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Coping with Drought by Adjusting Land Tenancy Contracts: A Model and Evidence from Rural Morocco

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Summary. — We explore vulnerability to drought in Morocco by analyzing household coping responses to a severe drought. We find that nearly 25% of households increased or decreased their cultivated land via short-term land tenancy arrangements. We use this pattern to motivate a model in which drought shocks induce the reallocation within communities of usufruct rights to land. We show how different liquidity constraints can lead some households to invest in crop production as others divest. Empirical analysis finds some support for the model but also highlights how pre-existing tenancy arrangements strongly determine a household's reliance on land tenancy markets for coping.

Key words — North Africa, Morocco, drought, asset dynamics, land tenancy, risk sharing

1. INTRODUCTION

Of the many hazards that rural households face, periodic drought is particularly pernicious. Its covariate nature limits the effectiveness of informal risk sharing networks in communities and local organizations. Moreover, the threat of drought induces households to invest in coping mechanisms and choose livelihood strategies that reduce exposure to drought over those with higher expected returns. While both *ex ante* (preparation) and *ex post* (mitigation) strategies likely reduce the risk of disastrously low consumption in any one period, they also divert resources from the most productive longer term uses (Elbers, Gunning, & Kinsey, 2007). Finally, it is rural households—the poorest and most vulnerable in most countries—that are particularly sensitive to drought. These features of drought imply that its burden falls disproportionately on the poorest households who, lacking other options, rationally divert resources toward reducing risk and buffering consumption at the cost of future productivity. From this perspective, climate change scenarios that foresee more frequent and more severe droughts in many parts of the developing world are deeply troubling.

Although the Middle East and North Africa (MENA) region is particularly drought prone and continues to wrestle with persistent rural poverty, compared to other parts of Africa and South Asia, relatively little empirical work has been done to study drought vulnerability in this context. Such an analysis, which we aim to provide, is timely for at least two reasons: First, while climate change models forecast changes in drought severity and frequency in the coming decades in many places, the climate has already changed in this regard in much of the MENA region (Hoerling, Eischeid, Perlwitz, Quan, Zhang, & Pegion, 2011). In our study area, for example, average precipitation decreased dramatically in the early 1980s as a result of the North Atlantic Oscillation (Hurrell, 1995). Understanding how vulnerable rainfed farming households respond to drought in this context of recent changes in drought frequency and severity may shed light on settings that anticipate such changes in the coming decades. Second, while many factors seemed to set the stage for the Arab Spring of 2011, climate change—drought, in particular—may have played a role as a threat multiplier (Johnstone & Mazo, 2011). Extended drought in Syria, for example, forced many rural households to migrate to the urban fringes where protests sparked the early stages of instability (Sands, 2009). In the rapid and ongoing transformation of the MENA region, a detailed understanding of household responses to drought takes on even greater urgency. Within the MENA countries, Morocco has been identified as being particularly vulnerable to drought because Moroccan agriculture comprises a relatively large portion of the national economy, employs nearly half of the population (and most of the poor), and is highly dependent on rainfall (Schilling, Freier, Hertig, & Scheffran, 2012).

In this paper, we explore household vulnerability to drought in Morocco by analyzing specific and heterogeneous responses to a severe drought event in order to better understand the drought burden on rural households in this area. Some households react by drawing down productive and savings assets to finance consumption shortfalls, while others build up productive assets and invest precisely when income is most scarce. Somewhat surprisingly, households' drought responses commonly include the building up or drawing down of their access to cropland. We use these descriptive patterns to motivate an infinite-horizon intertemporal utility maximization problem in which, upon the revelation of stochastic crop income, households adjust their allocation of resources between consumption, savings, and investment in the following year's crop. In this model, land is a co-factor of production, and therefore a highly visible indicator of households' overall ability to invest.

The model demonstrates how differentially binding borrowing constraints and endogenous rental prices for land can give

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rise to two distinct coping strategies: For a household with access to credit, the *ex post* reallocation decision is decoupled from its immediate consumption needs—such a household is able to smooth consumption and, simultaneously, invest in the next season's crop, hastening its recovery from the drought shock. On the other hand, a household without credit access responds by destabilizing its consumption and divesting from crop production, postponing its recovery. The result is a stable equilibrium in which the households with access to credit are essentially "invulnerable" to individual drought shocks insofar as their consumption levels do not fluctuate, and the households without credit access are vulnerable. Moreover, these vulnerable households reduce agricultural investment for want of immediate cash, and, as a result, increase the supply of land, thereby lowering rental prices for the invulnerable. Thus the local land rental markets are at once a source of immediate liquidity for cash-strapped households and a source of land at discounted prices for those with the means to invest. This symbiotic interaction between constrained and unconstrained households can keep each in its respective role, with troubling implications for the former.

This model shares many features with the canonical models of risk coping: As in Deaton (1991), it presents the credit-constrained household with a precautionary savings problem—that is, how much it should save in order to ensure the future period's consumption. Households must also solve an income portfolio problem akin to that in Rosenzweig and Wolpin (1993), where the household can invest in both a risk-free, non-productive asset and a risky, productive asset. And as in Zimmerman and Carter (2003), differentially-constrained household types interact through endogenous input prices. What sets the present model apart from these and many other models of risk-coping is the way in which distressed households transact their productive assets: In contrast to models of asset dynamics, which typically assume that the productive asset is bought and sold, households in our model can rent in and rent out their productive asset (land) on a year-to-year basis. Where land (rental) markets exist, we are more likely to observe such temporary transactions than irreversible transactions (sales); indeed a common sentiment among our sample population is that selling land is an act of last resort.

Another innovation is in our approach to solving the model. We introduce a stylized two-state world ("good weather" and "bad weather") and use this framework to show the *direction* in which households will adjust their productive asset levels in response to bad-weather years. This approach permits a rare, analytic solution to a multi-asset, stochastic, infinite-horizon intertemporal utility maximization problem. And though we are unable to address long-term asset dynamics (because we do not explicitly solve for the values of the choice variables), the model generates intuitive coping policies for the two household types, which, combined, describe a symbiosis between borrowing-constrained and unconstrained households which parallels that described by Eswaran and Kotwal (1985).

Finally, we revisit the coping data with the model and its implications in mind. While our data do not permit us to directly test the model—that is, to establish causality between credit access and land tenancy changes, we observe patterns in the coping strategies that lend credence to the model's assumptions and, at the same time, generate new insights about the nature of local land rental markets.

The remainder of this paper is organized as follows: In Section 2 we briefly describe the empirical setting of this study—dryland agricultural households in Central Morocco, and summarize the responses of these households to the 2006–07 drought, a once-in-a-decade-type drought. In Section 3 we review relevant models of asset dynamics, risk-sharing, credit constraints, and land tenancy contracts. In Section 4 we develop a model in which households of different borrowing abilities interact in local land tenancy markets as they cope with drought shocks. In Section 5 we revisit the data and test some implications of the model. We conclude in Section 6 by discussing our empirical findings and the insights they generate.

2. COPING WITH DROUGHT IN MOROCCO

The fertile Saiss plateau of Central Morocco was recognized for its agricultural production potential as early as the 3rd Century BC when the Phoenicians founded a settlement in the region. Archeological evidence suggests that prior Neolithic inhabitants also appreciated its production capacity. By the 2nd Century AD, the Romans had established a thriving export of grains, olives, and animals from the plateau and developed the settlement of Volubilis into a relatively wealthy town of 20,000 inhabitants. The area, near modern-day Meknès, has maintained its agricultural importance, but rainfall patterns have changed markedly in recent years due largely to the North Atlantic Oscillation (Hurrell, 1995). While drought occurred on average one year in five before, it has occurred nearly every other year since 1990 (MADRPM, 2000), and changes in the timing of rainfall have reduced the average duration of the growing period by 30% in some areas (Benaouda, 2001). Understanding rural households' response to these more frequent droughts may shed light on other regions where such climate changes are anticipated. Moreover, since Morocco is expected to remain especially vulnerable to climate change relative to the rest of the instable MENA region (Schilling *et al.*, 2012), such an understanding may generate important insights into the near-term nexus of vulnerability, agricultural production, and human development in the area.

