INDUCING INNOVATION:
RISK INSTRUMENTS FOR SOLVING THE CONUNDRUM OF RURAL FINANCE

Michael R. Carter
Department of Agricultural and Applied Economics
BASIS Collaborative Research Support Program
University of Wisconsin, Madison
mrcarter@wisc.edu

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Abstract

The theory of induced agricultural innovation suggests that there is a path of appropriate technological change even for economies characterized by rapid population growth and increasing land scarcity. While some have given a quietistic interpretation to this theory—market signals alone are adequate to spur needed agricultural growth—recent experience suggests otherwise. This paper first considers the evidence on rural financial markets: how and why they tend to constrain the accumulation and investment needed for agricultural productivity growth, especially in economies in which small farms predominate. The paper will then consider a new generation of risk management interventions designed to alter the conditions that lead to dysfunctional rural financial markets and ultimately crowd in both the institutions and the innovations needed for sustainable technological change in agriculture.

Inducing Innovation:
Risk Instruments for Solving the Conundrum of Rural Finance

1. Introduction

In the pastoral regions of northern Kenya, risk and missing rural financial markets conspire to create a poverty trap. As Lybbert *et al.* (2004) show, households whose livestock holdings fall below a critical threshold level are unable to recover and rebuild their livelihoods, sinking into abject poverty. This poverty trap dynamic creates a world in which shocks can have irreversible consequences and create an ever-growing number of indigent, food aid dependent people.

Peru's north coast is a high potential agricultural area where the small farm beneficiaries of an earlier agrarian reform are the dominate feature of the rural landscape. And yet a recent study of this region estimates that financial market constraints may reduce small farm productivity and agricultural GDP by as much as 25% (Boucher and Guirkinger, forthcoming).

While far apart from each other geographically, these two regions are linked by faulty or missing financial markets that compromise the ability of rural households to productively use and accumulate assets. These distortions are costly to individuals and their economies, literally leaving potential and money on the table.

These observations of persistent and costly distortions contradict the claim of conventional economics that decentralized, private action coordinated by markets attains a social optimality in which economic potential is fully realized. Equally, these observations seemingly contradict the theory of induced innovation which posits that economies autonomously adapt to increasing land (or other factor) scarcity through the creation of

technologies that best use scarce factors and the innovation of institutions that provide the incentives needed to employ those technologies.[1]

Sub-Saharan Africa is the world region where induced innovation is most conspicuous by its absence. Despite growing land scarcity in many parts of the African continent, yields of cereal have been stagnant for nearly half a century (World Bank 2007). Understanding the reasons behind this stagnation is obviously important. In the 1980s (when the international development community was last paying careful attention to African agriculture) the so-called "Berg Report" (World Bank 1981) largely placed the blame for this stagnation on destructive government policies that got prices wrong and destroyed incentives for innovation.

Since the Berg Report, sub-Saharan Africa has seen significant economic liberalization and dismantling of the trade restrictions and state marketing boards that were much criticized by Berg. In addition, there have been continuing efforts to hasten the development of the individualized property rights systems hypothesized by many to be a necessary condition for sustained agricultural investment and growth.[2] While it might be unfair to declare these measures a failure (the 2007 World Development cautiously opines that "stagnation in sub-Saharan Africa "may be over"), it is also clear that Africa is a long way from the type of

[1] Hyami and Ruttan (1985) provide the classic statement of the induced innovation perspective. While they posit that innovation occurs in response to factor scarcity signals, they allow a role for public action in helping bring induced innovations to life, giving particular attention to public funding for research and development.

[2] See for instance the many studies contained in Bruce and Migot-Adholla (1994) as well as the more recent World Bank policy research report on land policy (World Bank, 2003).

sustained agricultural technological change that ushered in sustained economic growth and poverty reduction in South and East Asia.[3]

This paper begins with the perspective that innovation of technologies and institutions are far from automatic responses to land scarcity and need. Less clear, however, is the appropriate public response to this failure of decentralized induced innovation. In other words, what needs to be done to induce innovation?

In crafting an answer to this question, this paper identifies risk as a fundamental culprit blocking innovation in many environments. Inducing innovation in these environments will require mechanisms to manage risk and crowd-in financial market development. Past experience makes clear that the public sector cannot simply fill the void left by missing and incomplete financial markets. Instead, this paper argues that the public sector and development assistance need to underwrite the fixed costs of innovation and provide the public goods needed to get novel, index insurance mechanisms designed, implemented and adopted.

The remainder of this paper is organized as follows. Section 2 explores how risk can knot up the development of rural financial markets from both the supply and demand sides. Section 3 then explores the potential for index insurance which removes systemic risk to untie this knot and crowd-in the deeper financial markets needed for sustained innovation and adoption of new technologies. Section 4 then confronts a set of design and implementation

[3] The adequacy of liberalization and property rights reform has been explicitly questioned by Barrett and Carter (1999) and Platteau (1996).

issues that confront any effort to employ index insurance in a way that will solve the supply and especially the demand side of the rural finance problem. Finally, section 5 concludes the paper with thoughts on appropriate public action in this realm.

2. Risk, Displaced Distortions and Missing Financial Markets

The theory of induced innovation hyperextends the standard neoclassical economic claim that the invisible hand of price-making markets will see to it that, in Adam Smith's language, the "private interests and passions of men (sic)" are led in the direction "which is most agreeable to the interests of the whole society." However, just as we have learned that information costs can derail the efficacy of free markets and laissez faire policy,[4] so too they can disrupt the logic of induced innovation.

