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Risk Management Instruments for Food Price Volatility and Weather Risk in Latin America and the Caribbean

The Use of Risk Management Instruments

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Abstract*

This report examines some of the implications of price risk and volatility, and weather risks in the LAC region that are important threats to already vulnerable populations. It considers the advantages and limitations of a set of financial instruments for managing these risks; and identifies potential mechanisms for addressing concerns about the socioeconomic consequences of price and weather volatility. In reviewing the innovations that are being tested in the LAC region and around the world, what is striking is that they appear to be disparate and largely piecemeal solutions to the problems of price and natural disaster risk management—they are not integrated. A more efficient and holistic solution should draw upon the recent efforts of coordination among countries within regions. The importance of risk aggregation and pooling combined with the comparative advantage of International Financial Institutions to access capital and work in a regional context, suggests a strategy to develop a fully multicountry approach to risk management. This strategy calls for establishing a Regional Asset Management Platform (RAMP) that integrates central stakeholders and develops pricing and measurement tools for extreme weather risk management and price volatility in a more efficient fashion. Global drivers of price volatility for major commodities can be managed using international futures exchange markets to some extent. However, regional climate anomalies will also mean that individual countries can suffer price volatility that represents a basis risks when using international futures markets. Thus, combining risk transfer products for regional climate anomalies with the use of careful hedging strategies for global volatility may offer better risk management strategies for either lower than expected prices that adversely affect producers or higher than expected prices that adversely affect consumers.

Keywords: Commodity price risk, weather index insurance, agriculture, food security

* Using experience gained from a number of projects developing agricultural insurance and, in particular, projects in many lower income countries to introduce index insurance, GlobalAgRisk produced this report for the Inter-American Development Bank. Anne G. Murphy, Jason Hartell, Victor Cárdenas, and Jerry R. Skees prepared this report, and Celeste Sullivan provided editorial assistance.

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Executive Summary

This report examines some of the implications of price risk and volatility, and weather risks in the Latin American and Caribbean (LAC) region that are important threats to already vulnerable populations. It considers the advantages and limitations of a set of financial instruments for managing these risks and identifies potential mechanisms for addressing concerns about the socioeconomic consequences of price and weather volatility. The motivation for investigating new approaches is very clear. Recent substantial increases in the price of staple agricultural commodities, accompanied by greater price volatility, have caused difficulties for both producers and consumers, challenged the capacity of food importing countries to finance their consumption needs, and prompted renewed concerns about long-term global food security. LAC countries have been historically prone to domestic price instability and were not exempt from the increases in prices, first peaking in 2008 and again in 2011. The source of these events include those related to global commodity conditions, reactionary trade measures enacted by governments, the closer linkage of commodity markets with energy sector price volatility, and the shrinkage of commodity carryover stocks. While food prices have fallen from the highs of 2008 and 2011, a general upward price pressure has continued, attributed to increasing demand, particularly from Asia, and the effect of energy prices on production cost. Furthermore, the drought conditions in North America during the summer of 2012 will compound concerns about food security and result in higher global food prices.

Regional conditions that contribute to localized price disturbances and food security issues are also important, but sometimes overlooked. Large differences in the domestic structure, ownership, and returns to production exist across and within the agricultural sector of the LAC countries, which in turn impact the welfare effects of price movements. Price volatility of important stable crops, nevertheless, can hurt both producers and consumers. Correlated regional weather anomalies affecting agriculture and allied industries will only exacerbate existing poverty and deepen food crises. Production risk can result in negative welfare consequences and also create increased price volatility.

The use of financial instruments to manage production and price risks can help offset monetary losses in an agricultural value chain and provide households, enterprises, and the

public sector with the resources to implement contingency plans to confront supply and price shocks. A complete risk management scheme involves selecting a mix of mitigation, retention, and transfer approaches appropriate to the frequency and severity of the risk. Improving the management of and resiliency to these risks also creates a more stable environment for investment and growth in the agricultural sector. Yet, financial instruments alone do not resolve larger supply issues. To address risk exposure over the longer term requires additional and ongoing efforts to improve productivity and investment, aid producers in adapting their practices to changing climate conditions, and, at a limited level, create emergency food reserves and distribution systems for regions that are poorly connected to global markets. Market solutions for production and price risk management may be very limited, and in the absence of well-functioning risk management markets, governments assume a large part of the fiscal burden, adding another element of instability that can have the unintended consequence of stifling private investment and growth.

While governments can take steps to ensure that basic financial services—savings, credit and insurance—are available to households and businesses that are at risk, national authorities can also use similar financial mechanisms to transfer some of their fiscal exposure to natural disasters. National and regional approaches, such as the Caribbean Catastrophe Risk Insurance Facility (CCRIF) and African Risk Capacity (ARC) project, offer an opportunity to pool and offset risks before transferring excess exposure to international markets. These are designed to enhance a country's ability to respond to immediate food and humanitarian crises following a specified natural disaster at lower cost than by acting alone. It is notable that these regional and multicounty approaches have avoided the temptation to provide microinsurance for affected populations, instead relying on established distribution channels of government assistance. However, an important spillover benefit of these regional facilities results from the initial investments in the technical and financial infrastructure. The investments lower the costs for others who subsequently build tailored applications that reach to lower level aggregators, such as microfinance, and even individuals.

International financial institutions (IFIs) such as the Inter-American Development Bank (IDB) have worked extensively in developing economies, through project financing, capacity building, and technical assistance to improve the risk management capacity of various sectors. Perhaps one of the comparative advantages of IFIs is that they have access to lower cost capital

that can support development efforts when emerging economies cannot access capital in other ways that match the cost. A core question is how the limited capital from IFIs can be leveraged with proper buy-in from the sovereign nations they serve. The typical path is country-focused lending. Country-focused lending has an important role in public good investments. Country-focused lending still has an important role in providing financial technology transfer, links between credit organizations, and market development support for different types of risk management products. For instance, price risk management at the country level can include structured liquidity funds, supported by clear rules and good governance. IFIs can participate, as the cost of capital for some countries can be so high as to make these types of strategies inefficient. Furthermore, many countries do not have the credit rating that would facilitate these types of interventions. Nonetheless, given the highly correlated nature of weather and price risks, country-focused lending has its limits.

In reviewing the innovations that are being tested in the LAC region and around the world, what is striking is that they appear to be disparate and largely piecemeal solutions to the problems of price and natural disaster risk management—they are not integrated. A more efficient and holistic solution should draw upon the recent efforts of coordination among countries within regions. The importance of risk aggregation and pooling, combined with the comparative advantage of IFIs to access capital and work in a regional context, suggests a strategy to develop a fully multicountry approach to risk management. This strategy calls for establishing a Regional Asset Management Platform (RAMP) that integrates central stakeholders and develops pricing and measurement tools for extreme weather risk management and price volatility hedging. The aim is to create an efficient market-based facility that manages regional risk through multiple channels including reserving, access to contingent credit, futures exchange markets, and risk pooling and transfer for natural disasters. An important rationale for the RAMP is to take advantage of regional offsetting interests—potentials for natural swaps—among stakeholders exposed to regional and global production and price risks.

With sound governance, timely market positions could be taken to protect against global conditions that create price spikes that hurt consumers or that create low prices that hurt mid- to large-scale farmers and slow investments in agriculture. Having experts in global exchange markets work alongside climate experts to create a suite of parametric forecast-based risk transfer solutions will enhance both the management solutions for both price and weather risk in

the region. It is important that the RAMP achieve the economies of scale and critical mass to pool a diverse portfolio of risks using capital markets as a means to "crowd in" and enhance market solutions. The basic ingredients are emerging for the IDB and other donors to assist in creating a highly effective and robust financial platform to provide the LAC countries with access to financial engineering and management not only for prices but also those regional weather conditions that contribute to situations of food insecurity. The IDB is uniquely positioned to play a formative role in launching such an initiative given its experience and expertise in the region.

Section 1 Introduction

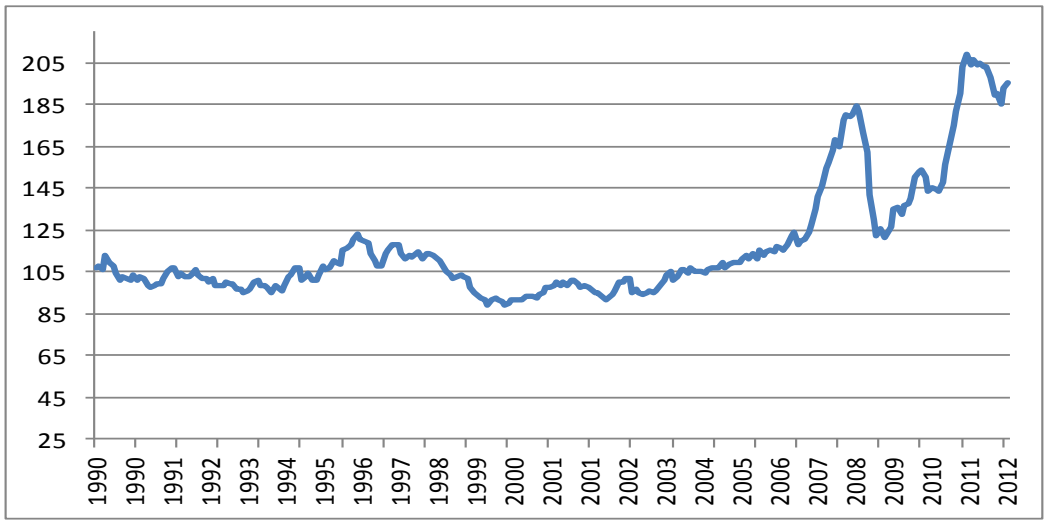
Commodity prices received by farmers are only one part of the story when considering world food conditions. Figure 1 provides a history of a clear downward trend in real commodity prices received at the farm gate. Technological innovation has outpaced demand drivers. Figure 1 shows three distinct spikes: 1) post-1972, when world markets were opened via changed monetary policy; 2) the mid-1990s, when global commodity shortages created short-lived spikes; and 3) the post-2007 period, characterized by an upward trend in basic commodity prices.

Figure 1. Real Maize Prices Received by U.S. Farmers

Source: Wright using USDA data deflated using U.S. CPI, 1982–1984=1.