To improve our understanding of drought vulnerability in this context, we surveyed a diverse group of farm households on the Saiss Plateau in 2007 and 2008 (full details are provided in Section 5 below). The agricultural year 2006–07 was widely considered a "severe" drought year.[1] In the 2008 survey, exactly one year after the poor 2007 harvest,[2] enumerators asked household heads what measures they had taken specifically as a result of the drought using the following script: "Last year's drought posed problems for farmers throughout the region. We would like to know what actions you have taken since last year in response to the bad year in order to survive or otherwise manage your affairs (actions that you would not take during or after good or average years)." Enumerators then asked about several pre-defined drought responses that had been formulated and pre-tested in farmer focus groups. These responses were "sold more grain than usual," "consumed more stored grain than usual," "sold more feeder animals (sheep, goats, and cattle) than usual," "sold more reproductive animals (sheep, goats, and cattle) than usual," "sold gold," "sold household goods," "began or increased off-farm work (agricultural and non-agricultural)," "borrowed money (from family, friends, and elsewhere)," "asked for money (from family and friends)," "installed irrigation," "sharecropped in a plot," "sharecropped out a plot," "rented in a plot," "rented out a plot," and "sold a plot." They were presented in this order, beginning with the lowest-cost actions and ending with the most desperate response of selling land.[3]

As reported in other studies of drought response, commonly stated actions included the sale of animals (e.g., Kinsey, Burger, & Gunning, 1998; Reardon & Taylor, 1996), borrowing money, drawing down grain stocks (e.g., Kazianga & Udry, 2006) and starting or increasing off-farm work (e.g., Kochar, 1999; Kinsey *et al.*, 1998). Figure 1 depicts these stated coping strategies across our four sampled districts in the Saiss Plateau. Here the most commonly given responses are aggregated into seven broader categories—"sold/consumed more grain," "sold more feeder animals," "sold more breeding animals," "sold household items," "sought/increased off-farm work," "borrowed/asked for money," "rented (or sharecropped) in more land," and "rented (or sharecropped) out more land"—and are listed in order of increasing severity down the vertical axis.[4] Each household in the sample is represented as a thin vertical column; these are ordered by district, and then by farm size within each district. Black shading indicates that the household reported employing the specific coping response.

Along the continuum of response severity a few seeming-anomalies stand out. Specifically, households relied less on grain stocks and household assets and more on land tenancy transactions than expected. We focus on the latter: temporary rental or sharecropping agreements as a drought response. Nearly a quarter of all households reported increasing or decreasing the area under cultivation, through changes in either fixed rent or sharecrop agreements. As expected, a portion of households (6.9% of the sample) leased out or sharecropped out more land. On these rented-out plots, households surrender their rights to cultivating and harvesting the plot in exchange for an immediate return in the form of the rental payment and are insulated from any production risk on the plot in the subsequent season. And by taking on tenants in sharecropping agreements, a household need provide only a fraction of the total requisite crop inputs, in exchange for a portion of the harvest, thereby conferring the added benefit of reducing the household's exposure to production risk. A larger portion of sampled households (17.4%) reported leasing in or sharecropping in additional land. Our sample is clustered by villages, which essentially define the spatial extent of the market for temporary land contracts, so the existence of households demanding more land—as counterparts to those supplying more land—is expected.[5]

That such a substantial portion of our sampled households transact in local land markets in response to severe drought seems to contradict conventional notions of land being particularly illiquid as an asset. It would even seem to contradict the continuum of response severity elicited from farmers themselves, as more households transacted in land contracts than drew down grain stocks, relied on off-farm work, or liquidated household assets—all of which were perceived as less severe responses than land transactions.

There are two possible explanations for this pattern. First, the drought could have been severe enough to disrupt the continuum of response severity. In other words, faced with a severe shock, some farm households may have skipped steps along this continuum, knowing, for example, that drawing down grain stocks would simply be inadequate to offset the income shock. Second, the market for land tenure contracts is highly localized, which implies that as soon as a few households in a given village resort to renting out land, others are drawn into the market. Although some of these households may be attracted by falling "prices" on these arrangements, non-price considerations are also likely to be operative since very local markets bring together households that know each other.

In the wake of a drought, households may use the land tenancy market as a mechanism for informal risk sharing, as suggested by Eswaran and Kotwal (1990). The frequency of land tenancy adjustments as a stated coping response in our study reflects that these local, socially-embedded markets draw in a sizeable portion of households as suppliers and demanders of

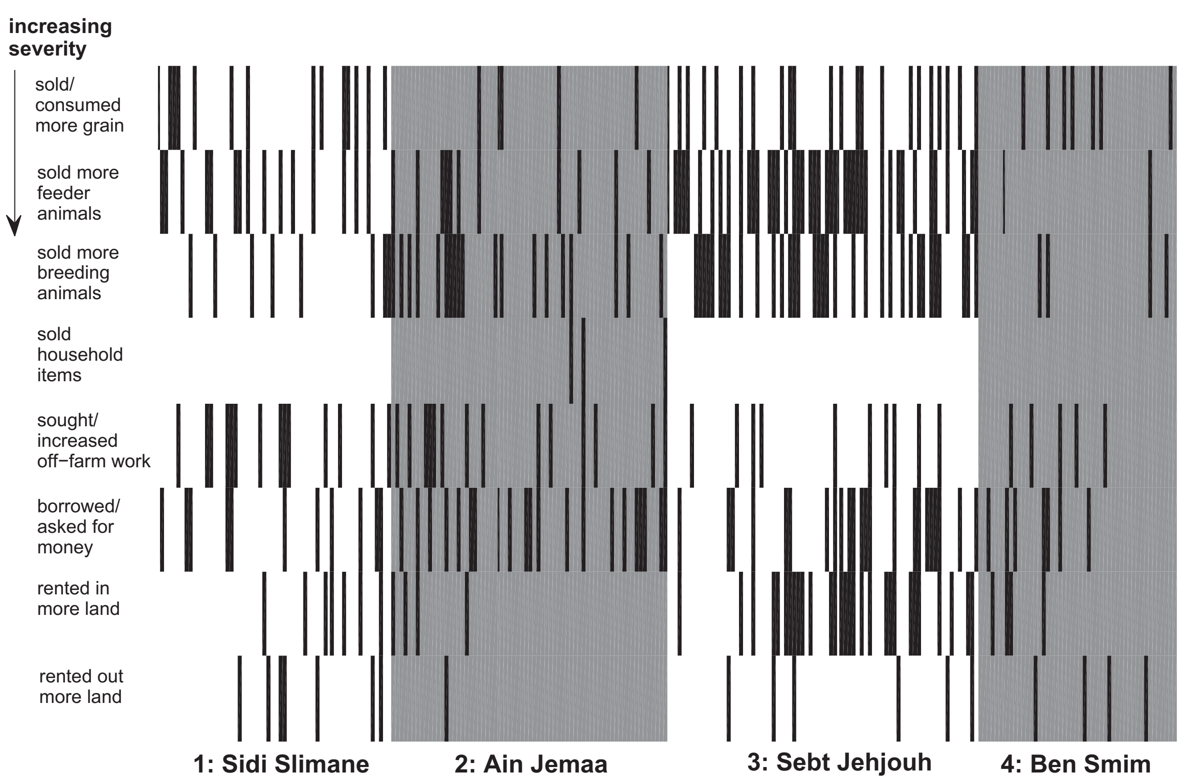

Figure 1. *Stated drought coping responses across four districts.*

land. In contrast, the livestock market extends well beyond villages and is integrated across Moroccan provinces, implying that local buyers are not drawn into the market by either price or non-price incentives. Finally, the highly local nature of markets for land contracts also likely reduces transactions costs that otherwise make land the distinctly illiquid asset it is typically assumed to be. Specifically, search costs may be lower and problems of moral hazard lessened in settings where transacting parties know each other well.