Missing Insurance Markets and Displaced Distortions

In a thought-provoking papers published some twenty years ago, Binswanger and Rosenzweig (1986) list the structural characteristics that make failures of markets and of induced

[4] As Carter (1997) discusses, a series of contributions launched in the 1950s scrutinized in detail the conditions under which the Smithian bundle of individual self-interest and social optimality holds together. The work of Arrow and Debreu (1954) was particularly important in this respect, establishing that the competitive market economy achieves Smithian social optimality (only) if there are full and complete price-rationed markets for all commodities, including markets for future and possibly contingent commodity transactions. While often seen as the paradigmatic embodiment of the liberal faith in the social efficacy of unencumbered markets, the Arrow-Debreu results can be viewed as a glass half-full, or half-empty--the apotheosis of Smithian liberalism, or its unraveling. What Carter calls post-Arrow-Debreu economics (for example the work of Joseph Stiglitz) has analyzed the ways in which information costs lead to intrinsic market failures and a world in which there is an important space for public intervention in the market economy.

institutional innovation especially likely in low income agriculture. Among these characteristics, two are especially important for our discussion:

- Costs of information acquisition and transmission are especially high in rural areas because of the spatial dispersion of the production process;
- Agricultural processes are subject to multiple sources of risk, and much of that risk (e.g., yield risk) is covariate across individuals within a given geographic area because of common exposure to weather and disease shocks.

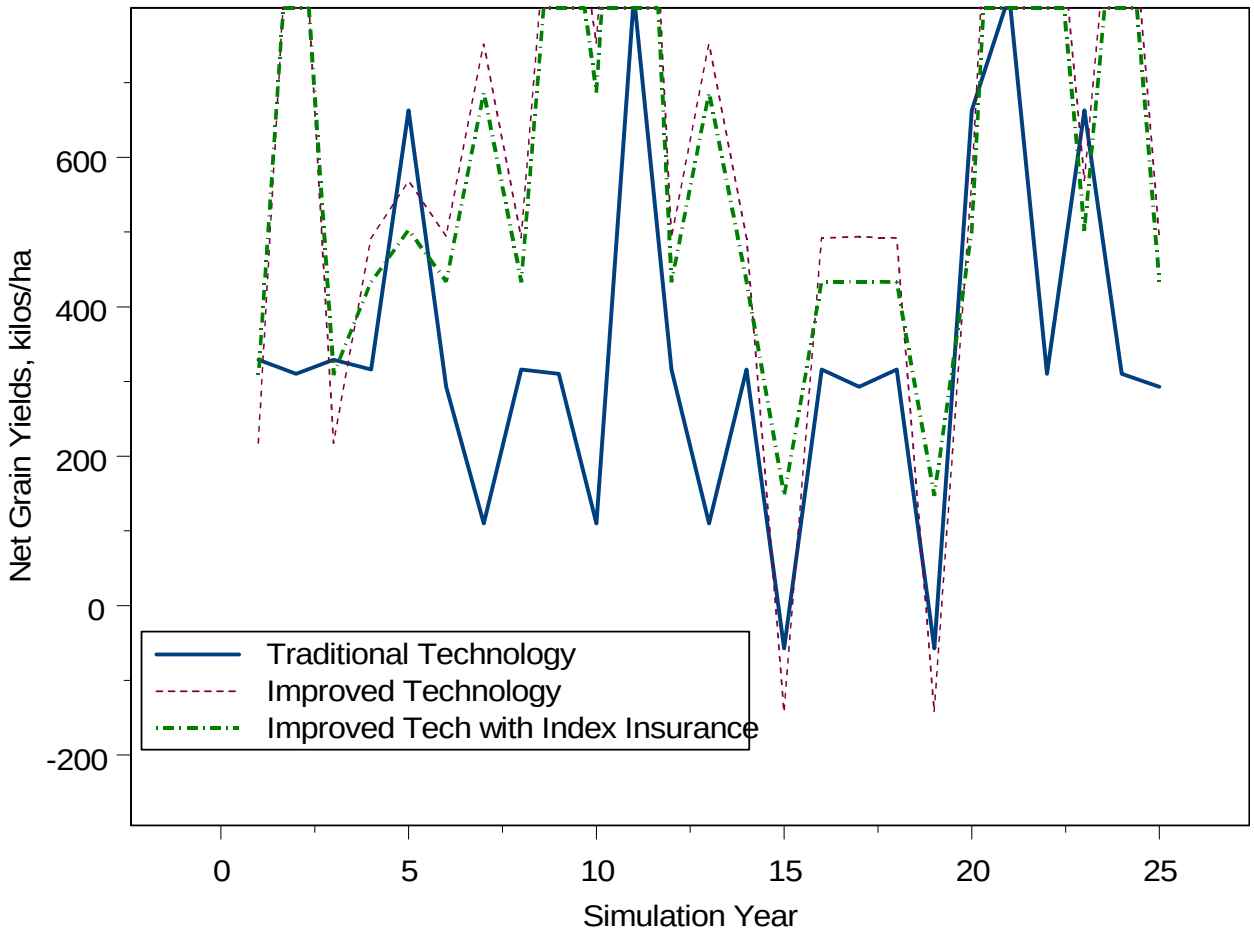
One consequence of these characteristics discussed by Binswanger and Rosenzweig is that agricultural insurance markets will fail to develop despite individuals' intense demand for insurance.

The absence of insurance can be very costly to rural households, leading them to forego economic opportunities that offer the prospect of significant income improvement. For example, a study of smallholder participants in an agro-export boom sector in Guatemala found that smallholders who failed to fully adopt highly profitable opportunities due to financial market constraints were paying implicit insurance premia equivalent to 50% of their income (von Braun, Hotchkiss and Immink 1989). This kind of behavior is called income smoothing as farmers forego technologies that would increase expected or average income in favor of safer technologies that offer lower average returns but also avoid the sharp declines in bad years that would threaten household subsistence needs. Over time, the safer technology would generate a smoother income profile (with lower peaks and shallower valleys).

