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Poverty Traps and Index-Based Risk Transfer Products

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Summary. — A growing literature suggests that in low-income countries, households with few assets can be trapped in chronic poverty. This article reviews relevant threads of the poverty traps literature to motivate a description of the opportunities presented by innovative index-based risk transfer products. These products can be used to address some insurance and credit market failures that contribute to the persistence of poverty among households in low-income countries. Applications are considered at the micro, meso, and macro levels.

Key words — index-based risk transfer products, insurance, poverty traps, risk management

1. INTRODUCTION

A growing literature suggests that in low-income countries, households with few assets can be trapped in chronic poverty. Due to high uninsured risk exposure, households may adopt low-risk, low-return strategies for using productive assets, reducing the likelihood that they can accumulate the assets needed to escape poverty through autarchic savings and investment. Thus, those with few assets may accurately perceive that time is not an ally in their daily struggle to climb out of poverty. The resulting hopelessness can be both probabilistically accurate and self-reinforcing. Others suffer uninsured asset losses that suddenly cast them into poverty and possibly onto a downward spiral from which they have a difficult time re-emerging. These themes from the emerging literature on poverty traps underscore the relation between risk and persistent poverty, as well as the opportunities afforded by innovations in risk management.

This article reviews relevant threads of the poverty traps literature to motivate a description of the opportunities presented by index-based risk transfer products (IBRTPs). These products can be used to address some insurance and credit market failures that contribute to the persistence of poverty among households in low-income countries. Applications are considered at the micro, meso, and macro levels. We discuss as well some of the key limitations of IBRTPs in low-income rural areas, where agricultural production is a dominant, though not necessarily exclusive, economic activity and where formal insurance and credit markets are likely to be most limited. The use of IBRTPs to pre-finance safety net and disaster assistance programs is also considered.

Separate literatures exist on both poverty traps and on IBRTPs. Our innovation is to highlight that the poverty traps hypothesis—in

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particular, the possibility of poverty traps based on multiple dynamic equilibria—substantially increases the stakes with respect to risk management. One of our primary objectives is to demonstrate the largely overlooked connections between the poverty traps and IBRTP literatures. While a poverty trap is not necessary for IBRTPs to be relevant in low-income countries—a simple market failure argument suffices to justify new risk transfer interventions, as we explain in Sections 3 and 4—the synergistic interaction between these two phenomena of growing interest merits more explicit attention than it has received to date.

While many factors contribute to the existence of poverty traps, limited access to insurance and credit instruments is commonly identified as a primary causal factor. In many low-income countries, formal insurance and credit markets are limited due to poor contract enforcement, asymmetric information, high transactions costs, and high exposure to covariate risk. With limited access to credit or insurance, households often have a difficult time managing the myriad risks they face. In recent years a number of innovative IBRTPs have been developed for transferring covariate risks outside the low-income rural economy. Relative to traditional insurance products, IBRTPs are characterized by fewer asymmetric information problems, lower transactions costs, and simpler contract designs, as we describe below. While to date most commercial applications of these instruments have been in OECD countries and India, substantial efforts are underway to extend these instruments to low-income countries. This is a potentially important innovation because social and institutional mechanisms for coping with covariate risk exposure are typically quite limited in low-income countries, especially among the rural poor.

Behavioral responses to risk can limit economic growth. Thus, IBRTPs hold promise as an important development tool. However, since both national governments and donor organizations face budget constraints, there is an opportunity cost to using scarce resources to develop risk management programs based on IBRTPs. Thus, it is critically important that decisions regarding IBRTPs be based on a clear understanding of both the advantages and limitations of IBRTPs and how these instruments may fit into broader development strategies.

The plan for the rest of the paper is as follows: Section 2 reviews the relevant poverty traps literature, with particular emphasis on how the combination of exogenous shocks, especially covariate shocks, and incomplete insurance and credit markets generates conditions that can trap households in poverty. These factors also affect meso and macro level institutions in ways that further constrain economic opportunities at the household level. Section 3 describes why insurance and credit markets often fail in rural areas of low-income countries. Many of the same factors that limit the availability of formal insurance and credit also limit the availability of insurance and credit through informal channels. Section 4 describes IBRTPs and recent efforts to extend availability of these instruments into low-income countries. IBRTPs can be used as a market mechanism to transfer covariate risks outside of the country or region. Alternatively, they can be used by governments, donors, or even non-governmental organizations (NGOs) to pre-finance safety net or disaster assistance efforts. However, experience to date suggests that IBRTPs targeted to the needs of low-income countries will not materialize without the coordinated efforts of national governments and donors. Section 5 therefore discusses implementation issues that affect the long-run sustainability of IBRTPs. We conclude, in Section 6, with some summary thoughts and concerns about the prospects and limitations for IBRTPs as a tool for addressing persistent poverty in rural areas of low-income countries.

2. POVERTY TRAPS

As research on and measurement of poverty has evolved over the past decade or two, increased attention has been paid to how well-being evolves over time, with much interest in resolving the important puzzle of why some individuals, households, communities and nations remain mired in extreme poverty for extended periods and how others are able to avail themselves of new market and technological opportunities to lift themselves out of poverty.[1] Increasingly, the former experience has become summarized as a "poverty trap." This concept has proved extremely influential in development policy circles, perhaps most clearly manifest by the United Nations Millennium Project (2005).

In the economics literature, there exist multiple sorts of poverty traps associated with different mechanisms by which these might emerge (for details, see Azariadis & Stachurski, 2005;

Barrett & Swallow, 2006; Bowles, Durlauf, & Hoff, 2006; Carter & Barrett, 2006). One special class of poverty traps requires the existence of multiple dynamic equilibria, at least one of which lies below a standard poverty line. This particular sort of poverty trap is uniquely relevant to the insurance literature because it is characterized by at least one critical threshold (an unstable dynamic equilibrium, in somewhat more precise, formal terms) above which the expected dynamics of the system are characterized by asset accumulation (i.e., growth and improvements in standards of living) and below which decumulation prevails. Unlike poverty traps based on a unique, low-level stable equilibrium, threshold-based poverty traps raise the stakes for risk management because only in the presence of multiple equilibria can shocks exogenously shift the accumulation dynamics, which bifurcate at the unstable equilibrium.

In a world without multiple dynamic equilibria, everyone follows a growth path towards a unique, long-run standard of living. This can occur at different rates and there may be temporary disruptions along the way due to various shocks, even different equilibria for different cohorts, as enshrined in the concepts of "club convergence" and "conditional convergence" in the macroeconomic growth literature. But, in such a world, shocks should have no permanent effect, although they can take some years to fully play themselves out. Risk merely adds noise to the inexorable process of convergence.

In the presence of a critical threshold, by contrast, shocks can have permanent consequences, flipping people from one growth path onto another. Rare, favorable shocks (e.g., winning a lottery or receiving a significant asset transfer) can suddenly make new investments worthwhile and lead a poor beneficiary to grow towards a higher-level equilibrium. By contrast, shocks that push people below the threshold can set them onto a downward spiral into destitution (a low-level equilibrium) from which they do not recover, or keep them from growing their way out of persistent poverty by regularly knocking them backwards as they struggle to climb out of the trap, a real-world Sisyphean tragedy (Carter & Barrett, 2006; Carter, Little, Mogues, & Negatu, 2005; Dercon, 1998, 2005; Krishna, 2006; McPeak & Barrett, 2001; Santos & Barrett, 2006a). Knowing this, people may go to extraordinary lengths to manage risk exposure, for example by selecting low-risk, low-return portfolios that reduce the risk of greater suffering but limit growth potential and investment incentives (Bardhan, Bowles, & Gintis, 2000; Carter & Barrett, 2006; Dercon, 2005; Eswaran & Kotwal, 1989, 1990; Rosenzweig & Binswanger, 1993). Among the poorest of the poor, a subsistence threshold likely exists. If household asset levels fall below this threshold, the path dynamics suggest that the household would not be expected to generate sufficient income to meet the most basic nutritional requirements (Zimmerman & Carter, 2003), thereby collapsing into a nutritional poverty trap (Dasgupta, 1993, 1997).

Risk can thus have two distinct, crucial effects in a system characterized by multiple equilibria. First, *ex ante* efforts to reduce risk exposure can dampen accumulation, thereby creating a low-level equilibrium. Second, the *ex post* consequences of a shock can knock people back into a poverty trap.

Of course, if markets exist to permit people to insure against shocks *ex ante*, or to borrow *ex post* so as to achieve quasi-insurance through *ex post* loan repayment (rather than *ex ante* insurance premium payment), these adverse effects of risk should be attenuated. The existence of risk need not then contribute to the existence of poverty traps. Unfortunately, credit and insurance instruments are routinely undersupplied in most low-income areas, and especially to the poorest peoples (Besley, 1995). Financial market failures thereby contribute both directly and indirectly to the persistence of chronic poverty (Carter & Barrett, 2006).

Many of the factors that contribute to poverty traps at the household level (e.g., barriers that create scale economies and limited access to insurance or credit) can also exist at more aggregate levels of analysis (Barrett, Carter *et al.*, 2006; Barrett, Marenya *et al.*, 2006; Barrett & Swallow, 2006). Poverty traps at higher levels of aggregation necessarily constrain economic opportunities at lower levels of aggregation and thus, accentuate poverty traps at the household level (Carter & Barrett, 2006; Mehlum, Moene, & Torvik, 2005). For example, the next section describes how, at a local level, covariate risk exposure may limit the availability of informal credit or insurance. But various meso and macro level institutions may also be exposed to high levels of covariate risk. Absent some mechanism for transferring this risk, these institutions will be reluctant to invest in illiquid but highly productive assets (e.g., transportation infrastructure, processing facilities, etc.). These choices then further constrain the opportunities available to households at the micro level (Dercon, 2004).