From the standpoint of the household that is drawn into these local land contract markets—either opportunistically, altruistically, or based on an expectation for future reciprocity—cultivating more land requires it to allocate more of its (diminished) cash on hand to productive inputs, in addition to any rental payments for the land itself. Such a household must also bear (in the case of a rental contract) or share (in the case of a sharecropping contract) additional income risk. Thus, the option of renting or sharing out land to cope with a drought shock requires a functioning local market for such land contracts with low search and transaction costs, possibly through kinship or pre-existing tenancy relationships. It also requires the presence of other households that are willing and able to expend more cash and to bear additional risk in order to expand their area under cultivation in the wake of the drought. We explore the nature of this local land market as a forum for coping with drought and the local household heterogeneity it requires.

3. LAND TENANCY MARKETS AND DROUGHT COPING: RELEVANT LITERATURE

The role that a household plays in the local land market following a community-wide drought shock may provide a signal about its *ex ante* position in asset space, its ability to bear risk, and its access to credit—all three of which are intimately linked. Furthermore, it is possible that, by using local land markets as a forum for coping, households reinforce these characteristics, making them more likely to play the same roles in subsequent droughts. In this section we review models related to these kinds of heterogeneous local land market responses to production shocks, and their implications for the longer-term vulnerability of households.

For some households, droughts and other periodic negative shocks may have little effect on investment strategies, and virtually no effect on consumption. These households have access to enough credit and/or possess high enough levels of assets that long-term productivity and therefore consumption are not threatened by periodic income shortfalls. While certainly affected by drought, such households are able to maintain a steady and adequate stream of consumption—in this sense, these households are "invulnerable." However, for a household that is less wealthy, a drought-induced income shortfall may nudge it uncomfortably close to a critical asset threshold, below which future productivity may drop discontinuously. For such a household, preserving the minimal productive asset base, or "asset smoothing," may warrant enduring periods of low consumption (Hoddinott, 2006; Carter & Lybbert, 2012). A household that is even worse off—one that cannot maintain a minimal productive asset base—will be cognizant of yet another critical threshold: subsistence. Faced with the prospect of immediate starvation, such a household will be willing to pay a high price (in assets) to stabilize consumption in the wake of negative shocks.

Increased activity in local land tenancy markets following drought shocks may be due to drought nudging some households closer to such critical asset thresholds, or by drought exacerbating inter-household differences in asset positions and risk-bearing capacity. As households move down in asset space, some may face binding cash constraints and cash crises, necessitating the renting out or sharecropping out of land to raise or conserve cash, while others may be less affected. Where some households are suddenly more cash-constrained than others, land tenancy transactions can facilitate the efficient reallocation of land between households. Though Eswaran and Kotwal (1985) make this observation based on a static context, it may also manifest itself in a dynamic, post-drought context. Eswaran and Kotwal (1990) also observe that land tenancy markets may permit the sharing of risk between households with differing risk-bearing capacities. Again, the authors make this observation based on a static cross-section of households, but risk-sharing may also motivate land tenancy agreements following droughts: A household suddenly made poorer by drought is now more risk averse and therefore has a stronger preference for "cashing out" its land endowment by renting it out, rather than betting on the next year's risky harvest.

As income falls, credit access matters more—specifically, credit can keep a household's cash constraint from binding. Morduch (1994) explicitly models the effect of cash constraints using a two-period investment model. The model demonstrates how binding cash constraints can cause individuals to forego increased future productivity in order to meet immediate consumption needs. The author suggests a pathway through which this behavior can generate persistent consumption effects, even when productivity shocks follow no such pattern: Bad seasons decrease income and reduce credit access, forcing household to invest in portfolios with less risk and lower returns. This, in turn, makes it more likely that the household is cash constrained in subsequent years. In a similar vein, Eswaran and Kotwal (1990) show how credit constraints diminish the risk-bearing capacity and therefore investment productivity of households, assuming that the more remunerative assets are also the riskier ones. The authors suggest that this behavior, combined with the assumption of credit being made available to only those with sufficient collateral, can exacerbate income inequality among households over time.

These model predictions are qualitatively similar to the simulation outcomes of Zimmerman and Carter (2003). Their result—a bifurcation in household shock responses into "defensive" (pursuing conservative asset portfolios but destabilizing consumption nonetheless) and "entrepreneurial" (pursuing more productive portfolios while also smoothing consumption) depending on initial asset levels—is driven over time by endogenous asset prices combined with the existence of a minimum consumption threshold. Though all households equally lack access to credit, they differ in initial asset positions. Those starting above a critical asset threshold end up, in equilibrium, pursuing the entrepreneurial strategy, while those starting below it end up employing the defensive strategy. Note, however, that in Zimmerman and Carter (2003), the productive asset is bought or sold, rather than rented in or rented out.

In the following section, we incorporate aspects of the abovementioned studies in a model in which differentially-binding borrowing constraints lead to households playing different roles in local land rental markets. We show that a credit-constrained household is not only forced to destabilize consumption, but to underinvest in the next season's crop. By contrast, the unconstrained household is able to simultaneously smooth consumption and invest optimally in the next season's crop. The model demonstrates how the repeated sharing of risk and the efficient re-allocation of resources between the two household types can, paradoxically, reinforce households' characteristics and ossify their respective roles, rendering one class of households essentially impervious to drought shocks and the other fully exposed and vulnerable.

4. A MODEL OF DROUGHT COPING VIA LAND TENANCY ADJUSTMENTS

We explore the analytics of differential drought responses using an infinite-horizon stochastic Ramsey model. Each season, upon the revelation of crop income, a household chooses new levels of consumption, farm investment, and savings that maximize the expected utility of consumption from the present and all future periods. Investment in crop production takes the form of cash (i) and land (l).[6] As in Rosenzweig and Wolpin (1993), there is limited substitutability between the production inputs. Specifically, we assume that the following season's return is a Cobb–Douglas function of these two inputs multiplied by an error term θ with a distribution that is known to the farmer. The household's land endowment is $\bar{l}$ and it can choose to rent it out or rent in additional land in the local market at endogenous rate w. Cash that is not invested goes either toward current consumption (c) or future consumption in the form of savings (s), where S_t is the stock of savings at time t and is defined as $S_{t-1} + s_{t-1}$. For simplicity, we assume for now that savings neither appreciate nor depreciate from one period to the next. The household's objective is to maximize its expected additively separable stream of utility from consumption each season subject to a constraint that links one period's investment and savings (including borrowing) decisions to the next period's asset stock. Each period's sub-utility is continuous and concave in consumption, and the marginal utility of consumption is strictly convex.[7] Future utility is discounted by $\beta < 1$.

$$\max_{\{\mathbf{c},\mathbf{s},\mathbf{i},\mathbf{l},\}} E_t\left[\sum_{t=1}^{\infty}\beta^{t-1}u(c_t)\right]$$

$$\text{s.t.}\quad c_t + i_t + s_t \leqslant \theta_t f(i_{t-1}, l_{t-1}) + w_t(\bar{l} - l_t) + S_t, \quad \text{for } t = 1, 2, \ldots$$

Suppose that one set of households is exogenously given access to credit, while the other is not. We model these latter households as having a non-negativity constraint on the savings stock which binds in some years and not in others. We then find the optimal consumption and investment strategies for each household type, assuming that the two interact in local land markets.

This set-up most closely resembles that of Zimmerman and Carter (2003), who model households as allocating stochastic income between savings (risk-free but low-return) and future production (risky but higher return) while interacting in input markets. Consequently this model, too, embodies both the aggregate savings problem (e.g., Deaton, 1991) and the portfolio choice problem (e.g., Rosenzweig & Wolpin, 1993). And as in Zimmerman and Carter (2003), we show that differentially-binding borrowing constraints and endogenous input prices can lead to qualitatively different coping strategies. However, the present model differs in two subtle but important respects: First, the productive asset, land, is transacted on a year-to-year, temporary basis. In this sense, the productive asset is considered to play a role that is closer to family labor than livestock. Such temporary, reversible transactions have received scant attention, even though they may be preferred over the selling of assets, which is obviously permanent. Second, the bifurcation of coping strategies is driven by differential credit access, which we assume to be exogenously determined. That is, the difference between the two households types is not whether asset levels are sufficiently high to prevent the savings non-negativity constraint from binding, but whether a household faces a non-negativity constraint at all. That is, after a poor harvest, all households deplete their savings, but critically, some are able to borrow.