By contrast, Figure 2 demonstrates that world real food prices are increasing at a more rapid rate and displaying greater volatility. In a global economy, many factors influence the differences between the prices farmers receive for basic commodities and what global consumers pay for food.

Figure 2. Real Food Price Index (2002–2004=100)



Source: FAO data (March 10, 2112) http://www.fao.org/worldfoodsituation/wfs-home/foodpricesindex/en/

It is beyond the scope of this report to provide a full explanation for these stark differences. However, to some extent the composition of the food price index is driven by changing diets, as a growing middle class in countries like India and China is demanding more processed foods and animal products (e.g., less consumption of rice and greater consumption of chicken).

To be clear, the data on a primary commodity in U.S. agriculture versus an aggregate index of food prices mask much of what is driving concerns about food security within individual countries. At the core, these concerns rest squarely on the upward trend of prices in basic commodities. This is a fundamental issue, but the focus here is the volatility around the trend in basic food commodities. When prices are lower than expected in any given year, farmers suffer. When prices are higher than expected in any given year, consumers suffer. Recent research on this latest trend suggests that new drivers are pushing basic commodity prices to higher levels; but the same drivers are likely adding to the price volatility of core food commodities. Whereas the volatility for U.S. corn was around 22 percent in the 1980s and 1990s, more recently that volatility has exceeded 26 percent. Commodity markets are more tightly linked, as in the case of the crude oil, corn, and ethanol markets (Trujillo-Barrera, Mallory, and Garcia, 2011). Given that crude oil has always had higher volatility than agricultural commodity

prices, greater volatility in agricultural commodity prices is likely to stay as long as food commodities are used as an energy source.

Greater price volatility and substantial increases in the price of staple commodities in recent years have caused difficulties for both producers and consumers, challenged the capacity of food importing countries to finance their consumption needs, and created serious concerns about long-term food security globally. Recent upward trends in prices have created expectations that agricultural commodity prices have entered a new regime where the underlying expected prices will continue to be higher than in previous periods. This is a yet-to-be-tested assumption. Farmers around the world are quite responsive to higher prices. Increased production may ultimately lead to lower expected prices.

There are many dynamic and interacting factors at play, including weather shocks, global market pressures, and speculative cycles. These risks can have grave economic and social consequences and can lead to civil unrest in situations of severe food insecurity. How countries plan for and cope with the emerging realities of price volatility, weather shocks, and food insecurity has serious implications for macroeconomic stability, income distribution, poverty, and civic order. Effective risk management planning is important for these phenomena across all levels, from the household to national and international strategies.

This report examines some of the implications of price risk and volatility, and weather risks in the Latin American and Caribbean (LAC) region. It considers the advantages and limitations of a set of financial instruments for managing these risks and identifies potential mechanisms for addressing concerns about the socioeconomic consequences of price and weather volatility.

The use of financial instruments to manage price risks and volatility can help offset monetary losses in the agricultural value chain and provide households, enterprises, and the public sector with the resources to implement contingency plans to confront supply and price shocks. There are additional benefits beyond the financial buffer provided by these mechanisms. For example, the use of market-based contingent claims products (i.e., those that are unsubsidized) provides awareness of the likelihood of a given risk, where the price of risk transfer is a clear indication of the riskiness of growing commodities in a region. An undistorted price signal better informs risk management decisions and longer-term planning. In addition, the process of assessing risks during the development of contingent claim products (e.g., estimation

of probable loss) also helps to quantify the financial exposure (i.e., the value of losses given an event) of those actors exposed to specific risks. In general, increased awareness and understanding of risk dynamics aids decision making and risk management planning in preparing for shocks as well as adapting to changing market and climate trends.

Improving the management of and resiliency to these risks also creates a more stable environment for investment and growth in the agricultural sector. Yet, financial instruments alone do not resolve larger supply issues. To address risk exposure over the longer term, these measures should be combined with additional efforts to improve productivity and investment, aid producers in adapting their practices to changing climate conditions, and, to a limited extent, create emergency food reserves and distribution systems for regions that cannot easily connect to global markets.

Section 2 provides a context for understanding the significance of weather and price risk in the LAC region, specifically the manifestation of risk and uncertainty in the agricultural value chain. Section 3 discusses strategies for managing the impacts of price volatility and food shortages on producers, consumers, and the fiscal exposure of the public sector. Section 4 examines weather risk management strategies for agricultural value chains.

The myriad of topics discussed and solutions presented in this report cannot address the issues surrounding global commodity prices and the effects on food security within any particular country in the region. Upon review, it has been determined that a workable solution that takes a more holistic approach has yet been tried. With some risk and with a full understanding that the devil is in the detail, this review has inspired a look into a more holistic solution. Section 5 provides this with a discussion of the role of governments and multilateral donors in supporting a range of potential risk management strategies. It also proposes a strategy for how the IDB could improve accessibility of financial risk management instruments in the LAC region through the development of a Regional Asset Management Platform (RAMP).

Section 2 Agricultural Sector Risk and Food Security: Policy Relevance

Great contrasts exist within the agricultural sector across the LAC region and within LAC countries. Commercial agricultural production is a major component of many of the region's economies, yet aggregate agricultural statistics conceal the large inequality that exists within the sector. Though many LAC countries have a strong commercial agricultural sector consisting of large landholdings and highly mechanized production, smaller producers have less access to risk management mechanisms such as insurance and exchange markets. As a result they are more vulnerable to production price shocks, and food insecurity.

> *In LAC countries there are 15 million family farms covering 400 million hectares. Of this number, 10 million can be characterized as subsistence farmers who rely on non-farm income, 4 million are partially integrated into agricultural markets, and 1 million are engaged in productive, market-oriented production (Berdegué and Fuentealba, 2011).*

Though per capita GDP has increased 25 percent over the past 30 years in the LAC region, poverty and inequality remain high, particularly for the rural poor, with inequality rankings for rural income and land access higher than those for Africa. With an economically and culturally important agricultural sector, 119 million rural inhabitants, 62 million who are classified as poor, and 35 million who are considered chronically food insecure, the LAC region is highly vulnerable to the impacts of price risks and food security concerns (Berdegué and Fuentealba, 2011).

While many LAC countries are net food exporters, the degree to which producers and the larger economy benefit from higher export prices depends on the domestic structure, ownership, and returns to production. Severe declines in market prices of export-oriented cash crops will mainly impact producers, but may have little effect on domestic consumption, while price spikes can threaten domestic consumption and the ability to import staple foods. Overall, price volatility of important staple crops can hurt both producers and consumers (Timmer, 2011).

Regional weather anomalies affecting agriculture and allied industries will only exacerbate existing poverty and deepen food crises. Yield risk can have as severe welfare consequences as price risk, although the different actors may feel the consequences to different degrees.

Price Volatility. In recent years, aggregate food commodity prices began rising in 2007, followed by more rapid price spikes and volatility in 2008. While prices fell during 2009, they never fully returned to previous levels. The pattern of high and volatile food prices then repeated itself starting in late 2010. The international community was understandably concerned. The unexpected rise in food prices contributed to a number of serious transitory regional food security challenges and threatened earlier gains in the Millennium Development Goal of reducing chronic poverty and hunger. Several different explanations have been given for food commodity price increases and volatility episodes. While it may not be possible to precisely apportion the various contributors, some understanding is needed to formulate an appropriate policy response.

Both the 2007–2008 and, less so, the 2010–2011 food price shocks can be traced to unexpected production shortfalls in major exporting regions. This is only part of the explanation, however, given that global grain production did not fall significantly. The unanticipated shortfall, possibly coupled with speculative pressure and low global food reserve stocks, contributed to price volatility that shocked some exporting nations into believing they would face food shortages. In some cases, export control measures were imposed and often later rescinded, which contributed to even greater price volatility.

Inelastic industrial demand pressure for certain types of food commodities has also contributed to the rise in prices. In particular, the biofuels policies of some developed countries are blamed for distorting world food markets, again exacerbated by low world food stocks (Wright, 2011). Carryover stocks and the production situation in many food-importing countries have improved since 2009, but price pressure has continued. This is attributed to both higher demand, particularly from Asia, and higher production costs resulting from increased energy prices.

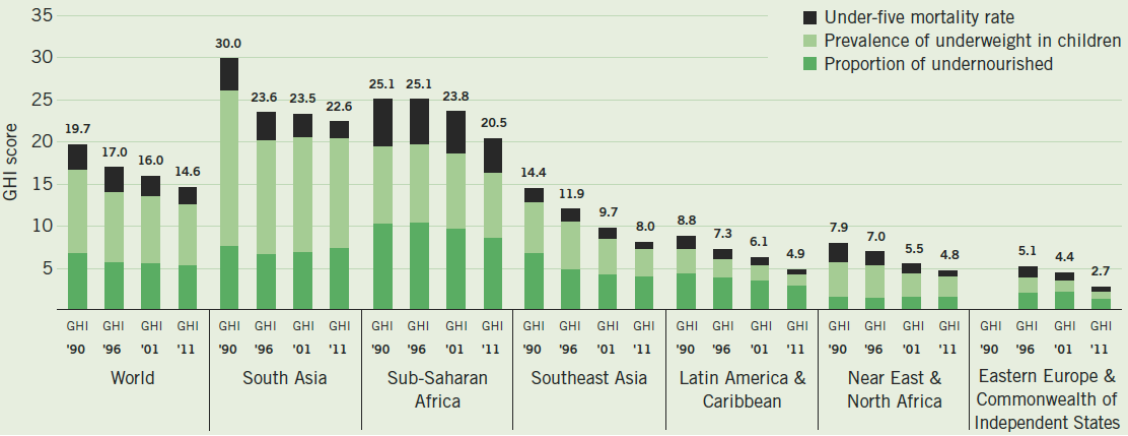
Box 1. Price Volatility in Latin America

A 2005 World Bank report on food price volatility analyzed the price sensitivity of dominant staples to international prices. The analysis revealed that Latin American countries are among those most prone to domestic price instability, most likely stemming from exchange-rate devaluations and domestic production shocks. Bolivia, Brazil, and Mexico ranked among the countries with the highest variance in domestic maize prices (World Bank, 2005). This analysis preceded the recent increases in food prices and volatility, yet highlights the point that, as certain factors increase the vulnerability of countries to food insecurity (e.g., domestic production and consumption patterns, and exposure to weather shocks), risk management strategies appropriate for developing economies must be keyed to these characteristics.