The simulation results reported in Figure 1 illustrates the basic problem that generates income smoothing behavior. The figure was generated using data from field trails of a new technological package developed by the Collaborative Crop Research Program (2008) for millet

producers in West Africa. Compared to the traditional technology, the new CCRP technology offers higher yields (629 net kilos of grain per-hectare versus 350 for the traditional activity) and indeed offers more millet most (but not all) of the time. To illustrate the farmer's dilemma in choosing whether to adopt a new technology in the absence of insurance, we created two 25 year histories for a farmer by randomly sampling from the net returns generated by the CCRP field trails. One history (the solid line in Figure 1) shows the sequence of net grain yields under the traditional technology. The dashed line shows the sequence under the improved technology.

Fig.1 Index Insurance & Technology Adoption



Two observations follow from inspection of Figure 1. First, it is not obvious that a farmer vulnerable to a subsistence crisis would necessarily choose the improved over the traditional technologies. In 7 of the 25 years, the farmer would be significantly better off with the traditional technologies (by approximately 100 kg of grain per-hectare). While farmers of course deal with the vagaries of nature through grain storage, livestock accumulation and mutual informal insurance, these mechanisms can be costly, imperfect and liable to breakdown in the face of repeated poor years (or when bad outcomes are highly correlated across households, as they would be in a drought year). It is thus an open question as to which of the two income streams the farmer might prefer. Using the language of Barrett (2006), the behavior of a farmer who chose the safer technology might be described as a "displaced distortion" in the sense that the underlying problem is the missing insurance market that spills over and mishapes behavior in the realm of production and technology choice.

In addition to its effects on how individuals use the productive assets that they have, uninsured risk can also distort the savings and accumulation behavior. If distorted asset used makes people poor, distorted savings and accumulation keeps them poor over time. Carter, Barrett and Ikegami (2008) analyze in detail the impact of risk on accumulation incentives in a theoretical poverty trap model. They show that exposure to risk and shocks play especially pernicious roles when poverty traps exist. *Ex post*, realized shocks can have irreversible consequences for agents who are pushed below the critical asset threshold from which recovery is not possible. In addition, the *ex ante* anticipation of shocks shifts out the endogenous threshold, making escape from poverty less likely as agents become less willing to sacrifice current consumption to accumulate risky assets. In this environment, policies that

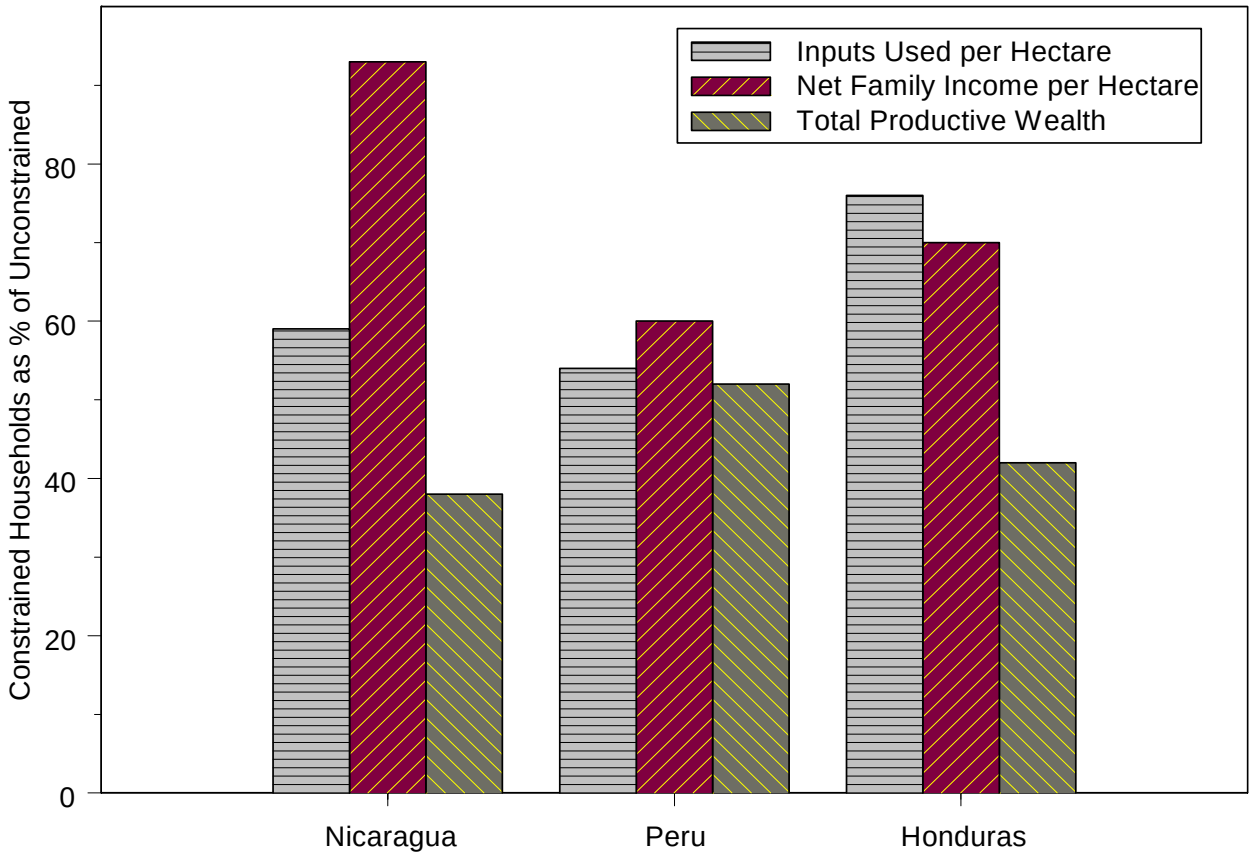
compensate individuals for the effects of realized shocks or insure them against future losses can crowd-in investment and have a major effect on the incidence of chronic poverty. The challenge is how to deliver such insurance and make it credible.