In solving the model, we assume a stable equilibrium between the credit-constrained and unconstrained households. By definition, this disallows households whose assets grow indefinitely and also those that slip into destitution. This assumption sets the model apart from the dynamic asset models used in the poverty-traps literature, which emphasize the divergence of asset holdings. Rather, what we describe here is a steady-state symbiosis between two classes of households: one in which households take actions that hasten recovery after a drought, and another which, for lack of credit, divests from the productive activity, thereby postponing recovery. While the former is clearly better off than the latter, the asset holdings of both are assumed to be stationary. The model can be thought of as describing the short- and medium-term interactions between poorer and richer households within a community. This abstraction permits the rare analytic solution to a infinite-horizon, stochastic, intertemporal utility-maximization problem.

(a) *Unconstrained households maintain the same level of consumption across good and bad years*

Assuming that consumption, cash investment, and cultivated land are non-negative in every period, but permitting the savings stock to be negative, we write the Lagrangean function.

$$\begin{aligned}\mathcal{L} = {} & u(c_t) + \lambda_t\{\theta_t f(i_{t-1}, l_{t-1}) + w_t(\bar{l} - l_t) + S_t - c_t - i_t - s_t\} \\ & + \beta E_t[u(c_{t+1}) + \lambda_{t+1}\{\theta_{t+1} f(i_t, l_t) + w_{t+1}(\bar{l} - l_{t+1}) + S_{t+1} \\ & - c_{t+1} - i_{t+1} - s_{t+1}\}] + \beta^2 E_t[u(c_{t+2}) + \lambda_{t+2}\{\theta_{t+2} f(i_{t+1}, l_{t+1}) \\ & + w_{t+2}(\bar{l} - l_{t+2}) + S_{t+2} - c_{t+2} - i_{t+2} - s_{t+2}\}] + \ldots\end{aligned}$$

where λ_t is the multiplier on the cash constraint at time t. We assume that the cash constraint binds in every period, and therefore $\lambda_t > 0, \forall t$. From the Lagrangean function we obtain the following first-order conditions that implicitly determine the choice variables c_t^*, i_t^*, l_t^*, and s_t^*:

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

$$\frac{1}{\beta} = E_t\left[\theta_{t+1}\frac{u'(c_{t+1})}{u'(c_t)}\right] f_i(i_t, l_t) \tag{2}$$

$$\frac{w_t}{\beta} = E_t\left[\theta_{t+1}\frac{u'(c_{t+1})}{u'(c_t)}\right] f_l(i_t, l_t) \tag{3}$$

Following LeRoy and LaCivita (1981), we assume two states of the world that occur with equal probability: "good" and "bad," with respective productivity shock values θ_g and θ_b, where $\theta_g > \theta_b$, and that productivity shocks are not autocorrelated. We use this two-state framework, the first-order conditions above, and the assumption of functioning local land rental markets to show that households unconstrained in their borrowing will maintain the same levels of consumption across both states of the world.

Expanding the expectations operator in Eqn. (1) conditional on the state realized in year t, we obtain

$$\frac{1}{\beta} = \pi(g|b)\frac{u'_g}{u'_b} + \pi(b|b)\frac{u'_b}{u'_b} \text{ given a bad season}$$
$$\frac{1}{\beta} = \pi(g|g)\frac{u'_g}{u'_g} + \pi(b|g)\frac{u'_b}{u'_g} \text{ given a good season}$$

where $\pi(g|b)$ denotes the probability of a good outcome in $t+1$ conditional on a bad outcome in t and u'_b (u'_g) denotes the marginal utility of consumption in a bad (good) season. Because the household's discount rate β is the same across states, we can set the right-hand-side terms of the above expressions equal to each other.

$$\pi(g|b)\frac{u'_g}{u'_b} + \pi(b|b)\frac{u'_b}{u'_b} = \pi(g|g)\frac{u'_g}{u'_g} + \pi(b|g)\frac{u'_b}{u'_g} \tag{4}$$

Since $\pi(g) = \pi(b)$, it follows that $\pi(g|b) = \pi(b|g)$ and $\pi(b|b) = \pi(g|g)$[8] (and $\pi(g|b) = \pi(b|b) = \frac{1}{2}$ and $\pi(g|g) = \pi(b|g) = \frac{1}{2}$). Eqn. (4) can only hold if consumption is equal across both states and the level of consumption in a "good" ("bad") state is always the same.[9] Thus we achieve the standard steady-state result of consumption smoothing given non-binding borrowing constraints ($c_b = c_g$). This finding, combined with the first-order condition with respect to cash (Eqn. (2)), allows us to conclude that the marginal productivity of cash allocated to the following year's crop will also stay constant across the years, a finding that we will use subsequently: Expanding Eqn. (2) conditional on the realized states and setting the two expressions equal to each other, we obtain

$$[\theta_g\pi(g|b) + \theta_b\pi(b|b)]f_i(i_b, l_b) = [\theta_g\pi(g|g) + \theta_b\pi(b|g)]f_i(i_g, l_g) \tag{5}$$

Because the transition probabilities are all equal, the terms in square brackets on both sides of the equation above are equal and therefore $f_i(i_b, l_b) = f_i(i_g, l_g)$ for unconstrained households.

(b) *Constrained households destabilize consumption in response to bad years*

For many rural Moroccans, savings assets may not adequately cover income deficits and borrowing may not be an option; indeed, a significant portion of households in our study reported being refused credit from formal institutions in the past. A borrowing-constrained household is one for which the non-negativity constraint on the total savings stock binds. ($S_{t+1} = S_t + s_t = 0$). Instead of borrowing from their future income and savings, these households borrow from their future productivity and, as we show here, also destabilize consumption as a result of bad seasons.

When the non-negativity constraint on savings binds, the marginal utility of consumption in the current season is greater than the discounted expected marginal utility of consumption by $\eta_t > 0$, and the original first-order condition for consumption (Eqn. (1)) changes:

$$u'(c_t) = \beta E_t[u'(c_{t+1})] + \eta_t$$
$$1 = \beta E_t\left[\frac{u'(c_{t+1})}{u'(c_t)}\right] + \frac{\eta_t}{u'(c_t)} \tag{6}$$

As before, we set each of the state-conditional expectation terms equal to each other.

$$\beta\left[\pi(g|b)\frac{u'_g}{u'_b} + \pi(b|b)\frac{u'_b}{u'_b}\right] + \frac{\eta_b}{u'_b} = \beta\left[\pi(g|g)\frac{u'_g}{u'_g} + \pi(b|g)\frac{u'_b}{u'_g}\right] + \frac{\eta_g}{u'_g}$$
$$\frac{1}{2}\beta\left[\frac{u'_g}{u'_b} + 1\right] + \frac{\eta_b}{u'_b} = \frac{1}{2}\beta\left[\frac{u'_b}{u'_g} + 1\right] + \frac{\eta_g}{u'_g} \tag{7}$$

Assume that the borrowing constraint binds in seasons with bad realizations ($\eta_b > 0$), but not in those with good realizations ($\eta_g = 0$). Eqn. (7) makes clear that as long as $\eta_b > 0$, then $u'_b > u'_g$ and therefore $c_b < c_g$. That is, the binding of the borrowing constraint in bad seasons will induce households to destabilize consumption across states ($c_b < c_g$). This implies that the marginal productivity of cash will be greater following a bad state than following a good state for constrained households. Again, we expand Eqn. (2) conditional on the realized states and set the two expressions equal to each other:

$$\left[\theta_g\frac{u'_g}{u'_b} + \theta_b\right]f_i(i_b, l_b) = \left[\theta_g + \theta_b\frac{u'_b}{u'_g}\right]f_i(i_g, l_g)$$

Since $c_b < c_g, \frac{u'_g}{u'_b} < \frac{u'_b}{u'_g}$, and therefore $f_i(i_b, l_b) > f_i(i_g, l_g)$ for constrained households—we use this result in the following section.