Despite these dramatic food price shocks, measures of hunger incidence have declined globally over time, although regional disparities can be quite large, and the LAC region has generally performed better than many other regions in the world (Figure 3). Importantly, large differences exist within the region, and countries such as Nicaragua, Guatemala, Haiti, the Dominican Republic, and Bolivia are worse off than their neighbors.

Serious subnational humanitarian crises, typically fueled by weather-induced production shocks, are masked by aggregate statistics. For example, protracted drought in the region of Zacatecas, Mexico, has resulted in high food prices and local famine. Recent unusually high rainfall in southern Mexico, Central America, and Colombia have caused widespread flooding and contributed to a building food crisis.

Figure 3. Global Hunger Index, by Components



Source: IFPRI, 2011.

Aggregate snapshot indicators, while encouraging overall, may not be durable and may well reverse. Food price shocks can make poor households more vulnerable to future price movements as well as to other types of risk, particularly from natural disasters. The potential for vulnerable populations in LAC to move out of poverty will depend strongly on measures adopted to manage food price and related risks.

Poor households everywhere suffer the most from the consequences of food price increases and volatility. The primary reason is that in order to maintain the same level of caloric intake as wealthier households do, the poor must spend a greater proportion of their income on food purchases. Poor households have less opportunity to reallocate income when food prices increase. Temporary relief may be possible through the sale of household assets, but once these are depleted, hunger will rise. Emergency liquidation of productive assets makes households worse off by prolonging the path to recovery once food prices stabilize. In addition, such households are also now less able to absorb, and are hence more vulnerable to any future shocks. These effects of food price volatility contribute to the persistence of the highly skewed income and wealth profile found in LAC countries.

Food Insecurity. A state of food insecurity exists when there is insufficient physical, social, or economic access to food (FAO, 2009). A country's vulnerability to food insecurity depends on many interacting factors, both endogenous and exogenous, including localized price effects of production patterns and consumption preferences, production shocks, and new demand drivers. However, a close relationship can be observed between being a low-income and

predominantly staple-based country. The greater the concentration of demand for any given staple, the greater the risk that any variation in the supply price of the commodity will affect the country's food security.

In the context of food security, a key challenge for implementing financial risk management mechanisms is that economic agents lack information about future prices and returns. This increases inefficiency and aversion to making productive investments. Price volatility exacerbates this problem by creating an unstable, uncertain market environment (Timmer, 2011). To the extent that smaller-scale producers lack access and negotiation power in commodity, financial, and risk markets, they stand at a major disadvantage that contributes to persistent poverty. For these producers, the lack of access to more efficient risk management solutions is likely contributing to food insecurity. The challenge is how to facilitate markets to improve the range of risk management options available to these producers.

Understanding this challenge opens the possibility for national and local governments, multilateral organizations, international financial institutions, NGOs, and the international donor community to fill in the gap where markets do not.

Risk and Uncertainty

Concern about risk management has peaked in recent decades as a consequence of a spate of costly catastrophic natural disasters and humanitarian crises. The latter has spurred an interest in risk management methods for vulnerable populations in developing countries, which often derive their livelihood directly or indirectly from agriculture. Unmanaged or poorly managed risks have a negative and disproportionate impact on the livelihood of agriculture-dependent households. Further, these risks contribute to an unstable environment for planning, investment, and growth.

A general catalogue of the main risks in the agricultural sector includes production, price volatility, legal and policy, technological, and financial risks (Moschini and Hennessy, 2001). These risks can be further classified along a continuum by how they manifest themselves spatially—from localized to regional or countrywide effects (Table 1). This continuum is measured by the spatial correlation of loss ($0 \leq \rho_{ij} \leq 1$) that ranges from idiosyncratic or independent risks with no correlation (zero) among those exposed to an event, to nearly perfectly correlated (approaching 1), systemic exposure to risk that affects many people similarly over a

widespread area. How a risk event is expressed across geographic space has important implications for which risk management tools will be most effective.

While Table 1 summarizes the extent of risks affecting agriculture, this document focuses on those driven by price volatility and extreme weather events that are thought to be particularly important threats to already vulnerable populations. Hence, attention is largely placed on the more highly correlated, or covariate, risks that confront agricultural participants, that is, high-impact, low frequency risks that pose particular challenges to the supply of risk transfer to the agricultural sector.

Table 1. Drivers and Scale of Selected Agricultural Risks

	Type and level of risk		
Source of risk	Idiosyncratic micro level†	Covariate meso level‡	Systemic macro level*
Price volatility		Changes in output and input price, new requirements from food industry, price declines/rises (e.g., fertilizer prices)	Changes in input/output prices due to demand/supply shocks, trade policy, new markets, endogenous variability,.
Extreme weather events and diseases	Localized hail, frost, non-contagious diseases created by extreme weather events; quality/condition issues, personal hazards (illness, death)	Regional frost, excess rainfall or drought, damaging winds, saturation induced landslides, pollution (weather)	Floods, drought, pests, contagious disease (climate)
Production	Asset risks	Labor, technological change	Technological change and changes in consumer preferences
Technological		Industrial toxins, water contamination	Irradiation, food contamination, bio-contamination
Financing	Changes in non-farm sources of income	Policy and regulatory changes and restrictions	Changes in interest rates/value of financial assets/access to credit
Institutional/ Legal/ Policy	Liability risk	Changes in local policy or regulations, land use, ownership/use protection	Changes in regional or national policy and regulations, environmental laws, agricultural payments, land ownership status; trade restrictions

Table 1. Drivers and Scale of Selected Agricultural Risks

	Type and level of risk		
Source of risk	Idiosyncratic micro level†	Covariate meso level‡	Systemic macro level*

Source: Authors' elaboration, adapted from OECD (2009).
†Individuals and household.
‡Households, communities, financial institutions, agribusinesses, among others.
*Country or international regions.

Risk Dynamics in the Agricultural Value Chain

The agricultural sector is linked to other sectors in the economy through productive chains, as a recipient of inputs from other sectors or as supplier of products from the agricultural sector to other sectors. In this dynamic, there are local, regional, and international producers, suppliers, processors, distributors, financiers, and consumers. The impact of the recent emergence of the energy sector as a consumer of agricultural production illustrates the complexity of these linkages. The energy market has become more strongly linked to the food sector through its use of biofuels as an alternative energy source. As a result, the growing market for biofuels has led to an increase in prices and volatility for maize and sugar cane, as these crops for human and livestock consumption are increasingly used in ethanol production.

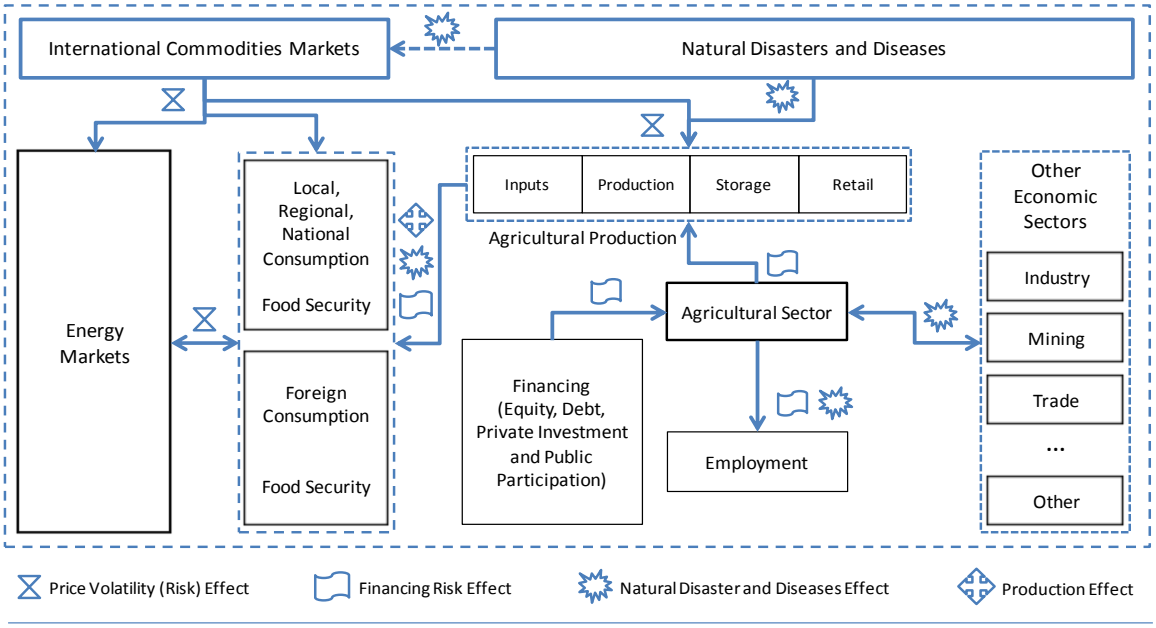
In the abovementioned cases, major commodities are typically commercialized in organized, global markets, and thus changes in demand directly generate impacts on local prices through international markets. Within the productive process, natural phenomena and their effect on the productive process are key exogenous factors for which, depending on the degree of vulnerability involved, stakeholders may have local, regional, national, and even global implications, given the interconnectedness of major commodity markets.

Figure 4 depicts the different actors within the agricultural sector, as well as their interactions. The energy sector stands out as an important and large consumer. Above them are commodities markets, where price changes are transferred to consumers and producers. Figure 4 also illustrates the common risks in the interactions between each of the players and components, identifying various drivers of price risk. Each symbol indicates the effect of one actor over other, whether direct or indirect.

For example, price volatility in international markets is an important source of uncertainty. It can increase the value of products, while at the same time making them more expensive in relation to other products. Alternatively, it can alter the opportunity costs for a producer and encourage a production shift away from certain crops in favor of others. As Figure 4 illustrates, the spread of volatility is large, affecting the entire sector.

Similarly, natural disasters and diseases are also a strong source of uncertainty. Nevertheless, in almost all cases these risks have an adverse effect on the value of production. Major catastrophes can, in some instances, affect supply in global markets, and consequently the prices of substitute products, human consumption, and even food security. For this reason, there is a connection between international commodity markets and natural disasters; in other words, the potential exists for this influential factor to emerge under certain, uncontrollable scenarios.

Figure 4. Agricultural Sector Relationships and Risk Effects



Source: Authors' elaboration with data from OAS (1991).