3. LIMITED ACCESS TO INSURANCE AND CREDIT

(a) *Insurance market failure*

In rural areas of low-income countries, formal insurance markets are typically incomplete and often nonexistent. This is particularly true for insurance that protects against crop production shortfalls or livestock mortality. A common reason for insurance market failure is the lack of effective legal systems to enforce insurance contracts. But even when effective contract enforcement mechanisms are in place, insurance markets often fail due to strong covariate risk exposure, asymmetric information problems, and high transaction costs.

(i) *Covariate risk*

Insurance is based on the statistical law of large numbers which implies that, for a pool of uncorrelated observations, the variance of the pool decreases with the number of observations (Priest, 1996). However, if insured units face highly covariate risks, the variance reduction that can be obtained by pooling is greatly reduced (Skees & Barnett, 1999). Spatially correlated catastrophic losses can then exceed the reserves of the insurer leaving unsuspecting policyholders unprotected. Such experiences explain why crop insurance policies are generally available only in countries where governments take on much of the catastrophic risk exposure faced by insurers (Binswanger & Rosenzweig, 1986; Miranda & Glauber, 1997). The presence of highly covariate risk is a major cause of insurance market failure in many low-income countries.

(ii) *Asymmetric information*

The principal-agent literature identifies two primary types of asymmetric information problems: adverse selection (or hidden information) and moral hazard (or hidden action). In insurance markets, adverse selection occurs when potential policyholders have proprietary knowledge about their risk exposure that is not available to the insurer (Rothschild & Stiglitz, 1976). Insurance underwriters assign potential policyholders into risk rating classes. Because underwriters do not have access to all the relevant information, many potential policyholders are misclassified. Those who are misclassified to their benefit (detriment) are more (less) inclined to purchase. As a result the insurance program is likely to experience losses that exceed the projections used to establish premium rates. In response, the insurer may increase premium rates for all classes. But this only compounds the problem and leads to an even more adversely selected group of insurance purchasers (Barnett, 1995). Unless the underlying information asymmetry can be addressed, adverse selection will cause insurance markets to fail.

Moral hazard, the second common asymmetric information problem, occurs when, as a result of purchasing insurance, policymakers engage in hidden activities that increase their exposure to risk. This behavioral response leaves the insurer exposed to higher levels of risk than had been anticipated when premium rates were established (Barnett, 1995). Unless the insurer can effectively monitor policyholder behavior so as to enforce policy provisions, moral hazard will also cause insurance markets to fail.

Adverse selection and moral hazard problems can be addressed, in part, by making certain that the insured continues to hold some risk. This is why insurance policies typically contain deductible and/or co-insurance provisions. However, even with these provisions, serious adverse selection and moral hazard problems still plague agricultural insurance programs in the United States and other OECD countries (Chambers, 1989; Coble, Knight, Pope, & Williams, 1997; Goodwin, 2001; Just, Calvin, & Quiggin, 1999; Quiggin, Karagiannis, & Stanton, 1994; Skees & Reed, 1986; Smith & Goodwin, 1996). Information asymmetries are likely even more pronounced in rural areas of low-income countries. In addition, since the scale of agricultural production tends to be small in low-income countries, the cost of underwriting and monitoring activities to address those information asymmetries is a much higher percentage of the insured value.

(iii) *Transaction costs*

The transaction costs of offering insurance in rural areas are much higher than in urban areas due to the distances that must be covered by sales agents and loss adjusters and the relatively small number of policy-holders in each locale. These costs are amplified by limited transportation and communication infrastructure (Binswanger & Rosenzweig, 1986).

Crop insurance, in particular, is characterized by extremely high transaction costs. It is not easy to determine the policyholder's expected yield since expected yields vary tremendously across regions, among farms in the same region, and even across parcels for the same large land holder. Assessing crop losses is both difficult and time consuming. Furthermore, loss assessment is required more frequently for crop insurance than for other lines of insurance. The magnitude of these transaction costs tends to be largely independent of the size of the policy. Thus, as a percentage of the insured value, the transaction costs of selling and servicing insurance are much higher for small policies than for large policies. [2] As indicated above, costs associated with addressing information asymmetry problems are also much higher in rural areas than in urban areas. Thus, high transaction costs are another important cause of insurance market failure in rural areas of low-income countries.

(b) *Informal risk management mechanisms*

While formal insurance and credit markets are limited in rural areas of most low-income countries, various informal risk-coping mechanisms are widely utilized. In general, these mechanisms can be classified as risk mitigation, self insurance, and risk transfer. Rural households can mitigate risk by choosing to produce lower risk outputs (e.g., cassava instead of maize), employing risk reducing inputs (e.g., irrigation), share tenancy, and diversifying income sources. However, the extent to which households can utilize any of these strategies is highly conditioned on local climatic, technological, and market conditions as well as on household asset levels (Barrett, Bezuneh, & Aboud, 2001; Barrett, Bezuneh, Clay, & Reardon, 2005; Little, Smith, Cellarius, Coppock, & Barrett, 2001; McPeak & Barrett, 2001; Reardon, 1997; Reardon, Delgado, & Matlon, 1992; Reardon & Taylor, 1996). Further, the implied risk premia on risk mitigation strategies can be very high (Morduch, 1995; Rosenzweig & Binswanger, 1993; Zimmerman & Carter, 2003).

Rural households also employ various methods to self-insure against adverse shocks. Currency-denominated savings can be used to smooth consumption over time. Yet institutions that accept savings deposits (e.g., banks and post offices) are quite sparse in rural areas of many low-income countries. Further, high rates of inflation can significantly reduce incentives for monetary savings (Besley, 1995; Dercon, 1998; McPeak & Barrett, 2001).

Due to macroeconomic uncertainty and cultural preferences, household savings in many areas are often held in semi-liquid productive assets such as livestock rather than in currency (Dercon, 1996). If necessary, these assets can be liquidated to temporally smooth consumption (Rosenzweig & Wolpin, 1993). Market conditions, however, can limit the effectiveness of this self insurance strategy. In the aftermath of a highly covariate adverse shock (e.g., drought that affects an entire nation or multinational region), market supply of the asset can increase dramatically, driving down the value of household savings just when it is most needed (Dercon, 1996). This can also happen with localized adverse shocks if markets for the asset are not spatially integrated (Rosenzweig & Binswanger, 1993; Zimmerman & Carter, 2003). Liquidating productive assets may also not be a viable self-insurance option for the poorest of the poor. Evidence suggests that extremely poor households recognize the danger of subsistence traps (or other undesirably low-level equilibria) and thus beyond some point choose to forego consumption rather than further liquidating assets (Kazianga & Udry, 2006; Zimmerman & Carter, 2003). In other words, they smooth assets rather than consumption. Such a decision may require reduced expenditures on school fees (i.e., removing children from school), health care, and food consumption (Barrett, Carter *et al.*, 2006; Barrett, Marenya *et al.*, 2006; Carter, Little, Mogues, & Negatu, 2006; Foster, 1995; Morduch, 1995). Resulting health and educational deficiencies can reduce the value of human assets, further trapping the household in poverty (Dercon & Hoddinott, 2005; Hoddinott, 2006; Hoddinott & Kinsey, 2001; Jacoby & Skoufias, 1997; Thomas *et al.*, 2004).

Other common self-insurance strategies include household migration, movement of range-fed livestock to better pasture, or more intensive use of common natural resources. As with risk mitigation, there is an implied risk premium for all self-insurance strategies. The implied risk premium for self-insurance strategies is either the explicit or the opportunity cost of undertaking the strategy. An example of the former would be the costs associated with migration or the movement of livestock. An example of the latter would be the opportunity cost of holding savings in a relatively liquid state so they can be used for consumption smoothing should a shock occur. The opportunity cost of keeping funds in such a liquid state is the higher rate of return that could be realized on less liquid investments. Further, some self-insurance strategies can generate adverse external effects. Among these are pecuniary externalities as in the case of distress asset sales following covariate shocks or environmental degradation when common natural resources are used more intensively (Barrett & Swallow, 2006).

A variety of informal risk transfer mechanisms are utilized to smooth consumption in rural areas of low-income countries (Besley, 1995). These mechanisms vary from socially-constructed reciprocity obligations within family, village, religious community, or occupation (Coate & Ravallion, 1993; Fafchamps & Lund, 2003; Grimard, 1997; Rosenzweig, 1988; Townsend, 1994, 1995) to semi-formal microfinance, rotating savings and credit, or state-contingent loan entities (Hoff & Stiglitz, 1990; Udry, 1994). These family and community oriented mechanisms may be better able to address the asymmetric information and transaction costs problems that plague formal insurance and credit markets (Arnott & Stiglitz, 1991; Rosenzweig, 1988; Stiglitz, 1990; Udry, 1994). However, social factors can prevent reciprocity obligations from functioning as effective mutual insurance (Platteau, 1997). Moreover, these informal mechanisms tend to fail in the presence of large covariate risks (Dercon, 1996; Rosenzweig, 1988; Rosenzweig & Binswanger, 1993; Townsend, 1994; Zimmerman & Carter, 2003) and can be compromised by the existence of threshold-based poverty traps (Santos & Barrett, 2006b).

Informal risk transfer mechanisms must tradeoff asymmetric information and transaction costs problems against covariate risk exposure. The more (less) geographically proximate the participants, the fewer (more) the asymmetric information and transaction costs problems but the higher (lower) the exposure to spatially covariate risk (Grimard, 1997). There is also evidence that access to these informal mechanisms is positively related to existing wealth (Jalan & Ravallion, 1999; Santos & Barrett, 2006b). This is not surprising since the poorest of the poor would have little to offer family- or community-based mutual-aid institutions.