Tying the Gordian Knot: Uninsured Risk and Rural Credit Markets

As discussed in the prior section, uninsured risk can directly distort economic decisions on the use and accumulation of assets. In addition, risk can undercut the development of rural financial intermediation and credit institutions, creating a second round of indirect effects of risk on innovation. This section explores how risk and information costs knot up the development of rural credit markets from both the demand and supply sides.

Going back at least to the seminal contribution of Stiglitz and Weiss (1986), the credit market has been one venue in which the impact of asymmetric information has been extensively studied. A key insight from this literature is that asymmetric information can result in quantity rationing in loan markets, meaning that some individuals are unable to secure desired loans at the market rate of interest. In conventional, price-rationed markets, such excess demand would provoke an increase in price (the interest rate) until supply and demand were equated. Stiglitz and Weiss show that lenders may find it profit maximizing to keep the price of their product low even in the face of excess demand. The economic impact is that some farms and businesses will face credit constraints and unable to adopt profitable, income improving technologies.

Figure 2 Incidence & Cost of Credit Constraints



Source: Boucher, Carter and Guirkinger, 2006

Figure 2, taken from material prepared for the recent World Development Report on agriculture, illustrates the ubiquity of constrained access to capital in 3 recent surveys of agricultural producers in Latin America. The constrained constitute some 40% of all producers. Constrained producers on average use only 50% to 75% of the purchased inputs of unconstrained producers and enjoy net incomes (returns to land and family labor) that are between 60% and 90% of the level of unconstrained farm households. As mentioned in the introduction to this paper, a recent econometric analysis of the data from Peru estimates that total agricultural output would be 25% in the region studied higher if all these credit constraints were eliminated (Boucher and Guirkinger, 2006).

Financial constraints are not only costly; they tend to be biased against lower wealth households. Figure 2 shows that the constrained farm households have wealth levels that average 50% or less of the wealth levels of unconstrained households. This pattern not only means that benefits from agricultural growth is less equally distributed then they might be, it also means that smallholders are less able to compete for access to land through either rental or purchase markets.

The root of the problem here is that especially formal lenders will tend to offer only a limited menu of contracts, restricted to those which have heavy collateral requirements.[5] In the first instance, this truncation of the contract menu may result in wealth-biased quantity rationing as just discussed. Second, the truncation of the contractual menu results in what recent theoretical work calls risk rationing, meaning that individuals turn down available contracts for which they qualify because they are unwilling to bear the risk of collateral loss (Boucher, Carter and Guirkinger 2008). In the Nicaraguan and Honduran studies illustrated in Figure 2, 20% and 40% of credit constrained borrowers are risk rationed.[6] In the case of Peru, where panel data is available, the fraction of constrained borrowers who were risk rationed rose from 20% to 50% between 1998 and 2003 (with the overall fraction of constrained

[5] Note that for a given default risk, a lender should be willing to tradeoff between the interest rate on a loan and the collateral required. In the presence of asymmetric information, lenders will prefer relatively low interest rate contracts with high collateral requirements as the collateral serves to reduce moral hazard and the probability of default.

[6] Eliciting information on credit constraints is difficult (see Boucher *et al.*, forthcoming). In the course of carrying out the research on the prevalence of quantity rationing, we discovered a not insignificant number of small farmers who report having access to a loan contract, but who choose not to accept the loan contract for fear of losing the collateral assets required by the contract. Typically such farmers reported an unwillingness to risk land loss that would threaten their future livelihood and that of their children who would also depend on that land.

households dropping form 56% to 43%). In all three countries, risk rationed producers behave almost identically to quantity rationed households, using fewer inputs and pursuing less remunerative income generating strategies.

Risk rationing thus illustrates the way in which uninsured risk spills over from the demand side and hampers the development of effective financial intermediation. Risk can also thwart the development of credit markets from the supply side. From a lender's perspective, agricultural loans are problematic because an important component of the risk faced by farmers is correlated, meaning that if one farmer is having trouble repaying a loan because of drought or other climatic reasons, it is highly likely that other farmers will be facing the same problem. A loan portfolio with too many agricultural loans will thus be unstable in the face of correlated risk.[7] A sufficiently large financial institution can potentially diversify a loan portfolio against correlated agricultural risk. Such risk is more problematic for many microfinance lenders that are smaller scale and locally based institutions. This observation is especially true for microfinance lenders that utilize borrower groups whose members are jointly liable for each others' loan repayment. Uninsured, correlated risk would thus seem to explain the limited impact of the microfinance revolution on small scale agriculture.

In addition to its direct effect on lender willingness to carry a portfolio of agricultural loans, uninsured correlated risk also has an indirect, political economy effect on rural financial markets. In the wake of the 1998 El Nino climate shock, indebted farmers in Peru pressed the

[7] Binswanger and Rosenzweig (1987) make a similar argument, noting that financial intermediaries which both drew deposits from and made loans to agricultural households would have severe stability in drought and other years of covariate shocks.

government for relief, arguing that their inability to repay was obviously not their fault. The resulting *Rescate Financiera* (Financial Rescue) mandated lenders to forgive agricultural loans.

Not surprisingly, lenders were unhappy with this rescue plan and reacted to it by furthering restricting the amount of their loan portfolio that they would place in agricultural projects. In a recent study, Tarazona and Trivelli (2005) interviewed all institutional agricultural lenders in Peru's north coast department of Piura. All lenders reported severe portfolio restrictions on agricultural lending because fears of both climatic and political risk. The largest regional financial institution indicated that they put no more than 3% of their loan portfolio in agriculture. To put this figure in perspective, Piura has an agriculturally dependent economy, with close to 50% of its regional GDP coming from agriculture.