As Figure 4 demonstrates, multiple factors influence the agricultural sector. Underlying factors, compounded by exogenous market forces and risks, can threaten not only economic performance within the value chain but also the supply and affordability of essential commodities for domestic consumption.

Risk Management in the Agricultural Sector

The agricultural value chain has long been the textbook example of an economic sector highly exposed to diverse risks. Exogenous weather perils are a defining characteristic the separates agricultural production from other sectors. Physical and biological risks have led to massive public investments in developed economies and by international research organizations in basic research and development for new technologies and management practices.

> *New plant varieties developed since the Green Revolution have strengthened plant tolerance to drought, adverse soil characteristics, diseases and pests — often at a regionally specific level. Advanced irrigation infrastructure, both increases productivity and also reduces risk from all but the most severe droughts. Management practices, especially in low input settings, emphasize crop diversification to cope with disease pressure and weather variability.*

Even with these and similar advances, the risks inherent in physical and biological process cannot be completely mitigated or avoided. Producers and others in the value chain must retain the residual production risk and have sought ways to address the financial consequences on their production and consumption paths.

Aside from the risks resulting from individual management decisions, most risks to agricultural production are not independent. One well-known exception is hail damage, which tends to be highly localized. Instead, the major perils to production are mostly covariate: damaging rain, high winds, drought, and disease and insect infestation affect many producers over a large area. Unseasonable killing frost is also covariate when production is highly concentrated geographically, as it is in the citrus industry. The misclassification of a covariate risk as an independent risk increases the chances of insolvency for insurance companies or financial lenders when massive claims are made or when borrowers incur widespread losses. Large insurance and financial companies can diversify their businesses geographically, but this is not common or necessarily feasible for smaller domestic companies, whose portfolios are likely to remain more concentrated and thereby exposed to covariate risks.

For the most part, covariate risks are not commercially insurable. Covariate risk overwhelms not only formal insurance but also many traditional risk management strategies. For example, crop diversification is effective for small variations in weather patterns, but not in the face of a severe drought. Mutuality, a common practice in developing countries, is subject to the

same problems as commercial insurance since the majority of the members will need assistance at the same time when faced with a destructive covariate risk.

Managing covariate risk requires diversification among a larger pool of insured or against offsetting risks (i.e., those that have a negative covariance). Diversification can be achieved via reinsurance or other mechanisms that transfer risks to global markets that are better able to diversify and absorb the exposure. Various financial instruments, often based on an index of the peril's severity to trigger payments, have been devised to facilitate this transfer. These are described in detail in subsequent sections. It is worth mentioning, however, that such index-based risk transfer contracts were primarily conceived to address pervasive problems with information asymmetry and transaction costs. For index-based contracts, a strong correlation between the index variable and the realized losses of the insured is precisely what is desired. For example, area yield policies, also known as aggregate loss policies, address the costs and limitations of trying to derive information about individual farm management practices and their effect on production by providing compensation only when a group of farmers experiences average yields below a predetermined threshold. These mechanisms obviate the need for individual loss assessment and surveillance, considerably reducing the administrative burden and the opportunity for moral hazard.

Segmenting and Sequencing Risk

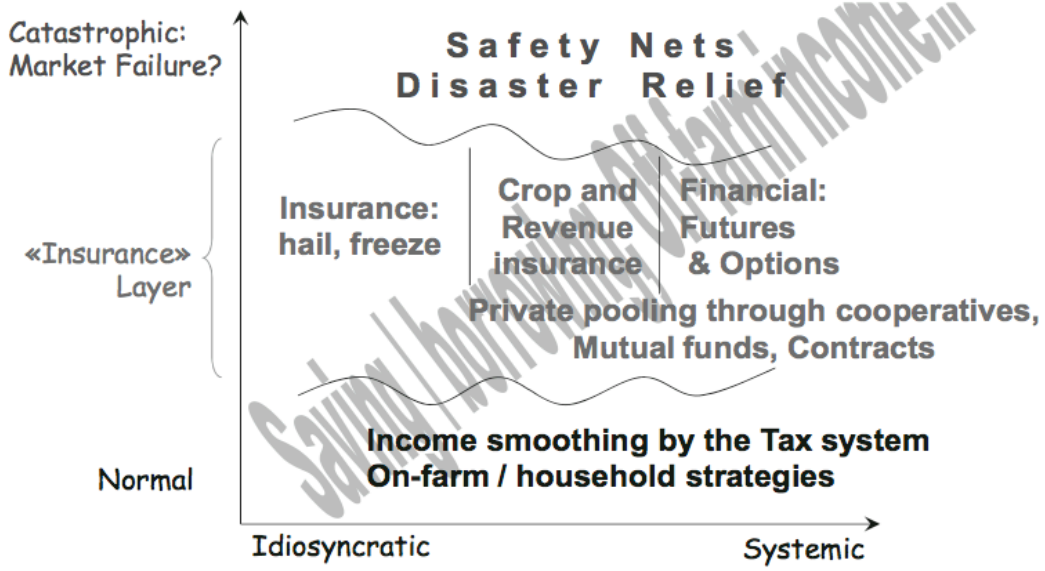
For minor production disruptions, individuals can smooth consumption using savings or, where basic financial services exist, through the use of credit. For events of greater severity, more robust strategies are needed. Here, different forms of contingent claims and insurance-like instruments may be used to smooth income or to provide resiliency against asset destruction. Various market-based financial instruments in developed economies have addressed these risks as they affect agriculture.

The classification of risk by the degree of spatial correlation is helpful in identifying which type of financial instrument may be most effective in addressing the financial impact of production disruption (see Figure 5). Idiosyncratic risks, where correlation of their occurrence across space is near zero, can be appropriately managed using traditional commercial indemnity insurance. When the risks are independent, pooling, or spreading of the risk by an insurance company has the effect of substituting the group's average loss for the actual loss of an

individual. In addition, when the number of insured units is large, the variance of the pooled losses is less than the sum of the variance of individual losses, and the distribution of losses tends to follow a standard distribution. Insurance pricing is most efficient when actual losses are similar to predicted losses, a situation where "objective risk" is said to be low.

However, when losses are covariate or systemic, the average loss approaches actual loss and the benefits of pooling break down. If many of the insured are likely to experience losses resulting from the same systemic event, pooling risk within a certain geographic concentration area will be ineffective for offsetting the exposure. Rather, the exposure is magnified. Thus, where there is the potential for covariate and systemic risks, a different set of instruments is needed to manage the risk.

Figure 5. Risk Management Strategies for the Agricultural Sector



Source: Authors elaboration, adapted from Cordier and Debar (2004).

In Figure 5, the vertical axis represents a range from mild to extreme losses and the horizontal axis represents idiosyncratic (independent) to systemic (highly covariate) risk. In between, there is a broad array of potential instruments that can be used to manage risk, from the lowest layers of risk to the highest. An assessment of the drivers and consequences of risk establishes the baseline for understanding risk exposure and determines the most appropriate strategies for risk reduction, coping, and financing. As a first step, a risk assessment reduces the

uncertainty surrounding sources of loss by revealing information about potential losses and their expected probabilities of occurrence. Access to such knowledge enables proactive planning for risk management strategies and investment.

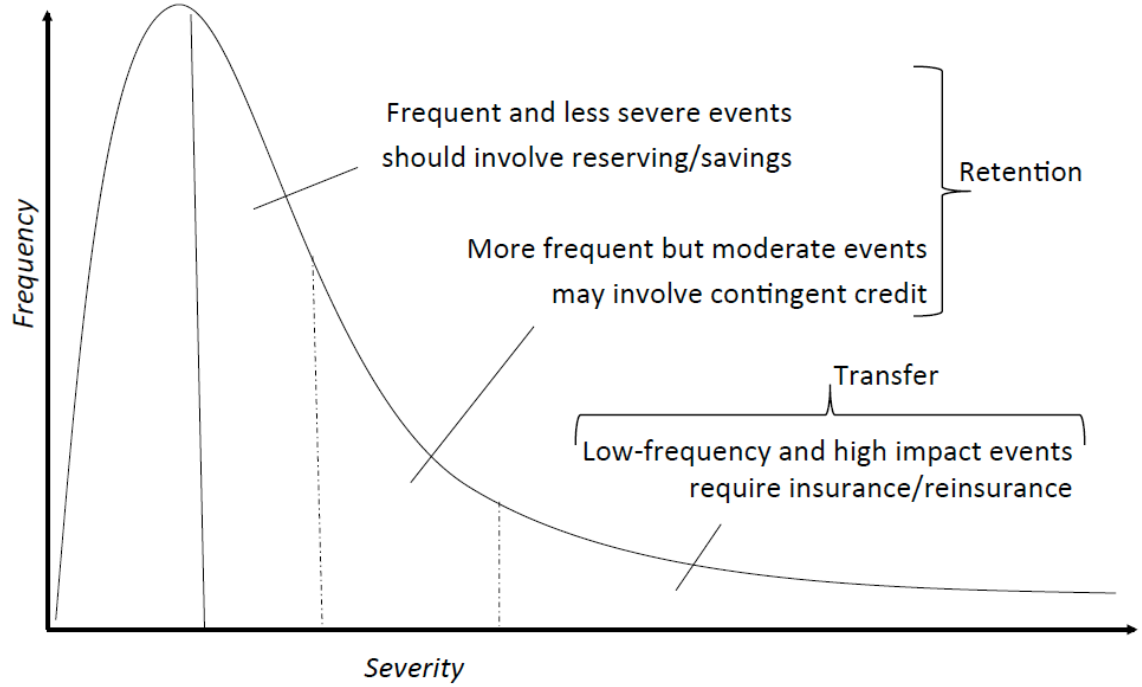
A risk management scheme—whether at the individual, enterprise, or government level—will involve selecting a mix of risk mitigation, retention, and transfer approaches as the frequency decreases and magnitude of the expected loss increases. Figure 6 illustrates the risk spread in a different way that emphasizes the segmenting of risk as frequency and severity change (see Box 2 for a differentiation between risk transfer and risk retention). The figure is of a generalized density function typical of many risks facing agriculture and value chain participants. The segmentation along the distribution is illustrative. Note that the distribution already subsumes risk mitigation that alters the probability or exposure to loss. All investments in risk mitigation display declining marginal effectiveness (or increasing marginal cost) such that it becomes cost effective to incorporate reserving and ex ante risk financing. Not only does risk mitigation become increasingly impractical in terms of cost, but also it is simply impossible to implement risk mitigation measures that can with certainty safeguard against the most extreme risk events. Thus, risk financing increases the efficiency of risk management investments and provides a form of protection beyond the limits of mitigation measures.