Limited access to insurance and credit, either formal or informal, contributes to the existence of poverty traps. Without effective means to transfer risk and smooth temporal consumption, adverse shocks can dramatically reduce the household's stock of productive assets *ex post*, either through direct destruction of assets or through distress liquidation. Recognizing this danger, households often choose low-risk, low-return, strategies that mitigate risk exposure but also lead to low expected returns and thereby a poverty trap.

(c) *Credit markets*

In the absence of formal insurance markets, credit can sometimes be used to temporally smooth consumption following the occurrence of a major shock (Binswanger & Rosenzweig, 1986; Eswaran & Kotwal, 1989). However, there is an important difference between insurance and credit markets. Insurance is an *ex ante* mechanism that requires only the payment of a premium. Credit is an *ex post* response that often requires either a previous history of repayment and/or assets that can be used as collateral.

In rural areas of low-income countries, formal credit markets also tend to be very limited and for exactly the same reasons that limit insurance markets. Contract enforcement is problematic. Asymmetric information problems make it difficult both to accurately classify borrowers prior to making loans and to monitor their behavior afterward (Binswanger & Rosenzweig, 1986; Braverman & Guasch, 1986; Freedman & Click, 2006; Hoff & Stiglitz, 1990). Transaction costs are very high, particularly as a percentage of funds loaned (Carter, 1988), and the lender is exposed to potentially high levels of covariate risk exposure (Rosenzweig, 1988). The lack of insurance markets further hampers credit markets since lenders may be unwilling to accept uninsured assets as collateral.

4. INDEX-BASED RISK TRANSFER PRODUCTS

The literatures on poverty traps and financial market failures in low-income rural settings point to a strong potential role for risk transfer mechanisms, both to help facilitate the development of insurance and credit markets and to provide a mechanism for pre-financing safety net and disaster assistance programs. Much of this potential is now being directed towards nascent applications of IBRTPs.

IBRTPs are financial instruments that make payments based on realizations of an underlying index relative to a pre-specified threshold. The underlying index is a transparent and objectively measured random variable. Examples include area average crop yields, area average crop revenues, cumulative rainfall, cumulative temperature, flood levels, sustained wind speeds, and Richter-scale measures. IBRTPs can take on any number of forms including insurance policies, option contracts, catastrophic bonds, or derivatives. [3] Some highly standardized IBRTPs are actively traded in secondary markets. However the focus here is on IBRTPs that are customized to fit the specific risk management needs of the purchaser. These IBRTPs are typically sold by international reinsurers and held by the purchaser until they expire.

Traditional insurance products pay indemnities when realized losses exceed a given threshold. Thus, traditional crop yield insurance pays an indemnity when realized farm-level crop losses exceed a stated percentage of the expected yield (the deductible). IBRTPs make payments when the realized value of the underlying index either exceeds or falls short of a given threshold. [4] The index is exogenous to the policyholder but correlated with the policyholder's realized losses. An IBRTP that protects against crop losses would be based on an index that is presumed to be highly correlated with farm-level yields. Examples include the Group Risk Plan (GRP) area yield and Group Risk Income Protection (GRIP) area revenue insurance products currently sold in the United States (Miranda, 1991; Skees, Black, & Barnett, 1997). IBRTPs with indices based on cumulative rainfall, cumulative temperature, area livestock mortality, and satellite imagery have also been proposed for agricultural producers (Deng, Barnett, Vedenov, & West, 2007; Mahul, 2001; Martin, Barnett, & Coble, 2001; Miranda & Vedenov, 2001; Skees & Enkh-Amgalan, 2002; Turvey, 2001).

Much recent attention has focused on the potential for using IBRTPs in low-income countries to protect agricultural assets from losses caused by various climatic perils (Hess, Richter, & Stoppa, 2002; Hess, Skees, Stoppa, Barnett, & Nash, 2005; Sakurai & Reardon, 1997; Skees, 1999a, 2000; Skees & Enkh-Amgalan, 2002; Skees, Barnett, & Hartell, 2005; Skees, Gober, Varangis, Lester, & Kalavakonda, 2001; Skees, Hazell, & Miranda, 1999; Varangis, Skees, & Barnett, 2002).

If an IBRTP is to be effective, the underlying index must meet several conditions. It must be highly correlated with the loss being insured against over a relatively large geographic area. Sufficient historical data must exist from which to estimate the probability distribution of the index. The process that generates random realizations of the index must be either inherently stationary and homoskedastic (as is true for some climatic variables) or else one must be able to manipulate the historical data using statistical trend adjustment and heteroskedasticity correction procedures to generate an accurate probability distribution of the index (as is often done with area yield indices). The index must be measured and reported in a timely manner by an objective third party. It must be observable, transparent, secure, and independently verifiable (Hazell & Skees, 2006).

(a) *Advantages and limitations*

IBRTPs have a number of advantages relative to traditional farm-level yield or revenue insurance. Since realizations of the index are exogenous to policy-holders, index insurance is not subject to the asymmetric information problems that plague traditional insurance products. Transaction costs are much lower since the insurer does not have to verify farm-level expected yields or conduct farm-level loss assessment. This is particularly important in low-income countries where farmers often do not have records of historical yields.

IBRTPs also have one significant limitation relative to traditional insurance—it is possible for a household to experience a loss and yet not receive a payment from an IBRTP. It is also possible that the household will not experience a loss and yet receive a payment. This "basis risk" occurs because the index is not perfectly correlated with farm-level losses. Of course, basis risk exists with many risk-management instruments (e.g., hedging using futures or options contracts). If the basis risk is relatively small, the instrument can still be a highly effective risk management tool. If the basis risk is quite large, the instrument will likely not be very effective. Various studies have empirically examined the effectiveness of IBRTPs in the presence of basis risk (Barnett, Black, Hu, & Skees, 2005; Black, Barnett, & Hu, 1999; Deng *et al.*, 2007; Martin *et al.*, 2001; Turvey, 2001; Vedenov & Barnett, 2004; Wang, Hanson, Myers, & Black, 1998). The findings from these studies are mixed. In some cases, basis risk can be reduced by carefully choosing the IBRTP parameters (e.g., the underlying index, the time period, and the indemnity function) so that indemnities are more highly correlated with actual losses incurred. However, for heterogeneous regions, such as those with many microclimates, basis risk may be too high for IBRTPs to be effective. It is important to remember that the very characteristic that causes basis risk in IBRTPs is also what eliminates asymmetric information problems—namely, that payments are based on realizations of the exogenous index rather than actual losses experienced by the household.

While farm-level insurance often fails in the presence of covariate risk, IBRTPs will not be effective unless risks are somewhat covariate. If, in a given region, farm-level risk exposure is completely idiosyncratic, no single index will provide effective risk transfer for farmers in that region. But if risk exposure is completely idiosyncratic, these risks could be easily pooled using formal or informal means. If farm-level risk exposure is completely covariate, there will be no opportunity for risk pooling at the local level but an IBRTP should provide effective risk transfer for all farmers in the region. [5] In reality, farm-level yield risks are generally neither completely idiosyncratic nor completely covariate. Instead, they are what Skees and Barnett (1999) call "in-between" risks. Losses are sufficiently covariate to limit risk reduction through pooling but they are also sufficiently idiosyncratic to cause basis risk with IBRTPs.

IBRTPs can be sold as "retail" insurance for households or businesses. For example, in Malawi a rainfall-based IBRTP is being offered to members of a smallholder farmer association. The IBRTP is bundled with credit for the purchase of improved groundnut varieties. In Mongolia an IBRTP pilot product based on aggregate levels of livestock mortality is being offered to individual herders. Some lenders, who believe that the IBRTP can reduce loan default risk, have also offered lower interest rates to borrowers who purchase the IBRTP.

Alternatively, IBRTPs can be used to reinsure portfolios of either index-based or traditional insurance policies. In OECD countries, IBRTPs are increasingly being used to reinsure portfolios of traditional property and casualty insurance policies against covariate risks associated with hurricanes and earthquakes. IBRTPs facilitate the transfer of such covariate risks into international financial markets. Large investors are attracted to IBRTPs for their diversification value since returns on IBRTPs are largely uncorrelated with returns on traditional debt and equity investments.

(b) *Risk layering*

In capital and reinsurance markets it is common for risk exposure to be described according to layers of losses. Likewise, when considering possible applications of IBRTPs in low-income countries, it is important to identify different layers of risk exposure. For example, consider an index based on cumulative rainfall during the month of August for a coastal weather station in Andhra Pradesh, India where weather-based IBRTPs are currently being offered. Figure 1 presents the probability distribution of the index. The central tendency

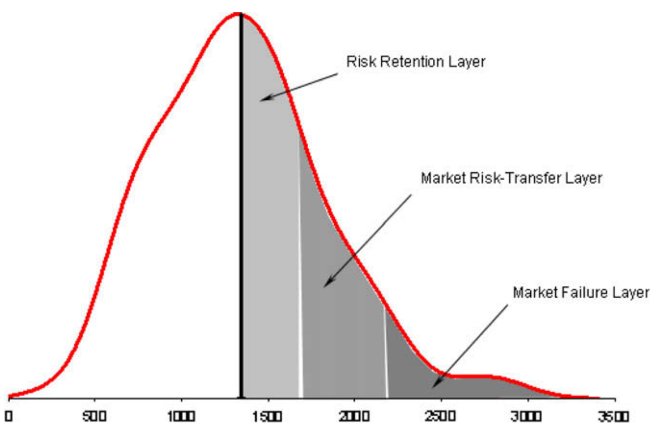

Figure 1. *Probability distribution of august cumulative rainfall for a coastal weather station in Andra Pradesh, India.*

is approximately 1,300 mm of rainfall. Excess rainfall during August causes losses for farmers and those working in economic sectors related to agriculture.