In summary, the particular features of the agricultural economy—information costs and correlated risk—militate against the development of deep and effective financial markets. This failure of institutional innovation and development is especially costly for smallholder farmers who are likely most averse to risk and least able to exploit outside financial options. It is little wonder that technological change has been hard to sustain in rainfed areas of Africa where smallholders predominate. In this context, it may seem that direct public provision of credit may be the best solution. Unfortunately, the prior dismal record of public agricultural banks suggest otherwise.[8] What then is the best way to untie the Gordian knot that holds down the development of rural and especially agricultural financial markets?

[8] There are, however, several interesting examples of redesigned public agricultural development banks that show substantial promise (see Trivelli, 2007 and World Bank, 2007).

3. Inducing Innovation and Crowding-in Market Development: The Index Insurance Hypothesis

There is a long history of direct government intervention in rural financial markets, and an equally long history of problematic and unsustainable programs. The basic reason for these policy failures is the simple one that the same constraints of risk and asymmetric information that inhibit the development of private financial markets also confront public efforts to substitute for private markets.

While recognition of the endogeneity of market failure warns against facile intervention, it also suggests a possible solution. In particular, were it possible to design a mechanism to independently insure and remove significant correlated risk from the agricultural economy, then we could expect to be to untie the Gordian knot of agricultural financial markets by:

1. Relaxing direct supply side constraints;
2. Undercutting the rationale for the destructive political economic cycle of disasters and financial rescues, further enhancing credit supply from the supply side;
3. Eliminating risk rationing and crowding-in credit demand if the insured covariant layer of risk is sufficiently important to small holders; and,
4. Inducing technology adoption and more effective portfolio and savings strategies by individual farmers and rural households.

Unfortunately, conventional insurance contracts, in which indemnity payments are based on the losses experienced by an individual, are unlikely to be sustainable nor provided by the market in smallholder agricultural sectors. Besides the simple transactions costs issue, moral hazard problems are severe with conventional agricultural insurance as it is almost impossible in agriculture for an insurer to monitor and control any negligent actions by the insured over a cropping season that can increase the probability of crop failure and insurance payouts.

Index Insurance Basics

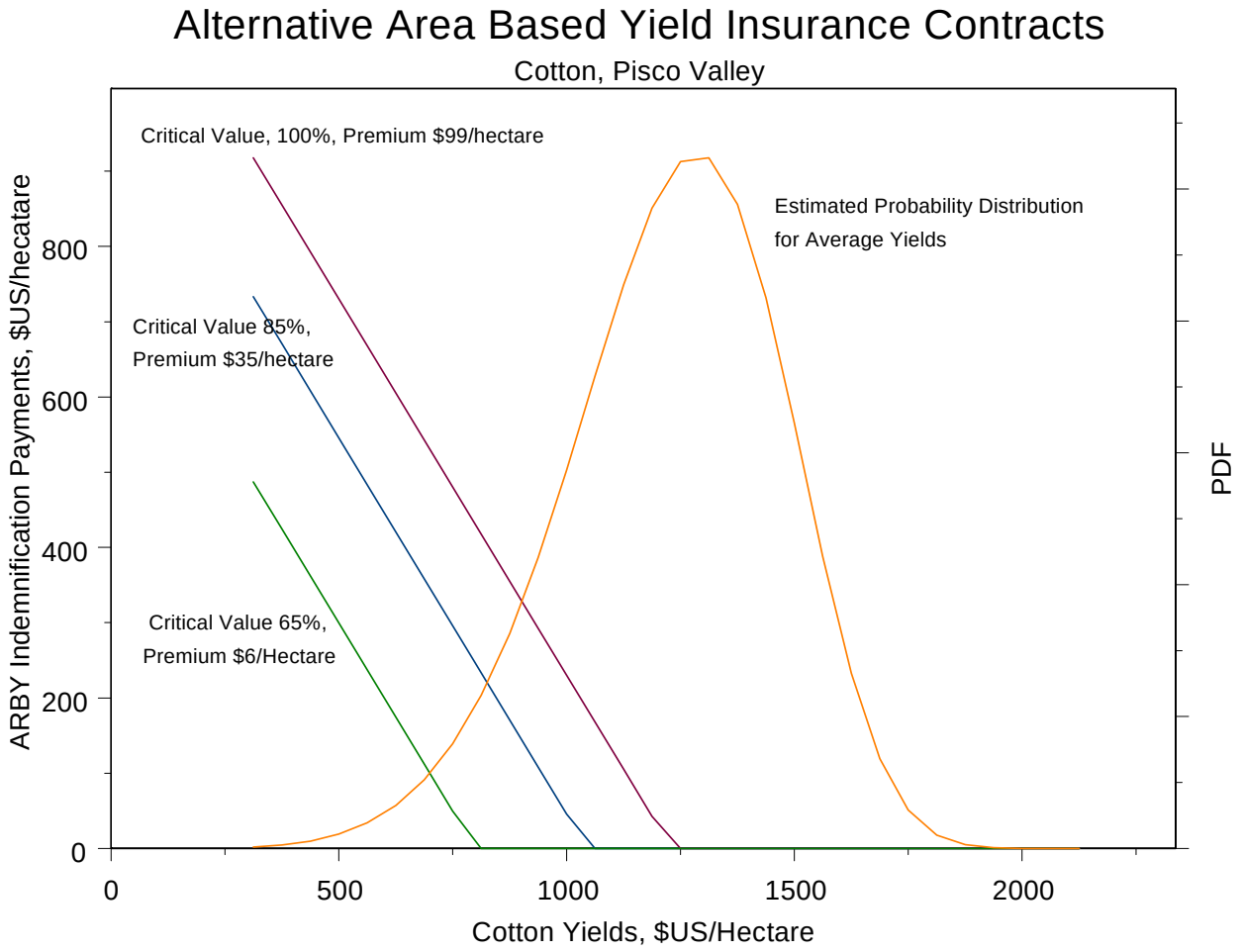
In contrast to conventional insurance contracts with individual loss and indemnities, index or parametric insurance contracts stand out as an innovative financial instrument that can potentially be sustainably offered for smallholder agriculture. The idea of index insurance is straightforward. Payouts are based not on individual outcomes, but on an aggregate index that is correlated with those outcomes. Because this correlation is likely to be imperfect, index insurance will cover only a fraction of the risk that the producer faces. The uncovered risk is referred to as basis risk. Using a data source that is promptly, reliably and inexpensively available (and not manipulable by either the insurer or the insured), the program makes the agreed indemnity compensation payment to insured beneficiaries whenever the data source indicates that the variable level reaches the strike point or insurance activation level. For agricultural contracts, indexes can be based on measures of average area yields (e.g., yields for a valley or other region), rainfall or other climatic information, and satellite information on ground cover. For livestock, possible indices include those based on average mortality measures, forage availability measures and again satellite measures of vegetative cover.