(c) *Unconstrained households increase agricultural investment while constrained households decrease agricultural investment in response to bad years*

So far we have used the first-order conditions with respect to consumption and cash investment to show that unconstrained households maintain the same level of consumption across good and bad states, and that their investment in the following season's crop is such that the marginal productivity of cash is the same, regardless of the outcome just realized. We have also shown that constrained households consume less in the wake of bad outcomes, and that the marginal productivity of cash invested in the next season's crop is higher after a bad outcome than after a good outcome for these households. Both household types can meet their respective conditions by increasing, decreasing, or maintaining their area under cultivation. We show, however, that certain combinations of land investment strategies lead to contradictions if we assume decreasing returns to scale in in the production technology and endogenous prices in local land rental markets—specifically, we assume that land rental prices cannot rise (fall) in the presence of excess supply (demand) and that the supply of leased land meets the demand for leased land.

The interactions of the two household types in local land markets can lead to rental prices increasing following a bad outcome ($w_b > w_g$), staying the same ($w_b = w_g$), or decreasing ($w_b < w_g$). Suppose $w_b > w_g$. By expanding the land FOC (Eqn. (3)) we can show that, for both household types, the marginal productivity of land must be higher following a bad outcome (i.e., $f_l(i_b, l_b) > f_l(i_g, l_g)$):

$$\left[\pi(g|b)\theta_g\frac{u'_g}{u'_b} + \pi(b|b)\theta_b\frac{u'_b}{u'_b}\right]f_l(i_b, l_b)$$
$$> \left[\pi(g|g)\theta_g\frac{u'_g}{u'_g} + \pi(b|g)\theta_b\frac{u'_b}{u'_g}\right]f_l(i_g, l_g)$$
$$\left[\theta_g\frac{u'_g}{u'_b} + \theta_b\frac{u'_b}{u'_b}\right]f_l(i_b, l_b) > \left[\theta_g\frac{u'_g}{u'_g} + \theta_b\frac{u'_b}{u'_g}\right]f_l(i_g, l_g)$$

(Recall that $\frac{u'_b}{u'_g} = \frac{u'_g}{u'_b} = 1$ for unconstrained households and $\frac{u'_b}{u'_g} > \frac{u'_g}{u'_b}$ for constrained households.) The unconstrained household can meet this and, simultaneously, its cash FOC ($f_i(i_b, l_b) = f_i(i_g, l_g)$) only by decreasing its cultivated land following a bad season. This is shown graphically in Figure 2, which depicts isoquants for marginal land and cash productivity as functions of those inputs.[10] Figure 2 shows that the

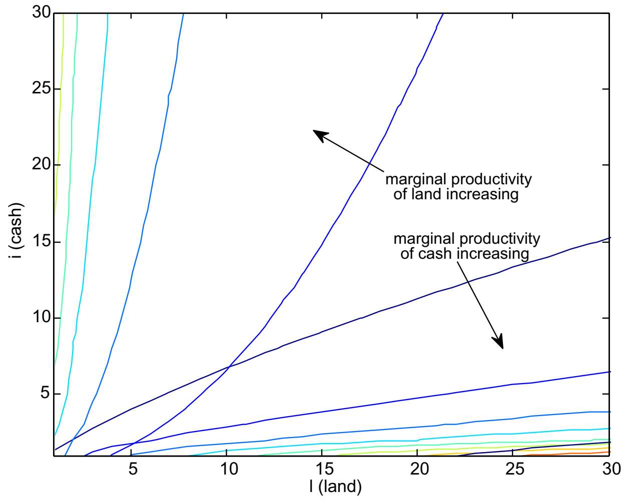

Figure 2. *Isoquants for marginal productivity of agricultural cash and land.*

same is true of constrained households, for which the cash FOC dictates that $f_i(i_b, l_b) > f_i(i_g, l_g)$. However, if both household types rent out more land (or even leave land idle), land rental prices cannot increase, leading to a contradiction. We therefore rule out the possibility of land rental prices increasing and both household types renting out more land following bad outcomes.

Now suppose $w_b = w_g$. The land FOC dictates that

$$\left[\theta_g \frac{u'_g}{u'_b} + \theta_b \frac{u'_b}{u'_b}\right] f_l(i_b, l_b) = \left[\theta_g \frac{u'_g}{u'_g} + \theta_b \frac{u'_b}{u'_g}\right] f_l(i_g, l_g)$$

For this relation to hold for an unconstrained household, it must be that $f_l(i_b, l_b) = f_l(i_g, l_g)$; again, as Figure 2 shows, it can satisfy this and its cash FOCs only by maintaining the same level of land. For a constrained household, the above relationship implies $f_l(i_b, l_b) > f_l(i_g, l_g)$. It can simultaneously meet its land and cash FOC only by decreasing its land investment. Given each household type's strategy, their interaction implies a dysfunctional land rental market in which borrowing-constrained households idle fields and prices do not respond to the excess supply following bad outcomes.

Now suppose $w_b < w_g$. Again, using the land FOC, we see that $f_l(i_b, l_b) < f_l(i_g, l_g)$ for the unconstrained household. Figure 2 shows that it can meet this and its cash FOC only by increasing its land under cultivation. In the case of the constrained household, the land FOC cannot not determine the direction in which the marginal productivity of land will change. However, given the optimal strategy on the part of the unconstrained households, market clearing dictates that the constrained households rent out more land following a bad outcome, and the change in rental price implies that the increase in supply from these households must be greater than the increase in demand from the unconstrained households. Note that the assumption of functioning land markets is sufficient to rule out the possibility of the land price increasing or staying the same, regardless of whether the production function is decreasing in scale or increasing in scale.[11]

Thus the assumption of functioning local land markets, combined with decreasing returns to scale of the production function, identifies a single internally consistent scenario following a bad outcome: Land prices fall and unconstrained households increase cash and land investments and maintain the same level of consumption, while constrained households cope by decreasing cash investments, land investments, and consumption. In other words, both types borrow from their future selves, except borrowing-constrained households do so at a higher price—they rent out land when land is cheap, and in doing so, forego the extra production in the following year.

(d) *Non-zero interest rates*

In order to maintain the focus on borrowing constraints, we have thus far modeled interest rates of zero on both borrowing and savings. We now show that non-zero interest rates can potentially change the results above and introduce some ambiguity into the general equilibrium modeling of the land rental market. We modify the budget constraint so that, each year, households make $(1 + r_s)$ on their savings stock ($S_t > 0$) and owe $(1 + r_l)$ on borrowed money ($S_t < 0$). The unconstrained household's budget constraint is

$$c_t + i_t + s_t \leqslant \theta_t f(i_{t-1}, l_{t-1}) + w_t(\bar{l} - l_t) + (1 + r_l \mathbb{1}\{S_t < 0\} + r_s \mathbb{1}\{S_t > 0\})S_t$$

where the indicator function $\mathbb{1}\{A\}$ equals 1 if A is true, and 0 otherwise.

As we show in Appendix A, unconstrained households may or may not smooth consumption across good and bad years; this depends on the relative magnitude of r_s to r_l. Such households will decrease (smooth, increase) consumption after a shock if the savings rate is less than (equal to, greater than) the loan interest rate.[12] The budget constraint for constrained households is

$$c_t + i_t + s_t \leqslant \theta_t f(i_{t-1}, l_{t-1}) + w_t(\bar{l} - l_t) + (1 + r_s \mathbb{1}\{S_t > 0\})S_t$$

For these households, the critical relationship is that between the savings rate and an internal shadow borrowing cost. This cost, derived in Appendix A, is a function of the household's marginal utility of consumption in bad periods, how tightly the borrowing constraint binds, and the intertemporal discount rate. When the savings interest rate is less than this borrowing cost, households will consume less in bad years. Note that by assuming a zero interest rate on savings, we automatically assume that this is the case. A non-zero interest rate opens up the possibility of households consuming *more* in bad years, when the savings rate it greater than or equal to this borrowing cost.