As a conceptual tool, three layers of losses are designated in Figure 1. The exact boundaries on these layers would vary depending on the nature of the risk and the circumstances of the end-user. The risk retention layer is characterized by high probability, but relatively low magnitude loss events. These events are best thought of as business expenses that are stochastic but not unexpected. The transaction costs would be very high to insure against these high frequency events. Thus, they are most efficiently handled through self-insurance or informal insurance mechanisms. For this example the risk retention layer is assumed to include rainfall events greater than 1,300 mm but less than or equal to 1,750 mm.

The market failure layer is characterized by very low probability, but high magnitude, loss events. For this example the market failure layer is assumed to include rainfall events greater than 2,300 mm. Individuals find it very difficult to correctly process information about such low probability events (Kunreuther, 1976; Rossi, Wright, & Weber-Burdin, 1982). Beyond some threshold, individuals tend to treat low probability as though it is zero probability (Kunreuther, 1996; Kunreuther & Slovic, 1978; Tversky & Kahneman, 1973). This cognitive failure reduces demand for insurance that protects against loss events in the extreme tail of the distribution.

At the same time, IBRTP suppliers are aware that some density exists in the tail of the distribution. When calculating the selling price for an IBRTP, they must estimate the density in the tail of the distribution based on very sparse data that causes insurers to add ambiguity loads to the cost of IBRTPs. Because of cognitive failure on the part of insurance purchasers and ambiguity loading on the part of IBRTP suppliers, markets for protection against events in this layer tend to clear at less than socially optimal quantities of risk transfer (Skees & Barnett, 1999). This market failure can be addressed through public provision of coverage for this layer or through premium subsidies (Hess *et al.*, 2005). Both of these responses however, can introduce political economy concerns and generate perverse behavioral incentives that must be carefully considered. These matters are discussed more fully below.

The market insurance layer includes loss events that are, at least in principle, insurable using IBRTPs. For this example, the market insurance layer is assumed to include rainfall events between 1,750 and 2,300 mm. However, a number of critical implementation issues must be addressed before the potential for IBRTPs becomes reality. While many of these issues are discussed later, we focus next on one very important implementation issue—who is the target market for IBRTPs?

(c) *Target market*

IBRTPs may be targeted to micro/household, meso, or macro level users. The target market has important implications for the choice of the underlying index. In choosing an appropriate target market and associated index, tradeoffs generally exist between transaction costs and basis risk. For example, separate rainfall IBRTPs could be offered based on each of several local weather stations. Alternatively, a single rainfall IBRTP could be offered where the index is a weighted average over all of the individual weather stations. If separate IBRTPs are offered for each weather station, transaction costs will be high but basis risk may be low relative to the single weighted average index. The single weighted average index will have lower transaction costs but may subject micro-level users to high basis risk, especially if rainfall events tend to be highly localized.

In many cases, households are not the appropriate target for IBRTPs. The transaction costs of servicing many small, household-level insurance policies are quite high. Further, at the household level, idiosyncratic risk may be a major component of overall risk exposure (Dercon, 2005; Lybbert, Barrett, Desta, & Coppock, 2004; McPeak & Barrett, 2001; Morduch, 2005; Townsend, 1995). This suggests both that basis risk for IBRTPs might be quite high at the household level and that opportunities exist for pooling of idiosyncratic risks through local (commonly informal) mechanisms.

Meso-level commercial enterprises, such as agricultural input suppliers, microfinance institutions, marketing cooperatives, transportation providers, agricultural commodity processors, and retail insurance suppliers, may be better targets for IBRTPs. These institutions can, at least to some degree, pool their exposure to household-level idiosyncratic risks but often remain heavily exposed to covariate risks (Hess *et al.*, 2005; Skees, Varangis, Larson, & Siegel, 2005; Varangis *et al.*, 2002). In addition, decision-makers within meso-level commercial enterprises are more likely to have some prior familiarity with contingent claims instruments than are household decision-makers (Platteau, 1997).

Consider the case of microfinance institutions (MFIs) or other rural lenders. When the losses experienced by borrowers are highly correlated, loan defaults are also likely to be highly correlated (Skees & Barnett, 2006). Returning to the earlier Andhra Pradesh example, a MFI in the region could purchase an IBRTP based on August cumulative rainfall to protect its portfolio against the risk of increased loan defaults caused by excessive rainfall. For rainfall less than 1,750 mm, the MFI would retain the risk. The IBRTP would make a payment for rainfall occurrences between 1,750 and 2,300 mm. For example, suppose that the microfinance institution purchased US$ 550,000 of protection. Since there are 550 mm in this layer, a simple payout structure would pay US$ 1,000 for each millimeter of rainfall beyond the 1,750 mm threshold. The full payout would occur when cumulative rainfall equals or exceeds 2,300 mm.

To further stimulate the availability of rural credit, the government or the international donor community could be involved in offering protection against extreme losses beyond 2,300 mm (Mahul & Skees, 2006; Skees, Hartell, & Hao, 2006). If governments wish to be involved in subsidizing the cost of IBRTPs, those subsidies should be focused on the market failure layer. Subsidies for other layers are likely to generate perverse behavioral incentives that cause even greater exposure to adverse shocks.

Local governments also have limited ability to withstand covariate shocks. Locally provided public goods (e.g., law enforcement, maintenance of road and water infrastructure, health clinics, schools) may suffer when public assets are destroyed by covariate shocks and/or public resources are diverted to relief efforts (Goes & Skees, 2003). Shocks that affect critical public goods can reduce spatial market integration, thus increasing local price volatility and reducing incentives for households to adopt production-increasing technologies (Gabre-Madhin, Barrett, & Dorosh, 2002). Local governments could use IBRTPs to transfer some of their exposure to covariate risks. Alternatively, national governments or donor agencies could purchase IBRTPs on behalf of local governments.

(d) *Pre-financing safety nets and disaster assistance*

IBRTPs can also be used to pre-finance safety net or disaster assistance programs (Alderman & Haque, 2006; Hess *et al.*, 2005; Hess & Syroka, 2005). Properly conceptualized and implemented for environments characterized by poverty traps, safety nets are not designed as income transfer programs to the poorest of the poor—as the term is sometimes used—but rather to protect productive assets of those who might otherwise fall below the critical threshold and thereby fall onto a decumulation path towards destitution (Barrett & Maxwell, 2005; Barrett & McPeak, 2005; Dercon, 2005). Safety nets are intended to keep those who experience transitory poverty following a negative shock from becoming chronically poor. However, many low-income countries find it difficult to finance safety net programs. International assistance tends to focus on acute, emergency needs rather than on funding safety net programs designed to keep households from falling into a vicious cycle of asset decumulation. When international assistance is provided for safety net programs it tends to be too little, too late, and in the form of food rather than cash (Barrett & Maxwell, 2005).

Government or donor agencies could purchase index instruments to pre-finance safety net programs. For example, since 2002 the National Fund for Natural Disasters (FONDEN) in Mexico, in collaboration with the government agricultural insurer (Agrosemex), has been purchasing IBRTPs to pre-finance natural disaster assistance (Agroasemex, 2006). Of course, effective, broad-based, safety net policies must be able to respond to all negative shocks, not just those that can be effectively tied to an underlying index. Thus, the extent to which IBRTPs can be used to pre-finance a broad-based safety net policy will depend on local conditions. In areas where negative economic shocks are often caused or amplified by measurable risk factors (e.g., drought, flooding, hurricanes), IBRTPs could play an important role in pre-financing a broad-based safety net policy. In other areas, it may be less important.

Government or donor agencies may also be interested in purchasing IBRTPs to pre-finance emergency food aid and other disaster relief efforts (Skees, Varangis *et al.*, 2005). Some covariate shocks, such as an extended, widespread, drought, do not occur suddenly. Instead they develop over time. After early warning systems are triggered, months may pass before the impact is seen in reduced food availability, incomes and anthropometric measures of nutritional status. Unlike with rapid onset emergencies such as earthquakes or hurricanes, there is time to prepare for slow onset emergencies before the full force of the shock hits. Unfortunately, the lead time available for preparing for slow onset emergencies, whether seasonal or regular, is not always well used. International political and financial support for humanitarian assistance often does not develop until the situation becomes quite dire (Barrett, 2006; Barrett & Maxwell, 2005). Thus, as demonstrated by the 2005–06 famine in Niger, even after accurate early warning of a looming disaster, many months may pass before assistance arrives in the affected areas. During this time, households have to decide between distress sales of productive tangible assets or disinvestment in human assets (e.g., malnutrition, removing children from school, forgone needed healthcare, etc.). Either decision leads to asset decumulation that may have long-term repercussions in the presence of threshold-based poverty traps. And even after the delays, response is often insufficient to provide adequate cover for losses experiences. The Consolidated Appeals Process established by the United Nations in 1991 to mobilize resources in response to emergencies has largely proved ineffective. Former UN Secretary General Kofi Annan reported in October 2005 that flash appeals had generated on average only 16% of the requested funds (Barrett, 2006).

This underscores the possibilities associated with IBRTPs that trigger based on an early indicator of food insecurity (e.g., rainfall measures or measures from drought early warning systems). IBRTPs could fund more timely humanitarian response efforts thus reducing the need for households that are already asset-poor to engage in asset decumulation coping strategies. For example, in March 2006, the United Nations World Food Program announced that it paid the French insurance company AXA Re US$930,000 for an IBRTP that would pay up to $7.1 million to help up to 67,000 Ethiopian households in the event of inadequate rainfall during the critical March–October period (Hess, Wiseman, & Robertson, 2006; Insurance Journal, 2006; New York Times, 2006). This particular IBRTP was intended to provide ready cash to fund early interventions as a major drought is developing.