The use of different instruments across the distribution of risk typically follows the sequence of investment in risk reduction and avoidance activities, reserving/savings, and then, successively, financing of risk retention followed by transfer. The sequence is driven by the opportunity cost of capital, which provides a natural limit to reserving and savings, and then the comparative cost of different financing alternatives (Culp, 2004; Andersen, 2011). The general optimization problem for determining which instrument to use along the loss distribution can be illustrated by comparing the marginal cost of each alternative (Mahul and Gurenko, 2006). For individuals, firms and most small governments, the opportunity cost of holding reserves or savings rises with the size of the reserves and so exhibits increasing marginal cost. Where this exceeds the marginal cost of ex ante debt financing, and subsequently the comparison of marginal cost of risk transfer, determines the sequence of financing across the loss distribution.

The opportunity cost of a forgone possible investment may be quite different between individuals, firms, and government such that the proportion of reserving relative to financing will differ. Furthermore, the clean distinction between different instruments based on a marginal

analysis is an ideal abstraction. Actual choices can be highly subjective, they are information intensive, and they depend on assumptions of comparative cost of different instruments (for instance, reinsurance pricing can rise substantially following significant industry losses) and default probability of debt providers that can change rapidly over time. A variety of constraints will also alter the choice set of different actors, including the availability of appropriately scaled instruments and absolute ability to purchase financing (Andersen, 2011).[1] The choice therefore is not static but must be routinely updated, and often requires using different "layers" and combinations of tools.

Figure 6. Risk Layering with Financial Mechanisms



Source: Authors' elaboration.

Market solutions for production or price risk management may not always emerge in a local or regional economy for a number of reasons. Low frequency but severe risks are one well-documented case where myopia and cognitive failure on the part of individuals and high ambiguity aversion on the part of risk bearers creates a price wedge in supply and demand for risk transfer. Uncertainty surrounding the probability and scale of catastrophic risks leads

[1] Risk management is "lumpy" in that there are fixed costs that are prohibitive for small transactions, which complicates a marginal analysis that assumes infinite divisibility.

insurance companies to add a "risk load" to the premium rate, increasing the price of the insurance. Meanwhile, individuals exposed to the risk are likely to discount the probability that they will experience a catastrophic loss, particularly for the most infrequent events, which are typically the most devastating (Kunreuther, Hogarth, and Meszaros, 1993; Skees, Hartell, and Hao, 2006).

More importantly, the very poor and marginalized have limited means to participate in the risk management market for solutions. In these cases, governments and international organizations may reasonably intervene and provide assistance, usually in the form of safety nets, risk-pooling mechanisms, and ex post disaster relief (see Figure 5). However, catastrophic risks can also overburden government resources. Structuring ex ante financing of these risks and transferring a portion of the exposure to global markets through re-insurance, catastrophe bonds (CAT bonds), or derivative contracts may be necessary to ensure that sufficient, reliable financing can be accessed when needed.

Box 2. Financial Risk Management Strategies

The main principal of a risk strategy is that the party most capable of accepting a risk does so. That implies that for any given risk there are two alternatives: retain or keep the risk, or transfer the risk.

Risk retention (i.e., savings and credit) is a lower cost option for less severe risks that occur more frequently. Within the retention segment, the holding of savings or reserves will exhibit lower opportunity cost than contingent credit up to the point where the expected value of investment return forgone over some time horizon exceeds the expected cost using credit. Using contingent claims such as insurance to finance frequent risks or even the majority of risk exposure would be prohibitively expensive, since these increase exponentially the more frequent the expected payment (Anderson et al., 2011).

Risk transfer via insurance or financial markets is more efficient for catastrophic losses and for losses that are likely to be widespread and substantial. In these situations savings or reserves may be easily exhausted, and credit may be difficult to obtain or impractical if revenue streams are jeopardized.

As described, financial instruments have a role in managing the residual risk that remains after the implementation of other measures. Savings/reserves and credit can be effective tools up to a point. However, these tools become impractical and ineffective for high-impact, correlated losses. The high-impact, widespread nature of such risks requires access to risk transfer mechanisms to shift the financial exposure to globally diversified capital markets where it can be more easily absorbed. Nevertheless, it is recommended that the development of financial instruments should be carefully structured to complement, rather than crowd out, other measures of risk reduction, and avoid creating perverse incentives that could exacerbate risk exposure over time.

This document focuses solely on financial risk management instruments, and specifically risk transfer. The following two sections discuss financial instruments for managing price volatility and weather risks respectively, two types of risks that are most difficult to address through self-retention and domestic risk transfer mechanisms.

Section 3 Price Risk Management

One of the main sources of uncertainty in agriculture, which has magnified in recent years, is price volatility of agricultural products. Sharp fluctuations in commodity prices can have serious implications for consumers and producers and lead to underinvestment in the sector. Price declines hurt producers' net revenue and their ability to recover investments in the production process. Commodity price spikes can threaten food security and heighten government fiscal exposure for countries dependent on the importation of staple cereals.

Financial instruments can help to mitigate price volatility, yet, as noted previously, they are ineffective in addressing longer-term downward or upward trends in commodity prices. Structural price trends should not be disguised by domestic price controls and supports, which distort market signals and stunt adaptive supply and demand responses.

This section describes the implications of price shocks and volatility resulting from cyclical moments of agricultural dynamics and exogenous factors, distinguishing between risk and expected variance. The various facets of risk and price risk management strategies are analyzed by type of risk holder. Potential areas of opportunity for international financial institutions are considered, as well as main lessons learned in relation to price risk for agricultural products.[2] For background, Appendix A contains descriptions of some of the more common financial instruments for price risk management.

Cyclical/Seasonal Volatility

The analysis of price formation and price variations over time looks for patterns, trends, and correlations with other variables or events. Price variation, however, is not synonymous with risk. Predictable cycles in prices are common in agriculture due to variances within seasonal production. For example, prices are more volatile during the growing season compared to post-harvest prices, which tend to increase more predictably to cover storage costs (the time value of money). Consistent, fairly predictable fluctuations in price do not represent risk per se in that there is minor variation around an expected pattern.

[2] In the jargon of commodities risk management, particularly for agricultural products, the concept of risk is understood by two additional concepts: price risk and physical risk. The former is related to changes in prices and the latter is related to fluctuations in commercialized volumes. This section focuses on price risk management.

Risk involves some degree of randomness and increases with the probability that an outcome differs from the expected value. Therefore, price risk can be defined as unexpected changes in prices fluctuations; that is risk arising from uncertainty. For agricultural products, price risk is a quantification of this uncertainty, represented by a measure of the probable impact of prices on the value of agricultural production. The impact could be negative (loss) or positive (gain) in the underlying value of the asset represented in its price.

Volatility is defined in terms of changes in variance over time. Price volatility can be closely linked to broad macroeconomic variables or the conditions of a specific commodity market, each one linked to its own sources of uncertainty. Attempts at forecasting price trends and volatility must take into account complex, interacting factors in commodity markets and production. These exogenous factors include domestic and global economic growth, international market interactions, energy prices, trade policies, production trends for substitute commodities, and supply and demand expectations, among others. For example, stochastic models are used to predict market behavior, simulating the interaction of known and historical information about macro and microeconomic variables and assumptions about the future.

Nevertheless, these models have their limits, especially with respect to key assumptions about weather and macroeconomic conditions. If these assumptions change, the analysis of the price will be directly affected. If the assumptions for the variables were defined for a range of diverse scenarios, the results of the projections will yield a range of projected values and uncertainty. While a certain range of variance is accepted, increasing volatility surrounding a trend creates greater uncertainty and challenges to planning and investment. As a result, price analysis and projections can be useful for predicting the general direction of a trend but are less effective for predicting price values and the degree of movements that would aid producer decisions.

Impacts of Price Risk

Price volatility implies different effects for the three main stakeholders in the agricultural sector: first, agricultural producers, who can be strongly affected by the effect of price changes on revenues; second, the poor, whose consumption is affected; and third, the government, which uses public finance for price compensation via subsidies and safety nets. This section explores the diverse facets of risk, to which different actors are exposed at the micro, meso, and macro

levels. In this way, we will be able to identify suitable strategies to address financial instruments for each risk holder.

Micro Level

The examination of price risks at the micro level looks at how individuals and households are exposed to and affected by price shocks. Two separate actors are considered as the micro level: producers and consumer households, namely the poor.

At the producer level, there are three sources of uncertainty that translate into price risks. The first is the price of direct inputs for the underlying product, such as seed and fertilizer, which can fluctuate given market conditions or changes in government policies. The second is production costs during the growing season (labor, irrigation, pesticides, equipment). Harvest prices are the final source of price uncertainty, as the prices received are not realized until after the producer has expended costs for the production process.

In an ideal world, producers of all scales would have access to market information, there would be no barriers to market entry, transaction costs would be minimal, and they would have access to financial services and risk management instruments. In such an ideal world, the producer would be able to develop the strategies and obtain the tools to minimize risk and maximize profits, given production technology.

Using a predictive model, the producer would establish a sequence of expected costs and expected variability, that is, adding the stochastic factor and expected incomes. In this way, the producer would align expected income and expenses to yield a profit. The financial instruments would enable the producer to gauge income, costs, and expected benefit against the price of risk management (e.g., interest, commissions, premium, etc.).

In the real world of diverse developing economies, small-scale producers lack access to the information and tools to optimize their production decisions and reduce their risk exposure. For these producers, price shocks (e.g., spikes in input prices, or declines in commodity prices) can quickly derail their investments in production and expected revenue. An unstable market environment limits the availability of credit and other financial instruments for smallholder agriculture. Price uncertainty leads to risk-aversion, which creates a vicious cycle of underinvestment, that is low-risk/low-return production choices that reduce opportunity for long-term livelihood gains. This is an important area of opportunity for public institutions, whether local, national, or multilateral.

At the micro level, consumers, particularly poor households, are also vulnerable to price risk, specifically when the prices of domestic staples rise. Poor households that already devote a large proportion of their income to food are extremely vulnerable to price increases. Prices increase may stem from a variety of sources, including production shortfalls due to adverse weather and global market forces (e.g., growing global demand). Smallholder producers also typically spend the bulk of their income on food. Thus, smallholders are at risk of price declines and volatility and also face the risk of price increases on staple commodities.