When interest rates are incorporated into the model, the number of household types changes from two (unconstrained and constrained) to six, where each household's type is a function of whether the borrowing constraint binds and the magnitudes of r_l and r_s. This could give rise to multiple internally consistent general equilibrium solutions. For illustrative purposes, however, let us assume that one of these is a scenario in which the land rental rate falls following negative productivity shocks. In which case, unconstrained households for which $r_s \geqslant r_l$ will increase land, as will constrained households for which r_s is at least as large as their internal borrowing cost. As in the original model, it is the households for which borrowing costs—external or internal—are too high that destabilize current consumption and decrease investment in agriculture.

As illustrated by the above discussion on non-zero interest rates and others caveats noted throughout the model exposition, our main results rest on many assumptions. Among these, the strongest may be that of stationarity of consumption for both household types. As noted earlier, our predictions require the assumption that all "good" periods are equally good (i.e., that consumption is always the same in all "good" periods) and that all "bad" periods are equally bad, regardless of the history of weather outcomes leading up to them. Because consumption is, in this sense, "memory-less," our model presents a narrative that differs fundamentally from those presented in typical models of asset dynamics (e.g., Carter & Lybbert, 2012). These simplifying assumptions permit an analytic solution to the problem, but also disallow potentially important asset dynamics, as will be discussed in the conclusions below.

5. EMPIRICAL EVIDENCE FROM DRYLAND FARMERS IN MOROCCO

With the model's implications in mind, we now revisit the farm household data from Central Morocco and delve more deeply into drought coping through land tenancy transactions. Although data limitations prevent a full and direct test of the model, the data do allow us to explore the determinants that shape which households rent or sharecrop land in or out. The empirical patterns that emerge are consistent with the model and add additional insight. We first describe in greater detail the sampling frame and survey used to collect the data we introduced in Section 2. We then present two empirical analyses of land tenancy transactions as a coping strategy.

In the summer of 2007 and again in 2008, a collaborative team of researchers from the Moroccan National Institute of Agronomic Research, the International Center for Agricultural Research in the Dry Areas, the International Center for the Improvement of Maize and Wheat, and the University of California-Davis implemented a survey of wheat-growing households in the province of Meknès. The 250 sampled households represented 21 villages in four distinct rural districts: Ain Jemaa, Sidi Slimane, Sebt Jehjouh/Ait Ouikhalfène and Ben Smim. The four districts are located, respectively, in the lowlands (300–400 meters above sea level (masl)), plateau (500–600 masl), foothills (700–900 masl), and mountains (1,200–1,500 masl) and were chosen to represent the diverse range of agricultural systems found throughout the province. Once the districts were identified, then villages, and finally households were chosen at random.

Sampled households depend primarily on income from rainfed annual crops (bread wheat, durum wheat, barley, oats, and pulses), livestock, olive and fruit orchards, off-farm employment, and remittances. As shown in Table 1, the relative importance of each activity differs widely between the rural districts, reflecting differences in altitude, terrain, rainfall, and proximity to urban centers. For example, the districts of Sidi Slimane and Ben Smim are located closer to urban centers; in these areas more households report sources of off-farm income. And ownership of livestock is far greater in the foothills and mountains. While not evident in this table, there is also substantial heterogeneity in household livelihood strategies within districts as well.

As a direct test of the model, we would ideally test the influence of credit constraints on households' decisions to increase or decrease cultivated land through land tenancy arrangements. However, in settings such as this where much borrowing and lending occurs informally, measuring credit constraints is challenging. Consider first what pre-drought determinants shape whether a household opts to respond to the drought via the local land tenancy market. We use proxy variables that may indicate binding credit constraints, and estimate these and other determinants in a complementary log-log model where the binary outcome variables are whether a household rented or sharecropped in additional land (increased land) and whether a household rented or sharecropped out additional land (decreased land) specifically in response to the drought.

Our proxies for binding credit constraints are herd size (sheep and goats) in 2006, a wealth score compiled from data on household durable assets, whether a household had a formal savings account, whether it had been refused credit in the past, the area of its private land, [13] the education level of the household head, and whether the household head belonged to a cooperative or a local farmers' association. As controls, we include the number of household members who earned off-farm wages, the number of domestic migrants, the number of international migrants, a measure of risk aversion, [14] and district dummies. To reflect the clustering in our sampling frame, we cluster errors by village. These results are shown in Table 2 in columns 1 and 3.

Table 1. *Variable averages by district*

District	Sidi Slimane	Ain Jemaa	Sebt Jehjouh	Ben Smim
Altitude (masl)	500–600	300–400	700–900	1,200–1,500
Households	58	68	77	49
Privately owned land (ha)	0.28	6.18	10.78	10.01
Other land[*] (ha)	3.27	3.91	5.65	0.81
Percentage of total crop income from cereals	0.57	0.47	0.88	0.73
Sheep and goats in 2006 (head)	4.80	13.03	74.64	122.00
Off-farm workers in 2006–07	1.01	0.48	0.36	0.73
Domestic migrants in 2006–07	0.76	1.52	1.16	0.64
International migrants in 2006–07	0.22	0.10	0.16	0.09
Educational attainment of household head[a]	1.40	0.58	0.39	1.51
Belongs to farmer cooperative or association	0.02	0.22	0.15	0.40
Wealth score[b]	1.05	−0.68	−1.14	1.48
Risk aversion (CARA)	0.0013	0.0012	−0.0010	0.0028
Owns savings account	0.17	0.06	0.05	0.33
Refused agricultural credit in past	0.35	0.28	0.29	0.30
Rented/sharecropped *in* any land in 2006–07	0.28	0.44	0.51	0.27
Rented/sharecropped *out* any land in 2006–07	0.09	0.07	0.10	0.20

[a] 0 = none, 1 = koranic school, 2 = primary school, 3 = secondary school, 4 = high school, 5 = college.
[b] Wealth score is calculated based on ownership of a list of durable goods.
[*] Land that is owned communally, but farmed by individual households in long-term arrangements.

Table 2. *Complementary log-log estimation of land tenancy changes*

	Increased land		Decreased land	
	(1)	(2)	(3)	(4)
Sheep and goats in 2006	0.001	−0.000	−0.016	−0.017
	(0.002)	(0.002)	(0.011)	(0.014)
Wealth score	0.199	0.401 *	−0.359	−0.277
	(0.154)	(0.224)	(0.312)	(0.399)
Savings account	−1.822 *	−3.368 ***	2.285	2.437
	(1.012)	(1.269)	(1.532)	(2.572)
Refused credit in past	0.387 *	0.258	0.686	0.387
	(0.219)	(0.248)	(0.624)	(0.931)
Private land	−0.003	0.008	−0.073	−0.153 **
	(0.016)	(0.017)	(0.055)	(0.074)
Education of household head	0.068	0.082	0.029	−0.189
	(0.083)	(0.132)	(0.240)	(0.298)
Member of coop./assn.	−1.381***	−1.034 **	1.916 *	1.860
	(0.326)	(0.415)	(1.017)	(1.286)
Off-farm workers in 2006–07	0.078	0.101	0.332	0.432 *
	(0.164)	(0.161)	(0.212)	(0.222)
Domestic migrants in 2006–07	−0.100	−0.038	0.113	0.064
	(0.112)	(0.102)	(0.227)	(0.181)
International migrants in 2006–07	−0.101	0.277	0.718	1.171
	(0.325)	(0.358)	(0.919)	(1.261)
Risk aversion (CARA)	−22.080	−8.051	36.877	29.156
	(17.251)	(17.651)	(23.121)	(38.677)
Rented in land in 2006–07		1.998 ***		−0.385
		(0.432)		(0.761)
Rented out land in 2006–07		0.696		2.831 ***
		(0.715)		(0.505)
Wald χ^2 statistic	50.12	995.61	98.32	3248.69
N	214	214	212	212

Cluster (village)-robust standard errors in parentheses. District fixed effects included, but not reported.
* Denotes 10% significance.
** Denotes 5% significance.
*** Denotes 1% significance.

The results show little evidence of the pre-drought credit and liquidity measures—pre-drought herd size, wealth, past credit denial, savings account, and private land—being systematically correlated with investments (or divestment) in agricultural land. Counter to our model predictions, we see that households increasing land tended to be those without savings accounts and those who had been refused formal credit in the past. These results likely reflect some notable imperfections in these proxies. Having a bank account in this context is as much an indication of a household's livelihood portfolio as it is a measure of credit access. Similarly, our credit refusal measure does not distinguish between households that sought out credit and those that did not, again implying that it is only an imperfect credit access proxy.