It is important to note however, that many humanitarian crises are either caused, or at least amplified, by factors other than climatic variability (e.g., conflict and lack of security, poor governance, lack of market integration, etc.). Thus, while IBRTPs are a valuable tool that can be used to pre-finance rapid responses to catastrophes caused by some climatic or natural events, they are certainly not capable of addressing all causes of humanitarian crises. As with safety net policies, emergency response policies should never be tied exclusively to IBRTPs. However, under certain circumstances, IBRTPs can play an important role within a broader portfolio of emergency response tools.

(e) *Experience to date*

While IBRTP programs are either in place or under development in several middle- or low-income countries (see Table 1), there is not yet sufficient experience to draw definitive conclusions about the long-run sustainability of these programs. [6] Except for India, existing IBRTP programs are in pilot stages so the volume of sales has been limited.

In India, ICICI Lombard General Insurance Company has sold IBRTPs to farmers since 2003. ICICI Lombard partners with local financial institutions to market the policies to farmers. The IBRTPs were first offered in the state of Andra Pradesh and marketed through the microfinance institution BASIX (Hess, 2003). In Andra Pradesh, the IBRTPs currently protect against insufficient rainfall during the sowing and crop growth phases of the Kharif (monsoon season) and against excessive rainfall during the harvest phase (Giné *et al*., 2007b). ICICI Lombard's rainfall-based IBRTP offerings have continued to expand such that in 2005, more than 7,600 policies were sold across six Indian states (Manuamorn, 2007). In 2004, the Indian parastatal insurance company AICI also began selling weather-based IBRTPs to farmers. In 2005–06, AICI sold IBRTP policies to more than 125,000 farmers, however most of the policies were sold in only one state—Maharashtra (Barnett & Mahul, 2007). Early analyses of IBRTP purchasing behavior in India have been conducted by Giné, Townsend, and Vickery (2007a), Lilleor, Giné, Townsend, and Vickery (2005).

Table 1. *Summary of index based risk transfer products in middle- and low-income countries*

Country	Risk event	Contract structure	Index measure	Target user	Status
Bangladesh	Flood	Index insurance for disaster relief			In development
Bangladesh	Drought	Index insurance linked to lending	Rainfall	Smallholder rice farmers	In development. Pilot launch planned for 2008
Caribbean Catastrophe Risk Insurance Facility	Hurricanes and earthquakes	Index insurance contracts with risk pooling for reinsurance coverage	Indexed data from NOAA and USGS	Caribbean country governments	Implemented in 2007
Ethiopia	Drought	Index insurance	Rainfall	World Food Programme operations in Ethiopia	$7 million insured for 2006. Policy not renewed for 2007
Honduras	Drought		Rainfall		In development
India	Drought and flood	Index insurance linked to lending and offered direct to farmers	Rainfall	Smallholder farmers	Began with pilot in 2003. Now index insurance products are being offered by the private sector and the parastatal insurer with an estimated 300,000 policies sold in 2006
Kazakhstan	Drought	Index insurance linked to Multiple Peril Crop Insurance program	Rainfall	Medium and large farms	In development
Malawi	Drought	Index insurance linked to lending	Rainfall	Groundnut farmers who are members of National Smallholder Farmers' Association of Malawi	Pilot began in 2005. 2,500 policies sold in 2006 pilot season. $7,000 in premium volume
Mexico	Natural disasters, primarily drought	Index insurance	Rainfall, wind speed, temperature	State governments for disaster relief. Supports the *Fondo por Desastres Naturales* program	Began in 2001. Available in 26 of 32 states. Currently 28% (2.3 million Ha) of dryland cropland is covered. Expansion limited by data availability

(*continued on next page*)

Table 1—*continued*

Country	Risk event	Contract structure	Index measure	Target user	Status
Mexico	Major earthquakes	Cat bond and index insurance contracts	Richter scale readings	Mexican government to support *Fondo por Desastres Naturales* program	Introduced in 2006. Cat bond provides up to $160 million. Index insurance provides additional funding up to $290 million
Mexico	Insufficient irrigation supply	Index insurance	Reservoir levels	Water user groups in the Rio Mayo area	Proposed
Mongolia	Large livestock losses due to severe weather	Index insurance with direct sales to herders	Area livestock mortality rate	Nomadic herders	Second sales season of pilot completed in 2007. Offered in 3 provinces. 14% of eligible herders are participating
Morocco	Drought		Rainfall		No interest from market due to declining trend in rainfall
Nicaragua	Drought and excess rain during production, excess rain during harvest period	Index insurance	Rainfall	Groundnut farmers	Launched in 3 departments in 2006
Peru	Flooding, torrential rainfall from El Niño	Index insurance	ENSO anomalies in Pacific Ocean	Rural financial institutions	Proposed
Peru	Drought	Index insurance linked to lending	Area-yield production index	Cotton farmers	Proposed
Senegal	Drought	Index insurance linked to area yield insurance	Rainfall and crop yield	Smallholder farmers	Proposed
Tanzania	Drought	Index insurance linked to lending	Rainfall	Smallholder maize farmers	Pilot implementation in 2007
Thailand	Drought	Index insurance linked to lending	Rainfall	Smallholder farmers	Pilot implementation in 2007
Ukraine	Drought	Index insurance	Rainfall	Large farms	Pilot launched in 2005, discontinued due to insufficient sales
Vietnam	Flooding during rice harvest	Index insurance linked to lending	River level	Smallholder rice farmers	In development

5. IMPLEMENTATION ISSUES

Index instruments, if they are to be effective and sustainable, must be designed with careful consideration of several critical implementation issues. [7]

(a) *Defining the index*

What measurable stochastic variable or combination of stochastic variables will be used as the index? At what location or locations will the stochastic variables be measured? Is the measurement process secure, objective, and transparent? Over what time period will the index be measured? Do adequate historical data exist to estimate the probability distribution of the index? As discussed previously, the answers to these questions often involve a tradeoff between transaction costs and basis risk.

(b) *Estimating the probability distribution of the index*

Assuming that adequate historical data are available, what procedures should one use to estimate the probability distribution of the index? Generally, sufficient data will not be available to simply use empirical distributions—especially for estimating the all-important tail density of the distributions. Various parametric and non-parametric statistical procedures can be used to estimate the distribution. The choice of procedure often depends, in part, on the extent of available historical data. Do the historical data suggest that the distribution of the index is non-stationary and heteroskedastic? If so, statistical correction procedures must be used to estimate the probability distribution of the index. While a number of common correction procedures are available, decisions regarding which procedure to employ and how the procedure is applied can have nontrivial implications for premium rating (Hess *et al.*, 2005).

(c) *Intertemporal adverse selection*

Index instruments do not require insurers to classify potential purchasers according to their risk exposure. Thus, they are not susceptible to the type of cross-sectional adverse selection problems that plague many traditional insurance products. Index instruments can however, be susceptible to intertemporal adverse selection. Within any given period, the distribution of the index may be conditioned on various factors. As an example, some climatic events exhibit serial correlation such as the impacts of El Nino—Southern Oscillation in some parts of the Western hemisphere. If potential purchasers have access to relevant information but premium rates are not conditioned on this same information, intertemporal adverse selection will likely occur. In designing index instruments it is critical to establish sales closing dates early enough that potential purchasers do not have access to information that can be used to intertemporally adversely select.

(d) *Legal and regulatory issues*

Most low-income countries have a government agency that regulates the insurance industry. To reduce delivery costs, IBRTPs are sometimes sold through existing insurance companies. However, the legal and regulatory environment that exists for the insurance industry may not be sufficiently flexible to accommodate IBRTPs. Thus, recent efforts to introduce IBRTPs in low-income countries have generally required changes in the legal and regulatory environment to accommodate risk-transfer instruments other than traditional insurance (Carpenter & Skees, 2005).

(e) *Delivery system*

What delivery mechanisms are available and sustainable? Index instruments can take many forms and can be delivered through various mechanisms. In some countries, insurance markets are sufficiently developed that IBRTPs can be marketed directly via existing insurance institutions. However, in many countries, finance, output processing, and/or input supply sectors are better developed than the insurance sector. Firms in these sectors may be willing to offer state-contingent contracts to clients if the firm can, in turn, transfer its state-contingent risk using IBRTPs (Skees & Barnett, 2006).

(f) *Subsidies*

Should governments subsidize IBRTPs premiums? Significant premium subsidies are likely to crowd out new or existing formal and informal risk transfer mechanisms. Premium subsidies that are denominated as a percentage of the unsubsidized premium will also create perverse behavioral incentives since those who take the greatest risks will receive the most in government subsidies (Barnett, 2003; Skees, 1999b, 2001). It is likely that the least distorting type of government premium subsidy would apply only to the market failure layer (characterized by cognitive failure and ambiguity loading). This layer could be financed by government or the broader international donor community.

Consider, for example, a World Bank-funded project on Index-Based Livestock Insurance in Mongolia. Insurance companies offer herders an IBRTP based on annual livestock mortality rates. For each species and county, mortality rates between 7% and 30% constitute the market insurance layer within which insurance companies make payments. The market failure layer is defined as species-specific mortality rates that exceed 30%. The government pays for those losses. In addition, the government has formed a reinsurance pool that covers insurance companies against losses in excess of 105% of herder premiums. If needed, the World Bank will provide the government with a loan to intertemporally smooth losses beyond those that are covered by the reinsurance pool and to pay for disaster response costs for mortality rates that exceed 30% (Mahul & Skees, 2006).

