1.97	1.98	1.69	1.74
	(0.47)	(0.31)	(0.49)	(0.52)
Transitory income	-0.79		-0.89	
	(0.120)		(0.09)	
Transitory + Unexplained		-0.79		-0.85
		(0.100)		(0.095)
Unexplained income	-0.77		-0.7	
	(0.39)		(0.49)	
Constant	-38.4	-38.2	-42.5	-42.1
	(0.22)	(0.25)	(0.31)	(0.28)
Observations	333	333	333	333
Number of HHs	115	115	115	115
R^2	0.38	0.38	0.41	0.41

Two-tailed p-values (in parentheses) are based on bootstrapped, robust standard errors.

Table 5
Grain stocks consumption response to income components on either side of the estimated herd value threshold L^* with two-tailed p-values in (.).

	Net Grain Stocks Consumption (CFA)					
	Pooled		Below L*		Above L*	
	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)
	With Household Fixed Effects (L^*=24.1 TLU)					
Permanent income	1.62	1.62	2.14	2.11	0.96	1.01
	(0.003)	(0.002)	(0.011)	(0.012)	(0.42)	(0.32)
Transitory income	-0.23		-0.26		-0.27	
	(0.058)		(0.07)		(0.27)	
Transitory + Unexplained		-0.18		-0.21		-0.14
		(0.062)		(0.041)		(0.46)
Unexplained income	-0.13		-0.15		0.25	
	(0.29)		(0.22)		(0.71)	
Constant	-15.6	-15.5	-26.4	-25.6	-6.41	-7.23
	(0.18)	(0.17)	(0.14)	(0.16)	(0.79)	(0.73)
Observations	371	371	331	331	40	40
Number of HHs	126	126	117	117	16	16
R^2	0.16	0.15	0.17	0.1	0.31	0.23

P-values, shown in parentheses, are based on bootstrapped, robust standard errors (clustered in 'with fixed effects' models).

the distance of these iso-curves from the complete smoothing locus (solid diagonal line) captures the total consumption smoothing provided by different combinations of livestock sales and grain stocks consumption. With a few assumptions,[14] the complete smoothing locus in this figure is akin to a smoothing ratio of one and the origin is akin to a smoothing ratio of zero. We superimpose our point estimates and 90% confidence intervals in both directions for our pooled and split samples on this iso-smoothing space.

Clearly, while households above L^* appear to use grain stocks about as much as below L^* to smooth consumption, they achieve a much greater degree of total consumption smoothing. Together, the estimates shown in Fig. 4 summarize two key results: (i) a statistically significant herd size threshold distinguishes near complete consumption smoothers (80–90% smoothing) from very limited consumption smoothers (25–30% smoothing) and (ii) the near complete consumption smoothers rely heavily on livestock sales whereas the very limited consumption smoothers rely relatively heavily on grain stocks. These key results suggest that the critical livestock threshold effectively separates asset smoothers from consumption smoothers.

6. Conclusions

Despite solid theoretical foundations for the notion that households —especially poor households—will smooth consumption, even in the face of liquidity constraints, the consumption-smoothing hypothesis has not always withstood empirical scrutiny. Unfortunately, much of the empirical literature has not tested consumption smoothing against a theoretically well-defined alternative. If households are not smoothing consumption, then what are they doing?

Armed with an explicit alternative model, based on the theory of poverty traps, this paper has reapproached a particularly puzzling instance in which data reject the consumption-smoothing hypothesis, despite descriptive evidence that some of the observed households do in fact liquidate assets in the wake of shocks in order to defend their consumption standards. Poverty trap theory indicates that the marginal value of assets will become extraordinarily high in the neighborhood of critical wealth levels. Households in these neighborhoods will be reluctant to liquidate assets even in the face of economic shocks. For these households, asset smoothing or protection or strategies can emerge as either a transitional strategy, or—in other poverty trap models—as an equilibrium strategy. Both of these perspectives imply that any given sample may be comprised of two distinctive behavioral regimes, consumption smoothers and asset smoothers.