The inclusion of two variables indicating pre-drought land tenancy agreements—"rented in land in 2006" (which takes the unit value if the household had rented or sharecropped in any land during the 2006–07 agricultural year) and "rented out land in 2006"—somewhat changes these first results and suggests a pattern: in the absence of clean measures of credit access, coping responses appear largely to be functions of pre-existing relationships. As the coefficients in columns 2 and 4 show, a household that normally rents out land is significantly more likely to rent out even more land as a response to drought, and, similarly, a household that normally rents in land is more likely to rent in additional land as a drought response. We also find that households with members working off-farm before the drought are more likely to use increased wage labor as a drought response, though the results from this particular regression are not shown here. It appears that the observed drought responses are, for the most part, the result of households making adjustments at the margin of extant activities. These findings are consistent with a transactions cost explanation in which many coping mechanisms have significant attendant fixed costs and each household's menu of potential coping strategies is circumscribed not only by the availability of various assets, but also the economic relationships cultivated in "normal" times. While it is beyond the scope of this paper, this merits attention in future work.

Recall that households reported employing coping strategies other than increasing and decreasing cultivated land. Of the households that reported using any of the coping responses listed by the enumerator, nearly half used two or more, suggesting that many households formulate response portfolios rather than isolated responses. As a complement to the above analysis, we use cluster analysis to understand these coping response portfolios. [15] A standard regression approach would suffer from an obvious simultaneity problem: the ultimate mix of drought responses emerges as households concurrently respond to drought along several dimensions. While cluster analysis gives only descriptive results, it has the distinct advantage of more directly capturing a central prediction of the model—that households renting or sharecropping in more land will simultaneously take actions to raise the cash needed to invest in rent and productive inputs. Empirically, this approach also addresses the difficulty of measuring credit constraints *ex ante*: Rather than relying on pre-drought proxies of liquidity and credit access, this approach captures whether and

Table 3. *Variable means of cluster analysis groupings*

	Cluster 1 No pattern	Cluster 2 Sold animals	Cluster 3 Worked off-farm	Cluster 4 Used grain stocks Sold animals	Cluster 5 Increased land Borrowed money Sold animals	Cluster 6 Increased land Sold animals
Households	99	53	37	34	16	15
Sample percentage	39%	21%	14%	13%	6%	6%
Clustering variables						
Consumed/sold more grain	0	0	0.05	1.00	0.38	0.33
Sold more animals	0	1.00	0.22	0.53	0.69	1.00
Sought more off-farm work	0	0	1.00	0	0.38	0.07
Borrowed money	0.17	0.17	0.19	0.18	1.00	0
Decreased land	0.06	0.08	0.08	0.03	0	0
Increased land	0.06	0	0.11	0	1.00	1.00
Other variables						
Sheep and goats in 2006	52.87	51.68	13.00**	69.29	60.62	78.60
Wealth score	0.35**	−0.40	−0.14	0.36	−0.39	−1.01**
Member of coop./assn.	0.26**	0.15	0.11	0.24	0.06	0.13
Off-farm workers in 2006–07	0.55	0.64	1.00**	0.47	0.38	0.53
Percent cereal income	0.60**	0.67	0.61	0.74	0.75	0.83*

* Denotes that the mean differs from that of the rest of the sample at 10% significance.
** Denotes that the mean differs from that of the rest of the sample at 5% significance.

which households actually responded by borrowing or asking for money, regardless of the source.

We condense the 21 specific potential drought responses into six broader categories—consumed or sold more grain; sold more animals; began or increased off-farm work for wages; borrowed money from family, acquaintances, or others; decreased cultivated land; and increased land—and use cluster analysis on these. The top half of Table 3 presents the means of the clustering variable of the identified groupings. The bottom half of the table shows the within-cluster mean values of other variables that help to characterize the households in in each group. The largest group, cluster 1, is comprised of households that, for the most part, only weakly respond to the drought using the listed mechanisms. These households, which comprise 39% of the sample, share two other common features as seen in the bottom panel of Table 3: relative to the other 61% of the sample, they have a significantly higher average wealth score and lower proportion of income from cereal production. This suggests that households in cluster 1 did little to cope because they were the least exposed to the drought shock and therefore least likely to rely on any coping strategies.

Households in clusters 5 and 6 increased their cultivated land and financed this investment through borrowing, animal sales, and/or grain sales. Of particular interest are the 15 households in cluster 6; they raised money to invest in crop production solely through animal and grain sales—i.e., without borrowing. Surprisingly, their low mean wealth score and high mean percent income from cereal production together suggest that they are the poorest, most drought-prone households in the sample. While this is a counterintuitive finding, we can think of two possible explanations, one empirical and the other theoretical: Although the households in cluster 6 appear to be the least able to invest following a drought, it may be that they still have relatively more liquidity compared to the households that rented out their land. Such households are few in number and, because they are dispersed among four different clusters, cannot be compared to those in cluster 6. It is also possible that the households in cluster 6 would have benefited the most (in terms of consumption gains) from expanding land precisely because of their heavy reliance on cereal production. But again, because of the small number of households in this cluster, we cannot infer too much from these characterizations. Nonetheless, what this analysis *can* suggest is that renting and sharecropping in land may indeed signal the ability of households to raise cash—either by borrowing, or through the sale of assets. And, combined with the above analysis, it highlights the danger of ignoring informal channels of borrowing and buffer assets.

While these results lend some credence to our model, data limitations constrain the analysis and make it largely descriptive. A more rigorous test of the model—one that could identify a causal relationship between liquidity constraints and drought response strategies—would require clean measures of liquidity constraints that account for both formal and informal sources of credit and that are subject to some variation that is exogenous to households' drought coping strategies. Even without such a test, however, these results suggest the need to better understand how local markets and relationships between households mediate coping strategies through land tenancy adjustments specifically and short-term usufruct arrangements more generally.

6. CONCLUSIONS

In an era of persistent rural poverty and substantial and unmitigated vulnerability to drought in much of the developing world, a clearer understanding of household drought responses is essential to designing and refining policy measures and interventions that seek to improve rural household welfare. Climate change forecasts that anticipate more frequent and more severe drought events in the coming decades add urgency to this area of inquiry. We aim to contribute to such an understanding in the context of Morocco—one of the most drought-prone and climate-change-vulnerable countries in the driest, hottest, and most unstable regions of the world. Specifically, we explore a surprisingly common coping response observed in the wake of a severe drought in 2007: the reliance on adjustments to short-term land tenancy contracts.

As an analytical framework for understanding household drought responses, we have proposed a model in which a household's response to drought bifurcates depending on whether its cash constraint binds—unconstrained households are able to simultaneously smooth consumption and maintain, or even increase, agricultural investment following negative shocks, whereas constrained households not only destabilize consumption, but underinvest in the wake of such shocks. Where shocks are periodic, the ability to recover quickly may be the key to longer term drought resilience. Such a mechanism has the potential to stratify households into those well off and essentially invulnerable to drought, and the chronically poor whose consumption and investments are continually compromised by drought.

Based on detailed drought-response data, we find some support for the theoretical model: households that temporarily rent or sharecrop in additional land in the wake of the drought are those that are able to borrow or otherwise raise the funds necessary to make this recovery investment. However, we find no evidence that measures of *ex ante* credit access influence households' choice to expand their cultivated land through these local land tenancy markets. This lack of evidence may be due to data limitations that impede clean measurement of *ex ante* credit access or, perhaps more likely, to widespread reliance on informal borrowing through social networks and self-financing through selling off additional livestock—both of which are difficult to measure as *ex ante* options for a given household.

In contrast, we find that *ex ante* land tenancy contracts most strongly determine whether a household uses local land tenancy markets as a forum for drought coping and recovery. In conjunction with credit constraints writ large, this raises an additional explanation as to which households turn to these markets to cope and recover from drought: transactions and perhaps monitoring costs may make it much easier for households already active in the market for rental or sharecropping arrangements to transact in this market than for those with no pre-existing land tenancy contracts. The ability to buffer shocks using other seemingly-illiquid assets may similarly depend on economic relationships established in non-drought times because these relationships introduce heterogeneity in the transactions costs faced by households.