(g) *Other government or donor roles*

What else can government or donor agencies do to facilitate the development of IBRTPs? Government and donor interventions should focus on efforts that "crowd-in," or at least do not "crowd-out," new or existing formal and informal risk transfer mechanisms. Investments in the collection, warehousing, and dissemination of weather data would be an example. Significant research and development costs are required to design an effective IBRTP. However, once the IBRTP is developed, it can be easily copied by competitors. Government or donor agencies can facilitate the development of IBRTPs by absorbing some of these initial research and development costs. The World Bank is currently engaged in several such efforts (Hess *et al.*, 2002, 2005; Mahul & Skees, 2006; Skees *et al.*, 2001; Skees & Enkh-Amgalan, 2002). Government or donor agencies can also absorb some of the transactions costs of bundling IBRTPs for transfer into international markets (Hess *et al.*, 2005).

6. CONCLUSION

As researchers and policymakers increasingly focus on the tragedy of poverty traps, there is correspondingly increasing awareness of the central role that insurance and credit market failures play in perpetuating poverty in many low-income rural areas. Those market failures are caused by poor contract enforcement mechanisms, information asymmetries, high transaction costs, and covariate risk exposure.

IBRTPs can help address these market failures. Relative to traditional insurance, IBRTPs have simpler contract designs, fewer asymmetric information problems, and lower transaction costs. Further, IBRTPs are designed to transfer covariate risks out of a country or region and into international financial markets. For these reasons, IBRTPs may be a valuable instrument for addressing some of the insurance and credit market failures that contribute to chronic poverty in low-income countries. This realization has motivated many recent efforts to develop IBRTPs applications for low-income countries. Some of these efforts focus on making market-based IBRTPs available to businesses or households that are highly exposed to specific covariate risks. Others are attempting to use IBRTPs as the basis for pre-financing safety net or disaster assistance programs.

While IBRTPs have many promising features, they also have limitations that must be recognized and addressed, to the extent possible, through careful product design. Holders of IBRTPs are subject to basis risk that may leave them uncompensated for some significant losses caused by idiosyncratic rather than covariate perils. In design and implementation of IBRTPs, it is therefore essential that the index used is highly correlated with realized losses. A related issue is the availability, quality, security and transparency of the data required to establish and maintain the index. The form of the IBRTP and the choice of delivery mechanism will vary depending on local circumstances and existing institutions.

Significant investment in research and development is required to address these various location- and application-specific implementation issues. Once an IBRTP is developed, it is relatively easy for other firms to copy the design and sell competing products. International reinsurers may therefore be unwilling to make such investments in relatively small, low-income markets. Recognizing this, the World

Bank and other donor organizations have begun underwriting some of the research and development costs for low-income country applications of IBRTPs.

IBRTPs show considerable potential for addressing certain covariate risk-related financial market failures that contribute to some peoples' persistent poverty. However, because the development and provision of risk management programs based on IBRTPs have an opportunity cost of resources not allocated to alternative investments, it remains unclear as to the conditions under which IBRTPs are appropriate investments, when they might complement other development interventions, and how these instruments fit into broader development strategies. These are key topics for future policy-oriented research on poverty traps and IBRTPs.

NOTES

1. See, for example, the collections of papers in Baulch and Hoddinott (2000) or Barrett, Carter, and Little (2006).

2. For this reason, a major crop insurer in Mexico recently announced that it will only insure parcels of at least 25 ha.

3. Weather-based index insurance is a specific type of IBRTP that has been discussed in the agricultural economics literature (e.g., Deng, Barnett, & Vedenov, 2007; Barnett & Mahul, 2007; Chantarat, Barrett, Mude, & Turvey, 2007; Giné, Townsend, & Vickery, 2007b).

4. In a general sense, IBRTPs are conceptually analogous to European options on the underlying index (Barnett, 1999, 2000; Skees & Barnett, 1999). The instruments can be constructed as "calls" (a payment is made when the realized index value exceeds the threshold) or "puts" (a payment is made when the realized index value falls short of the threshold).

5. A reviewer notes that, for traditional insurance products, risk pooling at the local level is not necessary if the risk can be transferred into international reinsurance markets. While, in principle, this is true, pricing for reinsurance against covariate natural disaster risks has proven to be highly cyclical (Jaffee & Russell, 1997). Further, traditional reinsurance contracts are tailored instruments that generally have high transaction costs for legal fees and due diligence (Doherty, 1997). Thus, if the risk of concern is highly covariate, IBRTPs will often be a lower cost mechanism for transferring the risk.

6. See the following sources for additional information: Ethiopia (Hess *et al.*, 2006); Malawi (Hess & Syroka, 2005); Mongolia (Mahul & Skees, 2006, 2007); Peru (Khalil, Kwon, Lall, Miranda, & Skees, 2007; Skees, Hartell, & Murphy, 2007); Ukraine (Shynkarenko, 2007); and Vietnam (Skees *et al.*, 2007).

7. More detailed discussions of implementation issues are found in Barnett and Mahul (2007), Bryla and Syroka (2007), Carpenter and Skees (2005), GlobalAgRisk (2006), Hess *et al.* (2005) and Skees, Varangis *et al.* (2005).

REFERENCES

AGROASEMEX (2006). La Experiencia Mexicana en el Desarrollo y Operación de Seguros paramétricos Aplicados a la Agricultura. Working paper, April 19, 2006.

Alderman, H., & Haque, T. (2006). Countercyclical safety nets for the poor and vulnerable. *Food Policy, 31*, 372–383.

Arnott, R., & Stiglitz, J. E. (1991). Moral hazard and nonmarket institutions: Dysfunctional crowding out or peer monitoring?. *American Economic Review, 81*, 179–190.

Azariadis, C., & Stachurski, J. (2005). Poverty traps. In P. Aghion, & S. Durlauf (Eds.). *Handbook of economic growth* (Vol. 1A). Amsterdam: North-Holland.

Bardhan, P., Bowles, S., & Gintis, H. (2000). Wealth inequality, credit constraints, and economic performance. In A. Atkinson, & F. Bourguignon (Eds.), *Handbook of income distribution*. Amsterdam: North-Holland.

Barnett, B. J. (1995). The federal crop insurance program: Past, present, and future. *Journal of Insurance Issues, 18*, 75–100.

Barnett, B. J. (1999). US government natural disaster assistance: Historical analysis and a proposal for the future. *Disasters: The Journal of Disaster Studies, Policy and Management, 23*, 139–155.

Barnett, B. J. (2000). The US Federal crop insurance program. *Canadian Journal of Agricultural Economics, 48*, 539–551.

Barnett, B. J. (2003). The federal crop insurance program: Opportunities and challenges. Paper presented at the US Department of Agriculture's Agricultural Outlook Forum, Arlington, Virginia, February 2003.

Barnett, B. J., Black, J. R., Hu, Y., & Skees, J. R. (2005). Is area yield insurance competitive with farm yield insurance? *Journal of Agricultural and Resource Economics, 30*, 285–301.

Barnett, B. J., & Mahul, O. (2007). Weather index insurance for agriculture and rural areas in lower-income countries. *American Journal of Agricultural Economics, 89*, 1241–1247.

Barrett, C. B. (2006). Food aid in response to acute food insecurity. Background Paper prepared for the Food and Agriculture Organization of the United Nations State of Food and Agriculture 2006 report.

Barrett, C. B., Bezuneh, M., & Aboud, A. (2001). Income diversification, poverty traps and policy shocks in Cote d'Ivoire and Kenya. *Food Policy, 26*, 367–384.

Barrett, C. B., Bezuneh, M., Clay, D. C., & Reardon, T. (2005). Heterogeneous constraints, incentives and income diversification strategies in rural Africa. *Quarterly Journal of International Agriculture, 44*, 37–60.

Barrett, C. B., Carter, M. R., & Little, P. D. (Eds.) . *Understanding and reducing persistent poverty in Africa*. London: Routledge.

Barrett, C. B., Marenya, P. P., McPeak, J., Minten, B., Murithi, F., Oluoch-Kosura, W., *et al.* (2006). Welfare dynamics in rural Kenya and Madagascar. *Journal of Development Studies, 42*, 248–277.

Barrett, C. B., & Maxwell, D. G. (2005). Food aid after fifty years: Recasting its role. London: Routledge.

Barrett, C. B., & McPeak, J. G. (2005). Poverty traps and safety nets. In A. de Janvry, & R. Kanbur (Eds.). *Poverty, inequality, and development: Essays in honor of Erik Thorbecke*. Norwell MA: Kluwer Academic Publishers.

Barrett, C. B., & Swallow, B. M. (2006). Fractal poverty traps. *World Development, 34*, 1–15.

Baulch, B., & Hoddinott, J. (Eds.) (2000). *Economic mobility and poverty dynamics in developing countries*. London: Frank Cass.

Besley, T. (1995). Nonmarket institutions for credit and risk sharing in low-income countries. *Journal of Economic Perspectives, 9*, 115–127.

Binswanger, H. P., & Rosenzweig, M. R. (1986). Behavioural and material determinants of production relations in agriculture. *Journal of Development Studies, 22*, 503–539.

Black, J. R., Barnett, B. J., & Hu, Y. (1999). Cooperatives and capital markets: The case of Minnesota–Dakota sugar cooperatives. *American Journal of Agricultural Economics, 81*, 1240–1246.

Bowles, S., Durlauf, S. N., & Hoff, K. (Eds.) (2006). *Poverty traps*. Princeton: Princeton University Press.

Braverman, A., & Guasch, J. L. (1986). Rural credit markets and institutions in developing countries: Lessons for policy analysis from practice and modern theory. *World Development, 14*, 1253–1267.

Bryla, E., & Syroka, J. (2007). Developing index based insurance for agriculture in developing countries. *Sustainable development innovation briefs*. New York: United Nations Department of Economic and Social Affairs.