An advantage of index insurance is that preserves effort incentives for producers, as no individual farmer can influence the probability of an insurance payoff (i.e., no problems of moral hazard). Index insurance is also unaffected by the fact that only the most risky clients will seek out the product, because payouts do not depend on the personal characteristics of those who actually purchase the insurance (i.e., no problems of adverse selection).

Figure 3 illustrates an index insurance contract for a recently implemented pilot project for cotton farmers in the Pisco Valley in Peru (see Carter, Boucher and Trivelli, 2007). The solid

orange curve shows the estimated probability function for average cotton yields in Pisco. Under this distribution, long-term expected yields are $1230/hectare (or 1968 kilos/hectare). Indemnity payments to farmers are triggered when average valley yields fall below a critical value (or strike point). Figure 3 graphs indemnity payments as a function of realized average yields for a three alternative index insurance contracts: one with a strike point at 100% of long-term yields; a second with a strike point at 85% of long-term average yields; and a third contract with the strike point set at 65% of long-term yields. Note that lower strike points make indemnity payouts less likely. They also make the amount of the payout lower for any realized yield level.

Included in Figure 3 are the actuarially fair premiums that would be required for each variant of the index insurance contract. The actuarially fair premium is simply the premium that equals the expected indemnity payment. Note that this premium does not cover administrative, marketing or other costs of providing the insurance. As can be seen, with the insurance strike point set at 100% of long-term average yields, the ARBY insurance would cost $99/hectare. The 85% strike point insurance would cost $35/hectare and the 65% insurance would cost only $6/hectare. While these latter two forms of insurance are less expensive, they of course also protect the farmer against fewer risks. As can be seen from Figure 3, there is almost no probability that average yields in Pisco will fall below about $300/hectare (which corresponds to a physical yield of 500 kilos/hectare). At this extremely low and unlikely outcome, payments under the 100% strike point would be $918/hectare. Under the 85% and 65% strike points, these maximum conceivable payments would respectively be $733 and $487 per-hectare. To put these numbers in context, the lowest registered average yields in Pisco since 1986 were 950 kilos/hectare (or $620/hectare) in 1992. Similar, but slightly higher yields were recorded following the most recent El Nino year (1998).



Supply and Demand Side Effects of Index Insurance

The appeal of an index insurance contract should be substantial for rural lenders and potential rural lenders as such insurance removes most of the covariant risk that makes agricultural lending problematic for financial intermediaries. In a simulation analysis of weather and area yield contracts for the Lambeyeque Valley in Peru, Carter, Galarza and Boucher (2007) show that lender's default risk for an insured loan portfolio should drop to negligible levels. Consistent with this analytical result, the rural lender affiliated with the Pisco Valley cotton project offers 10% interest rate discounts for borrowers who purchase the index insurance

contract.[9] It remains to be seen if the existing lenders will expand their agricultural portfolio as insurance uptake increases and, or if new lenders will enter the market.

From the borrower or individual farmer perspective, much depends on the degree to which the index insurance contract is able to cover the farmer's risks. The green dot-dash line in Figure 1 above shows the results from a rough simulation of an area yield contract for West African millet producers assuming an 80% strike point and that producers pay an actuarially fair premium for the insurance.[10] As can be seen, while the improved technology developed by the CCRP failed to outperform the traditional technology in seven of the twenty-five years of the simulation, the improved technology with an index insurance contract outperforms the traditional technology in all but one year. Under modest assumptions about the nature of farmer's aversion risk aversion, it can be shown that the improved technology with index insurance is strongly preferable to either the traditional or improved technologies by themselves. These results open up the exciting prospect that matching innovations of agricultural technologies with financial technologies will open the door to the kind of sustained adoption needed to boost agricultural productivity growth in Africa. Our research group is currently at work on a plan to implement and monitor the impacts of technology matching activity (see Carter and Laaja, 2008). Similar efforts are underway to see if the provision of index based livestock insurance to Kenyan pastoralists will crowd-in more effective

[9] The lender typically charges clients 3.25% interest per-month and will reduce that charge to 3% per-month when insurance is purchased.

[10] The simulation is based on results in Carter (1996) on the relative magnitudes of covariant and idiosyncratic risks.

accumulation strategies and help to break down the destructive poverty trap dynamics described earlier (see Barrett, Carter and Mude, 2008).