This paper raises a few specific directions for future research. The first stems from a key implication of the model results; a second and third arise from limitations of this study. First, the option to lean on local land tenancy markets in times of need is inherently context-dependent. In settings with well-defined and respected private land ownership, temporary adjustments in rental or sharecropping arrangements need not threaten owners' tenure security. Although formal land titles may achieve this degree of security, these land tenancy markets are highly localized, village-level markets, which suggests that local norms may also be sufficient. Usufruct options for other seemingly illiquid assets—options that enable households to temporarily confer usage rights without transferring ownership rights—may similarly reflect local norms and introduce important dimensions of heterogeneity to the local welfare impacts of shocks. Understanding these usufruct options for buffering consumption with assets and how, given their highly localized nature, they interact with informal risk sharing and reciprocity arrangements is a potentially fruitful area for future research.

Second, although the data we use in this paper indicate whether households increased or decreased cultivated land via rental or sharecropping arrangements in response to the drought, they are not sufficiently detailed to study features of these land tenancy transactions directly. For example, we do not know how these drought-induced transactions affected the effective price of these contracts, nor do we know whether households renting or sharing in additional land were opportunistic or altruistic. A detailed understanding of these local markets and transactions is therefore beyond the scope of this paper, but merits attention since the efficacy and welfare implications of these coping and recovery strategies depend crucially on these details.

Finally, both the theoretical model and the empirical analysis in this paper share an important limitation in that both are inherently static. To make the stylized model tractable, past shocks are assumed to have no persistent effects. That is, a bad year that comes on the heels of several bad years is treated the same as a bad year on the heels of several good years, even though these are obviously two very different sequences. Moreover, the model assumes that households are in equilibrium. The combination of these simplifying assumptions prevent the asset and consumption sequences of credit-constrained and unconstrained households from diverging over time. A richer model, such as in Zimmerman and Carter (2003), is needed to capture these divergent asset dynamics, albeit at the expense of tractability. The empirical analysis is similarly unable to test long-run dynamics implied by differential coping strategies—in particular, via adjustments in land tenancy arrangements. The potential dynamic implications of using temporary usufruct contracts to buffer consumption in the face of welfare shocks are an important topic for future research.

NOTES

1. This year was preceded by a "good" year (2005–06) and followed by a "mediocre" year (2007–08).

2. The recall period thus spanned at least one year. For households that began responding to the drought as it unfolded—i.e., before the actual harvest occurred, the recall period would have extended back to a few months prior to the 2007 harvest.

3. Similar methodologies have been used to assess the severity of food shortfalls (see Maxwell (1996) and Maxwell, Ahiadeke, Levin, Armar-Klemesu, Zakariah, and Lamptey (1999)).

4. Not included in any of the six categories above are installing irrigation (2.4% of households responded having done this), selling gold (0.4%), and selling land (0%).

5. The discrepancy between the percentages of households renting or sharecropping in land (henceforth "renting in land") and those renting or sharecropping out land ("renting out") cannot be explained by the relative sizes of the transacted plots; both rented-in and rented-out plots were typically on the order of one or two hectares. Instead, this pattern may simply reflect our sampling frame, which only included a portion of households from each village in the sample.

6. Alternatively, l could stand for labor, or any other production factor that the household owns and can potentially transact.

7. The strict convexity of the marginal utility function is a necessary condition for precautionary savings (Deaton, 1991).

8. This is a standard result from a two-stage Markov process.

9. An implicit assumption here is that the savings and land variables neither grow nor shrink appreciably. It it were otherwise, we would no longer be able to assume that the level of consumption in a good (bad) state is independent of the exact history of weather outcomes preceding it. The consumption levels are, in this sense, "memory-less."

10. The general shape of the isoquants and the directions in which their values increase are a function of the decreasing-returns-to-scale assumption, rather than the actual degrees of substitutability between inputs. Therefore, this and subsequent claims will be true as long as the Cobb–Douglas production function is assumed to have decreasing returns to scale.

11. Incidentally, if the technology showed increasing returns to scale, then it would be the constrained households renting in more land from the unconstrained households.

12. It is difficult to make *a priori* assumptions about this relationship for our study area, given the various forms that savings assets take for the sampled households (e.g., cash, grain, animals) and the wide range of loan interest rates reported. Loan interest rates ranged from 0 (in approximately one-third of the reported loans) to as high as 25%. The average rate (excluding the zero-rate loans) is 8.6%.

13. As opposed to land that formally belongs to other entities (for example, the mosque or the community) but is farmed by the household under long-term agreements.

14. We use experimental data from the study to calculate the standard Arrow–Pratt coefficient of absolute risk aversion (CARA) (Arrow, 1971).

15. Cluster analysis (specifically, *k*-means cluster analysis) is a technique that groups "similar" individuals into a user-specified number of clusters. Individuals are initially clustered randomly, then swapped from cluster to cluster based on an algorithm that maximizes the variation of characteristics *between* the groups and minimizes the variation *within* groups. Brown, Stephens, Ouma, Murithi, and Barrett (2006) provide an in-depth explanation and demonstration using rural livelihoods data from Kenya.

16. Interest on savings is defined broadly and can include animal products as well as formal interest, depending on the form the savings asset takes.

17. It makes little sense to describe equilibria for households who save every year, or for households who never save, since such households are not in equilibrium.

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APPENDIX A

Here we examine how non-zero interest rates modify the result from the main model. Suppose households with access to credit can borrow money at constant rate r_l (where the subscript l denotes "loan") and all households accrue interest r_s (also constant) on positive savings. [16] The only plausible equilibrium scenario is one in which households with credit access both borrow and save, depending on the year; and those without credit access save in some years, but not others. [17] In the case of the unconstrained household, we modify Eq. (4) to reflect the assumption that it saves after good years and borrows after bad ones.

$$(1+r_l)\left[\pi(g|b)\frac{u'_g}{u'_b}+\pi(b|b)\frac{u'_b}{u'_b}\right]=(1+r_s)\left[\pi(g|g)\frac{u'_g}{u'_g}+\pi(b|g)\frac{u'_b}{u'_g}\right]$$

The above equation shows that the relationship between u'_g and u'_b (and hence c_g and c_b) depends on the relative magnitudes of r_l and r_s. Specifically, $c_b < c_g$ $(c_b = c_g, c_b > c_g)$ if $r_s < r_l$ $(r_s = r_l, r_s > r_l)$. If the interest rates are non-zero but equal to each other, we obtain the original result of consumption staying constant across good and bad weather outcomes and, based on this, the marginal productivity of cash also staying constant across the years.

When interest rates are non-zero, the equivalent relationship for households without credit access is

$$\beta\left[\pi(g|b)\frac{u'_g}{u'_b}+\pi(b|b)\frac{u'_b}{u'_b}\right]+\frac{\eta_b}{u'_b}=(1+r_s)\beta\left[\pi(g|g)\frac{u'_g}{u'_g}+\pi(b|g)\frac{u'_b}{u'_g}\right] \quad (8)$$

This is Eqn. (7), with the modification that the savings following good seasons accrue positive interest. We can see that it is no longer necessarily the case that $u'_b > u'_g$ (and hence $c_b < c_g$). Whether a household increases or decreases consumption following bad outcomes depends on the magnitude of the savings interest rate relative to the “shadow” borrowing cost. We see here that for constrained households, the cost of borrowing from future productivity is a function of how tightly the savings non-negativity constraint binds, the intertemporal discount rate, and the marginal utility of consumption after bad states.

$$c_b < c_g \quad \text{if } r_s < \frac{\eta_b}{\beta u'_b}$$

$$c_b = c_g \quad \text{if } r_s = \frac{\eta_b}{\beta u'_b}$$

$$c_b > c_g \quad \text{if } r_s > \frac{\eta_b}{\beta u'_b}$$

Note that the zero interest rate subsumed in the original model specification is a special case of $r_s < \frac{\eta_b}{\beta u'_b}$.