Unfortunately, the market forces driving price in the short term may be indicative of a long-term trend. In contrast, fluctuations due to unexpected supply shocks from extreme weather will have transitory, albeit important, effects on prices. In such cases social safety nets and long-term policy planning are needed to address food security concerns and ensure domestic consumption needs are met. Addressing the consequences of long-term trends is beyond the capacity of financial risk management instruments. At best, these instruments can smooth the transition to the new equilibrium price level.

Meso Level

Here we use "meso level" to refer to enterprises and institutions. Within the agricultural value chain, the meso level comprises producers association, agribusinesses, financial institutions, and other organizations linked to the sector that become risk aggregators through their portfolio of clients or business. Although value chain enterprises generally have advantages over individual producers in terms of market power and access to finance and other risk management mechanisms, such entities also face direct and indirect exposure to price and other production risks through the nature of their involvement in the sector.

For example, producer associations and exporters face similar uncertainties as individual producers with downside price risk and volatility in commodity markets that may limit their capacity for productive investments and growth. Financial institutions that lend to the agricultural sector are vulnerable to correlated default risk if their borrowers experience price shocks or weather-driven losses that leave them unable to repay their loans. The potential exposure to such risk has led to a contraction of credit to the agricultural sector in many countries and to conservative investment practices by these meso level actors as a form of risk management. However, this reaction restricts opportunities in the agricultural sector, particularly

for smallholder producers who are most affected by credit rationing and the more limited production possibilities as processors and exporters do not expand owing to underinvestment.

Macro Level

At the macro level, the main risk aggregators are national governments and supranational consortiums, as they are often the insurer of last resort, supporting vulnerable sectors and populations and compensating for market failures. For many years the presence of public resources was a constant in the agricultural sector. The government is part of the agricultural value chain, providing synchronization and coordination between the various stakeholders of the economy, and providing a source of financing and risk transfer for producers and consumers. Implicitly or explicitly, governments assume risk. As a result, in recent years, governments have sought to hedge against price risks, as well as natural disasters, that impact their fiscal exposure and threaten vulnerable populations.

Food security concerns warrant public sector intervention from a humanitarian perspective. The marginalized poor and impoverished are the most vulnerable to famine and price shocks, lacking the resources to withstand such events. Thus, provision of social safety nets and other forms of assistance to at-risk populations is an assumed government responsibility that can create a heavy fiscal burden. Similarly, government attempts to buffer the impact of price risk on consumers and producers through price supports and controls were financially and politically unsustainable. Nevertheless, governments face fiscal exposure to price risks through humanitarian obligations in times of food insecurity and price spikes, revenue shortfalls when export production or prices declines, and in providing support to sectors affected by these risks (e.g., providing loan guarantees or financing to lenders).

Some Lessons Learned

In price risk management it is important to underscore that prices, in general, are an efficient indicator of an asset's underlying value. Hence, distortionary policies or practices that interfere and contaminate the price formation process or the transmission of price signals to producers and consumers in the value chain can have unwanted consequences. At the same time, large price fluctuations will have negative effects on vulnerable groups of producers and consumers that could be mitigated with effective risk management strategies. The logic of risk management

implies that rather than applying price guarantees that distort markets and the incentives to adapt and take appropriate risk avoidance strategies, other approaches should be pursued, including partnerships among the public sector, private sector, and/or donor institutions to improve risk management. The case studies included in the appendices provide some examples of more market-oriented approaches to risk management.

In the agricultural sector of Latin American economies, the most common non-market price risk management mechanism has been risk retention through subsidies or direct transfers using public resources. These can be characterized as price stabilization policies. They range from subsidies for inputs like fertilizer to offset high import prices, price floors for staple crops, and subsidized provision of products to consumers. The inherent distortions created by these measures substitute market price risks for policy risk (since these policies are generally unsustainable), while they mask price trends that should drive the productive allocation of resources in the economy, and add a fiscal burden for the public sector.

Decades of international experience with the design, structuring, and use of financial instruments for large international corporations has confirmed that there are market-based instruments that are powerful tools for risk management and wealth preservation. Price risk management instruments can minimize uncertainty and reduce market risk. Price risk is most transparently managed via futures and options contracts traded on organized exchanges. Contracts for commodities such as coffee, cocoa, maize, soybeans and soybean products, sugar, wheat, and some livestock are traded internationally in well-developed financial markets and over-the-counter (OTC) transactions that allow market participants to hedge against a wide range of risks.[3]

Given the development and growth of financial markets and commodity exchanges, a logical question is why price risk management instruments are not more widely utilized by the agricultural sector in developing countries.[4] Producers, particularly those in developing countries, face significant barriers to accessing price risk markets. Few producers access price

[3] The largest, most active markets, the Chicago Mercantile Exchange (CME) and the European Market of Derivatives (EUREX), trade on a wide variety of globally traded commodities.

[4] There are several cases, for example, of organized derivatives markets in emerging economies; such as the Mexican or the Chilean economy, both with deep financial markets compared with their cultural neighbors. Those economies have sought to develop national exchange markets to improve access and relevance to domestic producers, but empirical evidence shows that they have developed slowly; many times these markets focus on a very small basket of products and lack sufficient volume to create necessary liquidity to function effectively.

risk markets directly. Small-scale farmers in developing countries are even less likely to participate due to large fixed costs associated with the large underlying volumes customary in futures and options trading (Larsen, Anderson, and Varangis, 2004). Reasons why farmers do not utilize risk markets include a lack of knowledge, limited collateral for margins, small scale of operations, basis risk between local crops and exchange traded commodities, and a modest perceived benefit relative to price, among others reasons. Direct use even among sophisticated commercial farmers in developed countries is low (Benavides and Snowden, 2006; Larson, Varangis, and Yabuki, 1998).

> *One approach to managing risks more effective is to aggregate local demand to facilitate access to price risk markets among producers, perhaps by pooling price risks from many small farmers and hedging them in the international market (Larson, Varangis, and Yabuki, 1998).*

The enormous challenges faced by the LAC region are representative of those faced by developing economies around the world. The scope of the challenges speaks to the need to seek scalable, market-based financial strategies that can be sustained over time, and that incorporate the following aspects: 1) increase producers' capacity through the transfer of financial technology and market knowledge; 2) build a robust infrastructure in two priority areas: regulatory and statistical information of underlying assets; 3) coordinate access through local stakeholder organizations, such as producers' associations; 4) increase governments' capacity for the proper use of a menu of market-based instruments; 5) increase funding sources for risk management; and 6) identify capable global risk managers who can take and offset risks cost effectively. In all of these aspects, international financial institutions can play a role. However, most critical in order to jump-start the use of market-based approaches will be their ability to provide low-cost capital and their willingness to take and share some of the underlying risks. In this effort, a critical target market will be small-scale producers in LAC countries, where there is a wide gap between the available tools in the market and the unmet demands of producers.

Aggregating local demand can facilitate access to price risk markets among producers. The idea is to create a system whereby an intermediary, either private or public, pools price risks from many small farmers and hedges them in the international market (Larson, Varangis, and Yabuki, 1998). As described in Box 3, and elaborated in Appendix B, the Mexican government

has established the organization ASERCA (Apoyos y Servicios a la Comercializacion Agropecuaria) to facilitate price hedging between producers and U.S. brokers.

Box 3. Macro Policy for Hedging Maize Prices in Mexico

In the wake of the North American Free Trade Agreement (NAFTA), Mexico moved to open its agricultural markets, thus exposing growers and consumers to unprecedented levels of price uncertainty (Larson, Varangis, and Yabuki, 1998). To mitigate the impact of commodity price volatility, the government launched a subsidized commodity-hedging scheme, initially to help cotton growers lock-in the selling price of their crop. Since then, the program has expanded to include a wide array of agricultural commodities as well fertilizers, natural gas derivatives, and diesel fuel (USDA/FAS, 2011).

The hedging program is intended to stimulate production, encourage consumption of domestic supplies, and stabilize important commodity markets by providing price certainty. It is administered through a decentralized agency reporting to the Ministry of Agriculture — Support and Services for Agricultural Lending (ASERCA), which acts as an intermediary, enabling producers and end users to access futures options traded on commodity exchanges in the United States. (Refer to Appendix B for more detail.)

Section 4 Managing Weather Risks in the Value Chain

Weather risks are an important driver of local and regional food price spikes, food shortages, and lost income through the effect of production consequences of extreme events. While the short-term price effects of these shocks can be addressed to some degree as described above, the production and hence financial impacts cannot be as easily remedied.

Catastrophic weather is one of the most pernicious risks to the livelihoods of smallholders in emerging economies, leading to the depletion of income and assets and contributing to persistent poverty. Weather risks also have broader adverse consequences for the extended value chain and the regional economy. Shortfalls in agricultural production can lead to financial disruptions for businesses and individuals who depend on agricultural inputs and commerce including processors, exporters, input suppliers, transporters, and the like. Even when yields are not severely affected, some weather disasters, such as heavy rainfall and flooding, can impede the marketing of commodities when transportation and communication networks are damaged. Such consequential losses can have long-term consequences, as reconstruction and recovery can become a prolonged process.[5]

Long-term changes in average precipitation and temperature associated with climate change are expected to exacerbate the incidence of extreme weather, in addition to altering growing conditions for agricultural production.[6] Expanding the options for managing weather risks is an important component of efforts to incentivize producers and enterprises to make adaptive and resiliency-improving investments to address this major source of current and future risk and uncertainty. The ultimate goal of these efforts is to create a more stable agricultural sector having greater capacity to recover from severe events in order to make the investment necessary to achieve the productivity gains needed to keep pace with growing food demand.

Impact of Weather Vulnerability and Potential for Risk Transfer

The expansion and growth of microfinance throughout the world has greatly improved access to financial services in rural areas. While savings, credit, and informal risk sharing mechanisms are

[5] For example, the 1997–1998 El Niño event in Peru in resulted in extensive flooding and damaged infrastructure that isolated some communities for nearly six months, which halted banana production due to the lack of market access. In such cases, the socioeconomic impacts of the disaster extend well beyond the primary agricultural sector.