4. Challenges to Workable and Effective Index Insurance

While index insurance has tremendous potential to untie the risk knot that olds down rural financial market development, it must surmount two key challenges if it is to realize this potential. The first is the challenge of designing a product that minimizes the basis risk faced by those who might purchase the insurance. The second is finding a way to make index insurance comprehensible for individuals who have never had any type of insurance, much less a complex, index insurance contract.

Designing Index Insurance to Minimize 'Basis Risk'

Data concerns are often central in efforts to create index insurance schemes. Quality historical data are needed to price the insurance contract, and future collection of the data need to beyond manipulation by any of the interested parties. For these reasons, weather-based indexes are prime candidates for insurance contracts of this sort.

While these data issues are important, the hypothesis that index insurance will induce innovation requires that both the supply and demand sides of the market find the insurance valuable. Weather indexes, for example, may leave farmers with significantly larger basis risk

than area yield indexes.[11] Area yield indexes are in turn more complicated to measure and more subject to manipulation.

Relying on micro farm-level data, Carter, Galarza and Boucher (2007) estimate the severity of basis risk under both weather index insurance and area yield insurance. In the particular case they analyze, they find that basis risk under the weather index is so large that a typically risk averse farmer would be unwilling to buy the insurance if it were marked up by 30% or more to cover costs of delivery, administration, etc. Put differently, area yield index insurance offers a better match to farmer goals and livelihood needs. Insurance that fails to meet those needs is unlikely to be purchased, much less reduce risk rationing and crowd-in new investment.

Making Index Insurance Comprehensible to the Never-Before-Insured

Insurance is an unusual commodity (we buy it and hope to get nothing in return). Index insurance, with its problem of basis risk, is even more complicated than standard insurance. Unless households really understand index insurance, demand for it will be low and the expected behavioral responses (by households and financial markets) will not take place. The mixed success of recent efforts to implement index insurance products in low income agricultural settings makes clear that we need to devise methods to ensure an informed clientele for the product.

One approach to solving this problem of understanding is to employ simulation games that mimic index insurance contracts. In the case of the Peruvian cotton insurance project

[11] Note that weather is only an imperfect predictor of average yields which are in turn only an imperfect predictor of individual yield outcomes.

described above, a game was devised in which a poker chip drawn randomly from a bag represented average yields for a group of players hwo form a fictive valley. Each player then individually draws their own idiosyncratic shock by selection a ball from a second sack. Individual yields and returns are then determined by both average yields and the idiosyncratic (with the latter of course representing uninsured basis risk). The probability of drawing different outcomes was carefully calibrated on the actual data about the correlated and basis risk faced by local farmers. Payoffs (in game currency) were in turn set to match actual prices, costs and returns for a typical small farmer. Players played long sequences of game years to learn about the probability structure and how insurance works.[12] After learning the game mechanics, farmers played a sequence of years in which they had to choose between an uninsured, loan financed, high return activity and a traditional, low risk fall back activity. Farmers were then allowed to the "replay" their lives with the additional option to purchase an insurance contract to insure the high return activity. Duplicating the actual contract currently available for purchase in Peru, insurance in the game was priced with a 30% mark-up or loading above the actuarially fair price.

While analysis of the game data and information on the effectiveness of the game as a learning device is still underway, several results stand out. First, approximately 60% of farmers

[12] A second critical design issue in the insurance game concerns the how to capture intertemporal incentives for insurance. Peruvian cotton farmers risk losing their land and future credit market access if they are unable to repay loans in any given year. A potentially important advantage of insurance is not only that it insulates current income from shocks, but also that it protects individuals against these inter-temporal or future period penalties. In the Peru game, if a farmer in any year they was unable to repay a loan, then in all future game years they were excluded from the credit market and could only employ the low return strategy. In addition, farmers were paid the value of their land at the end of the game . Farmers who had defaulted during the game were given a lower per-hectare payment for their land.

purchased the insurance (and chose the high return activity). In addition, roughly 25% of participants revealed themselves to be risk rationed,[13] turning down the loan contract and the high return activity when insurance was not available. When insurance was made available in subsequent rounds of the game, roughly half of these risk rationed farmers took the loan and the insurance and began to undertake the high return activity.

While these results are provocative, the real test will occur over the next few months as the research explores whether those who played the game are more likely to actually purchase the insurance. Should the game prove effective in establishing knowledge and confidence in insurance, then the next challenge will be to learn how to spread learning from game participants to non-participants.

5. Inducing Innovation: Next Steps?

While increasing resource scarcity provides powerful incentives to economize and use resources more productively, actually existing market economies are filled with examples of intrinsic market failures that lead to outcomes that are "not always most agreeable to the interests of the whole society" (to misquote Adam Smith). This paper has argued that risk and information costs have knotted up the development of the rural financial markets needed to assure effective resource use, productivity growth and poverty reduction in rain-fed, smallholder agricultural economies.

[13] Note that the game allowed all players to have access to a loan contract so that no one was quantity rationed in the credit market.