Using household panel data from Burkina Faso, which Fafchamps et al. (1998) and Kazianga and Udry (2006) used to test for consumption smoothing, we find strong evidence of the multiple smoothing regimes as predicted by poverty trap theory. Non-parametric estimates show that smoothing behavior changes radically along the key dimension

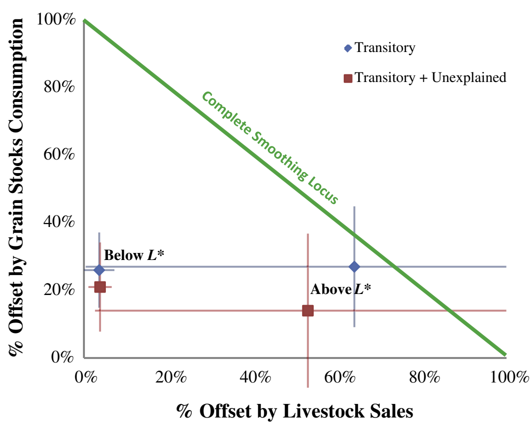

Fig. 4. Livestock sales versus grain stocks consumption as smoothing strategies with the complete smoothing locus depicted. Markers indicate point estimates for each regime (with household fixed effects included). Lines indicate 90% confidence intervals on these estimates.

[14] Namely, if we assume, on the one hand, that households can only reduce the variability of consumption through livestock and grain stocks and, on the other, that the full value of livestock sales finances consumption, then the smoothing ratio maps directly into an iso-smoothing curve in Fig. 4.

predicted by poverty trap theory, namely that of productive assets. We then employ Hansen's (2000) threshold estimation technique to formally test for the existence of two regimes along this dimension. The data neatly fall into two categories, an upper group where asset sales almost completely offset stochastic income losses, and another where assets are guarded even in the face of income declines.

The immediate welfare implications of these findings are obvious: in a world characterized by poverty trap dynamics, the losses in contemporaneous utility from consumption fluctuations can be higher and fall more heavily on the poor than standard consumption smoothing perspectives would suggest. This implication becomes all the more important if the presence of poverty traps also causes a breakdown in informal risk-sharing, as Santos and Barrett (2011) suggest. However, the longer-term welfare implications of these observations are perhaps more striking. First, the asset smoothing response we study may imply a departure from optimal herd management and marketing strategies, suggesting that this response may carry additional and nuanced dynamic costs. Second and more importantly, as Hoddinott (2006) notes, destabilizing consumption in order to preserve productive assets in the short-run can irreversibly harm the long-run physical and cognitive development of the youngest and most vulnerable members of a household (e.g., Alderman et al., 2006, Hoddinott and Kinsey 2001). In other words, what appears as asset smoothing today could well be an intergenerational asset transfer that could shape poverty in subsequent generations.

These comments strike us as a particularly powerful observation with direct relevance to the analysis in this paper. Not only can a careful characterization of smoothing strategies help to infer the presence of poverty traps, but these smoothing strategies themselves have important implications about the costliness of risk and the private and social returns to policies that ameliorate risk. Future research into asset and poverty dynamics and intertemporal smoothing tendencies should take this multidimensional view of smoothing into account. In the context of threshold estimation techniques, this suggests the potential for multiple thresholds or, possibly, thresholds that cut across multiple asset dimensions (e.g., productive assets and innate ability (Lybbert and Barrett 2011)).

Finally, from a policy perspective, evidence that risk is especially costly for asset smoothers suggests that additional efforts be given to the creation of viable insurance mechanisms. While the theoretical returns to insurance have been explored by Barrett et al. (2011) and Carter et al. (2011) there are multiple challenges to the implementation of insurance. While there are a few pilot projects attempting to implement these ideas (see Chantarat, et al. forthcoming), it remains to be seen if insurance mechanisms can be successfully employed to diminish the forces that contribute to the intergenerational transmission of poverty.

Acknowledgments

We thank Harounan Kazianga for his help with the data and variable construction and Munenobu Ikegami for his help with the numerical simulation. We also thank the seminar participants at the Pacific Development Economics Conference, the Nordic Development Economics Conference, George Washington University, Brigham Young University, Utah State University, the University of California—Riverside and the University of California—Davis for their comments and pointed questions. Two anonymous reviewers offered excellent feedback and suggestions, for which we are grateful.

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