Carpenter, R., & Skees, J. (2005). Index-based insurance products: Legal and regulatory issues. Unpublished paper prepared for the World Bank, September 2005.

Carter, M. R. (1988). Equilibrium credit rationing of small farm agriculture. *Journal of Development Economics, 28*, 83–103.

Carter, M. R., & Barrett, C. B. (2006). The economics of poverty traps and persistent poverty: An asset based approach. *Journal of Development Studies, 42*, 178–199.

Carter, M. R., Little, P. D., Mogues, T., & Negatu, W. (2005). The long-term impacts of short-term shocks: Poverty traps and environmental disasters in ethiopia and honduras. BASIS Brief 28, May 2005, Madison: University of Wisconsin.

Carter, M. R., Little, P. D., Mogues, T., & Negatu, W. (2006). Shocks, sensitivity and resilience: Tracking the economic impacts of environmental disaster on assets in Ethiopia and Honduras. International Food Policy Research Institute, Development Strategy and Governance Division, Discussion Paper No. 32.

Chambers, R. G. (1989). Insurability and moral hazard in agricultural insurance markets. *American Journal of Agricultural Economics, 71*, 604–616.

Chantarat, S., Barrett, C. B., Mude, A. G., & Turvey, C. G. (2007). Using weather index insurance to improve drought response for famine prevention. *American Journal of Agricultural Economics, 89*, 1262–1268.

Coate, S., & Ravallion, M. (1993). Reciprocity without commitment: Characterization and performance of informal insurance arrangements. *Journal of Development Economics, 40*, 1–24.

Coble, K. H., Knight, T. O., Pope, R. D., & Williams, J. R. (1997). An expected-indemnity approach to the measurement of moral hazard in crop insurance. *American Journal of Agricultural Economics, 79*, 216–226.

Dasgupta, P. (1993). *An inquiry into well-being and destitution*. Oxford: Clarendon Press.

Dasgupta, P. (1997). Nutritional status, the capacity for work, and poverty traps. *Journal of Econometrics, 77*, 5–37.

Deng, X., Barnett, B. J., & Vedenov, D. V. (2007). Is there a viable market for area-based crop insurance. *American Journal of Agricultural Economics, 89*, 508–519.

Deng, X., Barnett, B. J., Vedenov, D. V., & West, J. W. (2007). Using weather-based index insurance to protect against dairy production losses caused by heat stress. *Agricultural Economics, 36*, 271–280.

Dercon, S. (1996). Risk, crop choice, and savings: Evidence from Tanzania. *Economic Development and Cultural Change, 44*, 485–513.

Dercon, S. (1998). Wealth, risk and activity choice: Cattle in Western Tanzania. *Journal of Development Economics, 55*, 1–42.

Dercon, S. (2004). Growth and shocks: Evidence from rural Ethiopia. *Journal of Development Economics, 74*, 309–329.

Dercon, S. (Ed.) (2005). *Insurance against poverty*. Oxford: Oxford University Press.

Dercon, S., & Hoddinott, J. (2005). Health, shocks, and poverty persistence. In S. Dercon (Ed.), *Insurance against poverty*. Oxford: Oxford University Press.

Doherty, N. A. (1997). Innovations in managing catastrophe risk. *Journal of Risk and Insurance, 64*, 713–718.

Eswaran, M., & Kotwal, A. (1989). Credit as insurance in agrarian economies. *Journal of Development Economics, 31*, 37–53.

Eswaran, M., & Kotwal, A. (1990). Implications of credit constraints for risk behavior in less developed economies. *Oxford Economic Papers, 42*, 473–482.

Fafchamps, M., & Lund, S. (2003). Risk-sharing networks in rural Philippines. *Journal of Development Economics, 71*, 261–287.

Foster, A. D. (1995). Prices, credit markets and child growth in low-income rural areas. *Economic Journal, 105*, 551–570.

Freedman, P. L., & Click, R. W. (2006). Banks that don't lend? Unlocking credit to spur growth in developing countries. *Development Policy Review, 24*, 279–302.

Gabre-Madhin, E., Barrett, C. B., & Dorosh, P. (2002). Technological change and price effects in agriculture: Conceptual and comparative perspectives. In T. Bonger, E. Gabre-Madhin, & S. Babu (Eds.), *Agriculture technology diffusion and price policy*. Washington: Ethiopian Development Research Institute and the International Food Policy Research Institute.

Giné, X., Townsend, R., & Vickery, J. (2007a). Patterns of rainfall insurance participation in rural India. The World Bank working paper, May 18, 2007.

Giné, X., Townsend, R., & Vickery, J. (2007b). Statistical analysis of rainfall insurance payouts in southern India. *American Journal of Agricultural Economics, 89*, 1248–1254.

GlobalAgRisk (2006). *Index insurance for weather risk in lower-income countries*. Washington, DC: United States Agency for International Development, 2006.

Goes, A., & Skees, J. (2003). Financing natural disaster risk using charity contributions and ex ante index insurance. Paper presented at the annual meeting of the American Agricultural Economics Association, Montreal, July 2003.

Goodwin, B. K. (2001). Problems with market insurance in agriculture. *American Journal of Agricultural Economics, 83*, 643–649.

Grimard, F. (1997). Household consumption smoothing through ethnic ties: Evidence from Cote d'Ivoire. *Journal of Development Economics, 53*, 391–421.

Hazell, P., & Skees, J. R. (2006). Insuring against bad weather: Recent thinking. In R. Radhakrishna, S. K. Rao, S. Mahendra Dev, & K. Subbarao (Eds.). *India in a globalising world: Some aspects of macroeconomy, agriculture, and poverty*. New Delhi: Academic Foundation.

Hess, U. (2003). Innovative financial services for rural India: Monsoon-indexed lending and insurance for smallholders. The World Bank, Agriculture and Rural Development working paper 9, 2003.

Hess, U., Richter, K., & Stoppa, A. (2002). Weather risk management for agriculture and agri-business in developing countries. In R. S. Dischel (Ed.), *Climate risk and the weather market*. London: Risk Books.

Hess, U., Skees, J., Stoppa, A., Barnett, B., & Nash, J. (2005). Managing agricultural production risk: Innovations in developing countries. The World Bank, Agriculture and Rural Development Department, Report No. 32727-GLB, June 2005.

Hess, U., & Syroka, J. (2005). Weather-based insurance in Southern Africa: The case of Malawi. The World Bank, Agriculture and Rural Development Department, Discussion Paper 13.

Hess, U., Wiseman, W., & Robertson, T. (2006). *Ethiopia: Integrated risk financing to protect livlihoods and foster development*. <http://www.lead.virtualcenter.org/en/ele/econf_03_alive/download/s1_10_Ethiopia.pdf> October 2006.

Hoddinott, J. (2006). Shocks and their consequences across and within households in rural Zimbabwe. *Journal of Development Studies, 42*, 301–321.

Hoddinott, J., & Kinsey, B. (2001). Child growth in the time of drought. *Oxford Bulletin of Economics and Statistics, 63*, 409–436.

Hoff, K., & Stiglitz, J. E. (1990). Introduction: Imperfect information and rural credit markets—Puzzles and policy perspectives. *The World Bank Economic Review, 4*, 235–250.

Insurance Journal. (2006). UN's World food program insures against ethiopia famine with AXA Re. March 9, 2006. <http://www.insurancejournal.com/news/international/2006/03/09/66294.htm>.

Jacoby, H. G., & Skoufias, E. (1997). Risk, financial markets, and human capital in a developing country. *Review of Economic Studies, 64*, 311–335.

Jaffee, D. M., & Russell, T. (1997). Catastrophe insurance, capital markets, and uninsurable risks. *Journal of Risk and Insurance, 64*, 205–230.

Jalan, J., & Ravallion, M. (1999). Are the poor less well insured? Evidence on vulnerability to income risk in rural China. *Journal of Development Economics, 58*, 61–81.

Just, R. E., Calvin, L., & Quiggin, J. (1999). Adverse selection in crop insurance: Actuarial and asymmetric information incentives. *American Journal of Agricultural Economics, 81*, 834–849.

Kazianga, H., & Udry, C. (2006). Consumption smoothing? Livestock, insurance and drought in rural Burkina Faso. *Journal of Development Economics, 79*, 413–446.

Khalil, A. F., Kwon, H. H., Lall, U., Miranda, M. J., & Skees, J. R., (2007). ENSO-based index insurance for floods: Statistical risk analyses and application to Peru. *Water Resource Research*, *43*(10), Manuscript 2006WR005281.

Krishna, A. (2006). For reducing poverty faster: Target reasons before people. Duke University working paper.

Kunreuther, H. (1976). Limited knowledge and insurance protection. *Public Policy, 24*, 227–261.

Kunreuther, H. (1996). Mitigating disaster losses through insurance. *Journal of Risk and Uncertainty, 12*, 171–187.

Kunreuther, H., & Slovic, P. (1978). Economics, psychology, and protective behavior. *American Economic Review, 68*, 64–69.

Lilleor, H. B., Giné, X., Townsend, R., & Vickery, J. (2005). Weather insurance in semi-arid India. The World Bank working paper, March 23, 2005.

Little, P. D., Smith, K., Cellarius, B. A., Coppock, D. L., & Barrett, C. B. (2001). Avoiding disaster: Diversification and risk management among east African Herders. *Development and Change, 32*, 387–419.

Lybbert, T. J., Barrett, C. B., Desta, S., & Coppock, D. L. (2004). Stochastic wealth dynamics and risk management among a poor population. *The Economic Journal, 114*, 750–777.

Mahul, O. (2001). Optimal insurance against climatic experience. *American Journal of Agricultural Economics, 83*, 593–604.