[6] For a thorough discussion of expected climate changes and implications for Latin American countries see IDB (2010).

important tools for coping with unexpected costs and losses, these mechanisms fail to adequately address the widespread, often catastrophic losses that result from weather risks. Consequently, households and value chain enterprises are ill prepared when weather catastrophes occur.

In most developing countries, smallholder farmers have little to no access to risk management mechanisms capable of handling the potential magnitude of correlated losses. While there is greater penetration of agricultural insurance in the LAC region relative to Africa and Asia, this coverage varies greatly across and within countries. The majority of agricultural insurance programs in this region are multiple-peril crop insurance programs oriented towards large-scale commercial producers, which fail to address the needs of smallholder households and the risk exposure of the broader value chain (Iturrioz and Arias, 2010). Even where agricultural insurance does exist in developing countries, they often lack the capacity to absorb or transfer the large financial losses that can occur as a result of a covariate weather event. This and other shortcomings of a traditional insurance approach to covariate weather risk were outlined in Section 3.

Yet, weather risks pose a difficult challenge and mechanisms suitable for addressing the financial consequences on a broad scale are needed. Indeed, there is a great deal of potential value in risk transfer—on average, it is estimated that the LAC region experiences USD 3 billion in natural disaster losses *each year* (Andersen et al., 2010). This represents an impact having significance not only for the primary agricultural sector but also for a country's GDP, particularly that of a smaller country. Table 2 demonstrates the impact of a covariate weather disaster on the agricultural sector. In 1998 the category 5 Hurricane Mitch devastated Central American countries. Damages to the agricultural sector were severe for both export and staple crops and threatened food security in several countries, losses that were compounded by damage to the distribution and transportation infrastructure (PAHO, 1998).

Table 2. Agricultural Losses in Central America Resulting from Hurricane Mitch (1998)

Value of Lost Production by Activity, by Central American Country *(US$ thousands)*							
Activity	Costa Rica	El Salvador	Guatemala	Honduras	Nicaragua	Panama	TOTAL
I. Agriculture	23,945	50,539	241,991	642,253	82,570	5,917	1,047,215
A. Traditional exports	15,311	12,863	193,887	388,171	39,485	3,663	653,380
B. Basic grains	4,263	35,832	10,172	113,301	30,749	524	194,841
C. Fruits and vegetables	4,233	1,844	21,638	83,152	-	315	111,182
D. Others	138	-	16,294	57,628	12,336	1,414	87,810
II. Livestock	255	971	8,131	107,695	-	507	117,559
III. Fishing and aquaculture	-	8,783	14,030	46,488	35,762	-	105,063
TOTAL	48,145	110,832	506,143	1,438,688	200,902	12,340	2,317,050

Source: PAHO, 1998

The El Niño regional climate phenomenon offers another example of a risk that has historically had a strong effect on agricultural production throughout Central and South America. Among these countries, Peru has experienced considerable losses as a result of strong El Niño conditions, most recently in 1997–1998 and 1982–1983. Those two events brought rainfall 40 times above average to northern Peru, washing out crops, roadways, and irrigation infrastructure. In 1997, agricultural losses were estimated at USD 40 million in the province of Piura alone (Skees and Murphy, 2009).

Even under mild El Niño conditions, significant losses have been experienced. For example, agricultural losses due to the "mild" 2009–2010 El Niño totaled US$70 million were incurred by Costa Rica, El Salvador, Guatemala, Nicaragua, and Panama (Relief Web, 2010).

Ex Ante Risk Transfer

For firms in the agricultural value chain, business losses and disruptions resulting from catastrophic weather are seldom insurable using traditional approaches. Even where it exists, yield-based crop insurance excludes households that are not engaged in the production of major commodities and others whose livelihoods are at risk from extreme weather (e.g., flooding), or downturns in agricultural production (GlobalAgRisk, 2011). Though other coping strategies such as drawing on reserves or obtaining credit may be employed to manage losses, these ex post arrangements fail to address the longer-term constraints of operating within an environment of strong covariate risk. When weather risks are severe, businesses and lenders may limit their operations and services to minimize their risk exposure. Overall, having ex ante risk transfer in place enables better planning for farm-level investment, expansion, and diversification. For financial institutions, this can mean more willingness to enter previously underserved markets.

At the national level, governments predominantly rely on ex post risk financing mechanisms such as reserves, multilateral credit, or, in true disaster situations, international aid to cope with the consequences of catastrophic weather and provide assistance to affected populations. This role of government is important for socioeconomic well-being, reconstruction of public infrastructure, and in many instances maintaining civic order. In the absence of formal markets for managing catastrophic risks, governments (or donors) take on the role of de facto insurer, absorbing the economic and social costs. These impacts on government budgets and GDP can be significant.[7] This creates short-term financial hardships and economic uncertainty that may limit a country's ability to attract investment capital.

There will always be a role for ex post measures. However, governments should strive for greater ex ante management to protect government budgets and facilitate more efficient, timely, and targeted use of resources in the aftermath of a weather disaster.

[7] For example, in response to a major drought in 2005, the government of Malawi spent USD 200 million for food aid. Similar rainfall deficits and maize production shortfalls occurred in 2000 and 2004. Such shocks to national finances have increased government borrowing and threatened macroeconomic stability.

Contingent Claims Mechanisms

The following presents a number of contingent claims instruments—mechanisms that make a payment contingent on the occurrence of a pre-specified event—that can be used to finance weather risks. Insurance contracts are the most common form of weather risk transfer for developing countries. However, weather derivatives and catastrophe bonds can also be used to provide contingent financing in the event of extreme natural disasters. All are ex ante financing arrangements but with contingent credit representing retention rather than risk transfer. Index insurance can be applicable at all levels, from households to government, while the others are generally more appropriate for larger volume transactions by those who have experience with more complex financial tools. From a government and donor perspective, risk management should be considered with a broad view of how risks can be addressed and mitigated at each level in an integrated way so that new policies and strategies serve to enable rather than inhibit proactive risk management.

Index Insurance

In the late 1990s, index insurance, also known as parametric insurance, was advocated to address the challenges and limitations of providing traditional agricultural insurance in emerging market environments. Index insurance relies on the realized value of an underlying index as a basis of payment rather than an assessment of actual losses. Essentially, the index values are intended to be indicative of, and highly correlated with, the expected loss experience of the insured. Without the need for loss adjustment of individual policyholders, the administrative costs are less compared to traditional indemnity insurance. Payouts are easily and quickly determined against the index value and can be more rapidly disbursed. Additionally, since policyholders cannot influence the index to improve their odds of receiving a payout, moral hazard is practically eliminated. The value of the payouts is solely dependent upon the measured index value and the sum insured, regardless of the level of loss experienced by the policyholder. An important result is that index insurance actually preserves incentives for risk mitigation as the insured can be compensated for their efforts to reduce their risk of loss. Index insurance is not without its limitations, which have become recognized over the course of implementation efforts.

There are two main types of index insurance products, usually structured as either aggregate loss indexes or weather-based indexes. Aggregate loss data describe losses across many individuals, typically in the same geographic region. A common example of an aggregate

loss index is area-yield insurance. With area-yield insurance, average crop yields from a defined area (e.g., a county or district) are used as a measure of crop performance and in determining insurance payouts. For example, an area-yield contract may be structured to trigger payouts when the average yield for the season falls below 30 percent of the historical average.

Yields may be obtained through sampling conducted by a ministry of agriculture (crop-cutting experiments) or self-reported. The reliability of each of these methods in approximating the yield outcomes of farmers within the region is questionable and can be subject to a high degree of inconsistency and error. To minimize basis risk, area-yield insurance is most applicable to relatively homogenous areas where there is widespread production of a major staple crop such as corn or wheat. Area-yield insurance is crop specific and is primarily marketed towards producers to insure the value of production. However, it could also be offered to others in the value chain whose revenue is heavily dependent on the insured crop.

The Index-based Livestock Insurance (IBLI) Program in Mongolia is an example of a different type of aggregate loss index insurance (Appendix C). The Mongolian IBLI uses county-level estimates of livestock mortality by species collected by the National Statistics Office (Mahul and Skees, 2007).

With aggregate loss indexes, the aggregate data are on a large enough scale to reduce the likelihood that any individual insured can significantly influence an indemnity. Thus, these products present less opportunity for moral hazard and adverse selection than traditional insurance products.

Weather-based index insurance insures against the occurrence of a specific weather event rather than losses to the insured. A weather index relies on measurements of weather events that are highly correlated with losses of the insured as the basis for an insurance payment. The objective of the index is not to serve as a direct proxy for loss, but rather as a predictor or proxy for the insured event itself, such as a flood or drought. A commonly used weather-based index is rainfall data from local weather stations; however, other measures can be used. For example, the Normalized Difference Vegetation Index (NDVI), a satellite measurement of vegetation density, has been used to provide index-based drought insurance.

Aggregate loss indexes are generally easier to develop and scale up than weather-based indexes. However, both types require access to a long time series of disaggregated, reliable, historical data to support the risk assessment and underwriting. While many countries maintain

agricultural databases of crop and livestock production there are often inconsistencies and gaps in the records that present additional challenges for conducting risk analysis and underwriting. Access to historical meteorological data can also be difficult to obtain from the overseeing government ministry.

For index insurance to be effective at providing value to the insured, the index must be representative of realized losses. The index and individual losses are not expected to be perfectly correlated; as such, some basis risk will exist. A goal of insurance product design is to minimize basis risk, which is not a trivial matter, in order to offer effective protection for policyholders.

Basis risk is an issue for any index-based insurance.[8] Any discrepancy between the index values and individual losses affects the instrument's ability to transfer risk effectively. Such variance or basis risk depends on many factors, from product design, natural weather variations, geography, and the type of data underlying the index. For example, if weather stations are used to provide data, the lower the density of stations the higher the potential for basis risk for those insured located furthest from their reference station.

Basis risk is less likely to pose hurdles when index insurance is properly marketed in light of its limitations and when clients understand which risks are covered and which risks are not. Importantly, product design can significantly reduce basis risk. Concentrating on the most severe and highly spatially correlated risks minimizes basis risk, as does carefully choosing the target market for the index insurance product.