As is always the case with intrinsic market failures, the question is what if anything can be done to improve the situation. This paper has argued that a new class of index insurance mechanisms holds out the promise of removing sufficient risk from the rural economy that it will induce the innovation of deeper rural financial markets from both the demand and the supply sides. While such insurance can in principal be sold and reinsured by private actors, there are several barriers that stand in the way and merit redress by governments and the development assistance community. The first is the reliable information needed to establish and implement index insurance programs. Information on regional crop yields that would allow the creation of area yield insurance is in principal a public good, and yet it is one in very scarce supply.[14]

A second problem is that many of the potential beneficiaries of index insurance find themselves in precarious circumstances that make it unlikely that they can afford market-based premium. If the theoretically grounded hypothesis is correct that reliable insurance will crowd in accumulation and growth, then there is a serious public policy case for smart insurance

[14] An early effort to implement an area yield insurance scheme in Nicaragua fell apart because yield data was perceived by insurers and reinsurers as subject to manipulation and unreliable. In Peru, historical yield figures from the Ministry of Agriculture were arguably unbiased and adequate for pricing area-based yield insurance. However, the lack of scientific methodology for determining yields in future years (when payoffs created incentives for actors to distort information) demanded the creation of a new yield measurement methodology. While the pilot project is currently subsidizing the development and implementation of a reliable yield measurement scheme, the hope is that insurance will create demand for sustained public provision of this information.

subsidies, especially in comparison to the costs of letting poverty trap dynamics drive an every larger number of vulnerable people into a condition of food aid dependence.[15]

In the end, there is much still to learn about the feasibility, intelligibility and impact of index insurance. But perhaps the biggest challenge is to find out if new financial instruments can indeed induce innovation and solve the conundrum of rural finance.

[15] A new cash transfer program in northern Kenya plans to transfer roughly $15 per-month to indigent families. Insurance subsidies for the livestock of their slightly better off but vulnerable neighbors is estimated to cost $15 per-year (see Carter, Barrett and Mude, 2008).

References

Barrett, Christopher B. (2006). "Displaced Distortions: Financial Market Failures and Seemingly Inefficient Resource Allocation," *BASIS Brief* no. 32, http://www.basis.wisc.edu/basis_crsp/live/basbrief32.pdf

Christopher Barrett, and Michael Carter. "Microeconomically Coherent Agricultural Policy Reform in Africa," Chapter 13 in J. Paulson (ed) *African Economies in Transition, Volume 2: The Reform Experience* (MacMillan Press, 1999).

Boucher, Stephen, Michael Carter and Catherine Guirkinger (2008). "Risk Rationing and Wealth Effects in Credit Markets: Implications for Agricultural Development," *American Journal of Agricultural Economics* 90(2):409-423.

Boucher, Stephen and Catherine Guirkinger, "Risk, Wealth, and Sectoral Choice in Rural Credit Markets," *American Journal of Agricultural Economics*, 2007, 89(4): 991-1004.

Steve Boucher, Catherine Guirkinger and Carolina Trivelli (forthcoming). "Direct Elicitation of Credit Constraints: Conceptual and Practical Issues with an Empirical Application to Peruvian Agriculture," *Economic Development and Cultural Change.*

Carter, Michael. "Environment, Technology and the Social Articulation of Risk in West African Agriculture," *Economic Development and Cultural Change* 45(2):557-590, 1997.

Carter, Michael (1997). "Intellectual Openings and Policy Closures: Disequilibria in Contemporary Development Economics," in F. Cooper and R. Packard (eds.) *The Dynamics of the Production and Transmission of Development Ideas* (University of California Press, 1997).

Barrett, C.B., M.R. Carter and M. Ikegmai (2008). "Poverty Traps and Social Protection." World Bank *Social Protection Working Paper* no. 0804.

Carter, M.R., F. Galarza and S. Boucher (2007). "Underwriting Area-based Yield Insurance to Crowd-in Credit Supply and Demand," *Savings and Development* 3/2007.

Carter, M.R., C.B. Barrett and A. Mude (2008). "A Productive Safety Net for Northern Kenya's Arid and Semi-Arid Lands: The HSNP^{+} Program," BASIS Research Program, http://www.basis.wisc.edu/documents/HSNP+%20Proposal.pdf.

Carter, M.R., R. Laajaj and J. Foltz (2008). "Matching Agricultural with Financial Innovations to Achieve Economic Growth and Sustained Human Development," BASIS Research Program.

Carter, M.R., S. Boucher and C. Trivelli (2007). "Area-based Yield Insurance Pilot Project for Peruvian Agriculuture," http://www.basis.wisc.edu/documents/ARBY%20CONCEPT%20NOTE.pdf.

Collaborative Crop Research Support Program (2008). "Farmer-participatory improvement of sorghum and pearl millet genetic resources for increased adaptation to diverse production environments in West Africa" CCRP Report March 2007 – February 2008.

Hyami, Y. and V. Ruttan (1985). *Agricultural Development: An International Perspective* (Johns Hopkins).

Lybbert, T., C. Barrett, S. Desta and D.L. Coppock (2004). "Stochastic Wealth Dynamics and Risk Management among a Poor Population." *Economic Journal.*Migot-Adholla, S. and J. Bruce (1994). *Land Tenure Reform in Sub-Saharan Africa* (Kendall/Hunt Press).

Platteau, Jean-Philippe (1996). "The Evolutionary Theory of Land Rights as Applied to Sub-Saharan Africa: A Critical Assessment," *Development and Change*, vol. 27, no. 1, pp. 29-86.

Stiglitz, J. and A. Weiss (1981).Credit Rationing in Markets with Imperfect Information," *American Economic Review*, vol. 71, no. 3, June 1981, pp. 393-410

Tarazona, A., and C. Trivelli. 2005. "Situación del financiamiento rural en Piura." Project report, Instituto de Estudios Peruanos (Lima).

Trivelli, Carolina. 2007. "Banca de Desarrollo para el Agro: Lecciones desde las Experiencias en Curso en América Latina." Lima: Institute of Peruvian Studies.

Von Braun, J., D. Hotchkiss and M. Immink (1989). *Non-traditional export crops in Guatemala: Effects on income, production and nutrition.* Research Report 73 (International Food Policy Research Institute).

World Bank (1981), *Accelerated Development in Sub-Saharan Africa: An Agenda for Action* (Washington, D.C.: World Bank).

World Bank (2003). *Land Policies for Growth and Poverty Reduction.* New York: Oxford University Press.

World Bank (2007). *Agriculture for Development*, World Development Report, 2008. New York: Oxford University Press.