Mahul, O., & Skees, J. R. (2006). Piloting index-based livestock insurance in Mongolia. AccessFinance: A newsletter published by the financial sector vice presidency, The World Bank Group, Issue No. 10, March 2006.

Mahul, O., & Skees, J. R. (2007). Managing agricultural risk at the country level: The case of index-based livestock insurance in Mongolia. The World Bank Policy Research Working Paper WPS4325, August 1, 2007.

Manuamorn, O. P. (2007). Scaling up microinsurance: The case of weather insurance for smallholders in India. The World Bank, Agriculture and Rural Development Discussion Paper 36.

Martin, S. W., Barnett, B. J., & Coble, K. H. (2001). Developing and pricing precipitation insurance. *Journal of Agricultural and Resource Economics, 26*, 261–274.

McPeak, J. G., & Barrett, C. B. (2001). Differential risk exposure and stochastic poverty traps among East African pastoralists. *American Journal of Agricultural Economics, 83*, 674–679.

Mehlum, H., Moene, K., & Torvik, R. (2005). Crime induced poverty traps. *Journal of Development Economics, 77*, 325–340.

Miranda, M. J. (1991). Area yield insurance reconsidered. *American Journal of Agricultural Economics, 73*, 233–242.

Miranda, M. J., & Glauber, J. W. (1997). Systemic risk, reinsurance, and the failure of crop insurance markets. *American Journal of Agricultural Economics, 79*, 206–215.

Miranda, M. J., & Vedenov, D. V. (2001). Innovations in agricultural and natural disaster insurance. *American Journal of Agricultural Economics, 83*, 650–655.

Morduch, J. (1995). Income smoothing and consumption smoothing. *Journal of Economic Perspectives, 9*, 103–114.

Morduch, J. (2005). Consumption smoothing across space: Testing theories of risk-sharing in the ICRISAT study region of South India. In S. Dercon (Ed.), *Insurance against poverty*. Oxford: Oxford University Press.

New York Times (2006). The drought derivative. May 1, p. 18.

Platteau, J. (1997). Mutual insurance as an elusive concept in traditional rural communities. *Journal of Development Studies, 33*, 764–796.

Priest, G. L. (1996). The government, the market, and the problem of catastrophic loss. *Journal of Risk and Uncertainty, 12*, 219–237.

Quiggin, J., Karagiannis, G., & Stanton, J. (1994). Crop insurance and crop production: An empirical study of moral hazard and adverse selection. In D. L. Hueth, & W. H. Furtran (Eds.), *Economics of agricultural crop insurance*. Norwell MA: Kluwer Academic Publishers.

Reardon, T. (1997). Using evidence of household income diversification to inform study of the rural nonfarm labor market in Africa. *World Development, 25*, 735–747.

Reardon, T., Delgado, C., & Matlon, P. (1992). Determinants and effects of income diversification amongst farm households in Burkina Faso. *Journal of Development Studies, 28*, 264–296.

Reardon, T., & Taylor, J. E. (1996). Agroclimatic shock, income inequality, and poverty: Evidence from Burkina Faso. *World Development, 24*, 901–914.

Rosenzweig, M. R. (1988). Risk, implicit contracts and the family in rural areas of low-income countries. *Economic Journal, 98*, 1148–1170.

Rosenzweig, M. R., & Binswanger, H. P. (1993). Wealth, weather risk and the composition and profitability of agricultural investments. *Economic Journal, 103*, 56–78.

Rosenzweig, M. R., & Wolpin, K. I. (1993). Credit market constraints, consumption smoothing, and the accumulation of durable production assets in low-income countries: Investments in bullocks in India. *Journal of Political Economy, 101*, 223–244.

Rossi, P., Wright, J., & Weber-Burdin, E. (1982). *Natural hazards and public choice: The state and local politics of hazard mitigation*. New York: Academic Press.

Rothschild, M., & Stiglitz, J. (1976). Equilibrium in competitive insurance markets: An essay on the economics of imperfect information. *Quarterly Journal of Economics, 90*, 629–649.

Sakurai, T., & Reardon, T. (1997). Potential demand for drought insurance in Burkina Faso and its determinants. *American Journal of Agricultural Economics, 79*, 1193–1207.

Santos, P., & Barrett, C. B. (2006a). Heterogeneous wealth dynamics: On the roles of risk and ability. Cornell University working paper.

Santos, P., & Barrett, C. B. (2006b). Informal insurance in the presence of poverty traps: Evidence from Southern Ethiopia, Cornell University working paper.

Shynkarenko, R. (2007). Introduction of weather index insurance in Ukraine—Obstacles and opportunities. Presentation at the 101st EAAE seminar on management of climate risks in agriculture, Berlin, Germany, July 5–6, 2007.

Skees, J. R. (1999a). Opportunities for improved efficiency in risk sharing using capital markets. *American Journal of Agricultural Economics, 81*, 1228–1233.

Skees, J. R. (1999b). Agricultural risk management or income enhancement?. *Regulation, 22*, 35–43.

Skees, J. R. (2000). A role for capital markets in natural disasters: A piece of the food security puzzle. *Food Policy, 25*, 365–378.

Skees, J. R. (2001). The bad harvest. *Regulation, 24*, 16–21.

Skees, J. R., & Enkh-Amgalan, Ayurzana (2002). Examining the feasibility of livestock insurance in

Mongolia. The World Bank, Policy Research Working Paper 2886, September 2002.

Skees, J. R., & Barnett, B. J. (1999). Conceptual and practical considerations for sharing catastrophic/systemic risks. *Review of Agricultural Economics, 21*, 424–441.

Skees, J. R., & Barnett, B. J. (2006). Enhancing micro finance using index-based risk transfer products. *Agricultural Finance Review, 66*, 235–249.

Skees, J. R., Barnett, B. J., & Hartell, J. (2005). Innovations in government responses to catastrophic risk sharing for agriculture in developing countries. Paper presented at the workshop Innovations in Agricultural Production Risk Management in Central America: Challenges and Opportunities to Reach the Rural Poor, Antigua, Guatemala, May 2005.

Skees, J. R., Black, J. R., & Barnett, B. J. (1997). Designing and rating an area yield crop insurance contract. *American Journal of Agricultural Economics, 79*, 430–438.

Skees, J. R., Gober, S., Varangis, P., Lester, R., & Kalavakonda, V. (2001). Developing rainfall-based index insurance in Morocco. The World Bank, Policy Research Working Paper 2577, April 2001.

Skees, J. R., Hartell, J., & Hao, J. (2006). Weather and index-based insurance for developing countries: Experience and possibilities. In A. Sarris, & D. Hallam (Eds.), *Agricultural commodity markets and trade: New approaches to analyzing market structure and instability*. Northampton, MA: Edward Elgar.

Skees, J. R., Hartell, J., & Murphy, A. (2007). Using index-based risk transfer products to facilitate micro lending in Peru and Vietnam. *American Journal of Agricultural Economics, 89*, 1255–1261.

Skees, J. R., Hazell, P., Miranda, M. (1999). New approaches to crop insurance in developing countries. EPTD Discussion Paper No. 55, International Food Policy Research Institute, Washington DC.

Skees, J. R., & Reed, M. R. (1986). Rate-making and farm-level crop insurance: Implications for adverse selection. *American Journal of Agricultural Economics, 68*, 653–659.

Skees, J. R., Varangis, P., Larson, D. F., & Siegel, P. (2005). Can financial markets be tapped to help poor people cope with weather risks?. In S. Dercon (Ed.), *Insurance against poverty*. Oxford: Oxford University Press.

Smith, V. H., & Goodwin, B. K. (1996). Crop insurance, moral hazard, and agricultural chemical use. *American Journal of Agricultural Economics, 78*, 428–438.

Stiglitz, J. E. (1990). Peer monitoring and credit markets. *World Bank Economic Review, 4*, 351–366.

Thomas, D., Beegle, K., Frankenberg, E., Sikoki, B., Strauss, J., & Teruel, G. (2004). Education in crisis. *Journal of Development Economics, 74*, 53–85.

Townsend, R. M. (1994). Risk and insurance in village India. *Econometrica, 62*, 539–591.

Townsend, R. M. (1995). Consumption insurance: An evaluation of risk-bearing systems in low-income economies. *Journal of Economic Perspectives, 9*, 83–102.

Turvey, C. G. (2001). Weather derivatives for specific event risks in agriculture. *Review of Agricultural Economics, 23*, 333–351.

Tversky, A., & Kahneman, D. (1973). Availability: A heuristic for judging frequency and probability. *Cognitive Psychology, 5*, 207–232.

Udry, C. (1994). Risk and insurance in a rural credit market: An empirical investigation in northern Nigeria. *Review of Economic Studies, 61*, 495–526.

United Nations Millennium Project (2005). Investing in development: A practical plan to achieve the millennium development goals. New York: United Nations Development Program.

Varangis, P., Skees, J. R., & Barnett, B. J. (2002). Weather indexes for developing countries. In R. S. Dischel (Ed.), *Climate risk and the weather market*. London: Risk Books.

Vedenov, D. V., & Barnett, B. J. (2004). Efficiency of weather derivatives as primary crop insurance instruments. *Journal of Agricultural and Resource Economics, 29*, 387–403.

Wang, H. H., Hanson, S. D., Myers, R. J., & Black, J. R. (1998). The effects of crop yield insurance designs on farmer participation and welfare. *American Journal of Agricultural Economics, 80*, 806–820.

Zimmerman, F. J., & Carter, M. R. (2003). Asset smoothing, consumption smoothing and the reproduction of inequality under risk and subsistence constraints. *Journal of Development Economics, 71*, 233–260.