While there is the potential for significant gains from developing index insurance markets, there are also significant challenges that hinder market development and necessitate government and donor support to overcome certain market failures. The performance of index insurance pilots has been mixed, and the limited experience to date makes it difficult to draw any conclusions about the long-term welfare impacts of index insurance. What has been learned over the past ten years or so of experimentation is that index insurance, particularly when marketed as a microinsurance product, faces many of the same challenges as traditional insurance markets, such as high transaction costs relative to market volume, nascent insurance sectors and/or weak legal and regulatory frameworks, and limited historical data for underwriting. However, some of these challenges become inflated for index insurance due to the lack of experience with this type

[8] Basis risk is also present with price risk management instruments, for example, when local commodity prices do not follow futures prices.

of product and its limited market scalability (GlobalAgRisk, 2011). Building the technical capacity of domestic partners and ensuring that the product features and limitations are clearly understood by consumers is critical. While these challenges can be overcome, they are prohibitive to private sector development of index insurance products. For this reason, emerging index insurance programs have relied heavily on government and donor support to finance initial development and educational costs.

Derivatives

The main distinction between index insurance and a derivative for weather risk transfer is one of legal and regulatory framing.[9] Risk transfer organized as insurance provides regulatory oversight and consumer protection that is especially important when designing products for individuals and other consumers who are not positioned to undertake the due diligence required of a derivative contract. Insurance, at a minimum, requires clear articulation of an insurable interest to remove speculative potential that is associated with traditional derivative markets. Sometimes, however, for risk transfer for humanitarian and food security purposes, the purchaser cannot satisfy the insurable interest requirement because either they do not directly experience the losses or are not necessarily compelled to incur costs as a consequence of a weather event. The example that follows of the World Food Program (WFP) is one such case where insurable interest is lacking. For large organizations and government having capacity for due diligence, the derivative structure may be more expedient than the route of an insurance contract even if there is a clear insurable interest.

The WFP engaged in a groundbreaking transaction that was the first instance of a weather derivative being acquired for humanitarian purposes. It purchased a derivative contract on behalf of the Ethiopian Government to provide contingent financing in the event of severe drought in Ethiopia during the 2006 growing season. Payout from the derivative would be distributed to food insecure households through the country's existing social programs to enable the purchase of food from local markets. The contract was structured around a rainfall index as an indicator of

[9] Derivatives are most closely associated with price hedging through an organized exchange that reduces counterparty risk, as for example with futures contracts discussed previously. An over-the-counter derivative for weather risk transfer derives its value from the underlying costs incurred due to the triggering event and are usually priced in a similar manner as are insurance products, rather than the methodologies used for valuing derivatives based on price movements of an asset or traded security.

severe drought, relying on precipitation data from 26 weather stations throughout the country. The derivative had a notional value of more than US$7 million for which over USD 900,000 was paid for its purchase, with substantial financial support from USAID. Conditions during 2006 did not trigger a payout and the contract was not renewed, in part due to concerns that it was too costly relative to other financing mechanism available to government (Cummins and Mahul, 2009; Barrett, 2006; The New York Times, 2006).

More recently, the government of Malawi has purchased weather derivative contracts to support food security at the national level (Appendix D). The contracts are designed to provide contingent financing in the event of severe drought based on deficit rainfall levels as measured by weather stations around the country. The rainfall index is calibrated to correlate with the performance of maize production, providing an indication of production shortfalls that would warrant government attention to food security concerns.

Catastrophe (CAT) Bonds

Catastrophe, or CAT, bonds provide an ex ante mechanism for financing the upper limits of catastrophic risk exposure by tapping capital markets. A CAT bond transfers the risk of a specified event to capital market investors (typically large, institutional investors). The issuer of the bond, that is, the one ceding the risk, pays a premium that provides a yield to bond investors. Investors carry the risk with the potential to lose their capital if the triggering event occurs. In such a case, investors' capital is transferred to the cedant. Many, but not all, CAT bonds rely on a parametric index to trigger a payout. CAT bonds have mainly been used to provide contingent financing for natural disaster risks for the insurance and energy industries and public infrastructure, due to the massive losses such events can produce.

The advantage of catastrophe bonds over reinsurance or derivatives is that they provide access to the virtually unlimited resources of the capital markets. Pricing can be more competitive than reinsurance and historically has been less volatile than reinsurance pricing following large losses to the reinsurance sector (e.g., Hurricane Katrina). However, the upfront costs associated with CAT bond transactions make them most suitable for large amounts of financing, in the range of US$100 million or more. Additionally, these are complex transactions that benefit from in-house technical training and expertise (Michel-Kerjan et al., 2011). As a

strategy for managing weather or other risks in developing countries, the costs and complexity make them only suitable for national or regional risk financing.

In 2009, Mexico transferred US$290 million in exposure to hurricane and earthquake risk to capital market investors via a CAT bond to finance disaster relief in the event of one of these major events (Michel-Kerjan et al., 2011). The CAT bond represents one of several proactive risk financing initiatives by the government of Mexico to improve the management of disaster and agricultural risks and alleviate the fiscal burden imposed by unexpected catastrophes.

With increased investor interest and continued market growth, the transaction costs of bond issues and minimum bond size are both expected to decline. In the case of the previous example, the CAT bonds were issued by the government of Mexico, with the World Bank serving as an intermediary to facilitate the transaction. The World Bank co-financed the development costs via their MultiCat platform that is intended to ease entry into these markets for developing country governments by creating a standardized issuing platform (World Bank, 2009). However, to date, the Mexico CAT bond has been the only bond issued under the MultiCat platform. Likewise, there are efforts in the private sector to create a more standardized platform to open the market to more diverse and smaller scale risks that could make the use of a CAT bond as viable and flexible as a derivative contract.[10]

Contingent Credit

Contingent credit is another source of risk financing that can be called upon in the event of a disaster or other crisis. Like other forms of contingent financing, arrangements are made in advance to secure access to credit when an emergency situation arrives.

Contingent credit has advantages over ex post financing mechanisms in that there is an arrangement in place prior to the crisis to ensure faster, more reliable access to funds. Additionally, credit typically provides greater flexibility in the terms of disbursement in contrast to index insurance or CAT bonds in which payouts are contingent upon a specific triggering event. The flexibility afforded by contingent credit makes it effective for moderate risks as one component of a comprehensive risk management strategy that includes a combination of tools to manage different layers of risk (Clarke and Mahul, 2011).

[10] In 2011, a USD 11.95 million private CAT bond was issued on behalf of a mid-sized insurance company, setting a new precedent for small scale. http://www.artemis.bm/blog/2011/07/05/towers-watson-completes-private-placement-oak-leaf-re-2011-1-catastrophe-bond/

The World Bank has created a contingent credit structure for IBRD-eligible countries—the Development Policy Loan (DPL) with Catastrophe Risk Deferred Drawdown Option (CAT DDO). DPL with CAT DDO will provide loans of 0.25 percent of GDP, up to USD 500 million, as an intermediate source of financing for major natural disasters. Eligibility for the CAT DDO is conditional upon development and implementation of a comprehensive disaster risk management plan with the objective of reducing risk exposure over the long term. Access to the funds requires a declaration of a state of emergency by the member country (World Bank Treasury, 2009).[11]

The first CAT DDO arrangement was established with the government of Costa Rica in 2008. The government of Costa Rica called on US$15 million of their US$65 million limit to confront recovery after the 2009 earthquake. Since then, similar contingent credit agreements have been signed with other countries in Latin America and other parts of the world, including Colombia, El Salvador, Guatemala, and Peru (Ghesquiere and Mahul, 2010).

The IDB established a similar Contingent Credit Facility (CCF) in 2009, which provides up to US$100 million in contingent financing to eligible member countries for immediate disaster relief and initial recovery. Disbursements from the CCF are based on a transparent, parametric trigger. The Dominican Republic was one of the first beneficiaries of this facility that provides emergency financing in the event of a major earthquake or hurricane (Andersen et al., 2010).

Continent credit is a strategy utilized by many financial institutions. Credit may be arranged with higher-tier financial institutions, governments, or donor institutions. In LAC the Emergency Liquidity Facility (ELF) disburses emergency loans to assist microfinance institutions in affiliated countries following natural or man-made disasters, including economic and political crises—events in which microfinance institutions may experience a large number of defaults and withdrawals. The facility was established in 2005 by a consortium of bilateral and multinational institutions, including the IDB, as well as private investors. Affiliated institutions are prequalified to enable a rapid disbursement (2 to 3 weeks on average) of funds following an on-site post-disaster needs assessment. Access to the loans is conditional on the post-disaster assessment that considers, among other factors, the potential solvency of the microfinance institution following the event (Emergency Liquidity Facility, 2011). However, credit might not

[11] The general terms and conditions for the DDO loans can be found at the following link: http://treasury.worldbank.org/bdm/pdf/Handouts_Finance/DDO_MajorTerms_Conditions_Aug09.pdf

be granted if recovery is judged prolonged or if damage and losses to the MFI, its clients, and the community are extensive. The ELF loans do not offer the same flexibility in aiding recovery or mitigating losses as other types of ex ante financing might, yet they do provide rapid access to a source of contingent financing for immediate liquidity in the event of a financial shock stemming from any number of risks.

Beginning Principles for Contingent Claims Application

The following observations are based our experience with numerous index insurance pilots, feasibility studies, and a reading of a broad array of contingent claims applications initiated around the developing world. These principles address the beginning challenges of the development of risk transfer markets for weather and natural disaster risk in developing countries. The focus is on market applications and therefore mostly private sector risk transfers rather than contingent credit means of addressing risk exposure. The goal is to improve the sustainability of these markets by taking an approach that exploits the strength of indexed applications so that they can achieve sustainability and scale (GlobalAgRisk, 2011). These recommendations have evolved from recognition of the many problems associated, and by now well documented, with introducing farm-level weather (event-based) and aggregate loss insurance, and will help shape the overall recommendations of this paper.

- **Introduce products for risk aggregators first.** Risk aggregator refers to entities such as financial institutions, producer associations, exporters, and public sector agencies that are exposed to an aggregated risk due to the exposure of their clients or activities. For example, given the correlated nature of some weather risks, lenders may suffer liquidity risks if many of their clients withdraw deposits and default on their loans at the same time. For a processor or exporter of agricultural produce, a natural disaster can greatly reduce their volume of business. Products developed for risk aggregators face fewer data constraints and costs associated with capacity building, administration, and product delivery. Products sold to risk aggregators represent larger-volume contracts with lower relative transaction costs, which are more likely to attract commercial insurers and reinsurers, resulting in improved market viability. Furthermore, risk aggregators are positioned such that basis risk associated with contingent claims is much less prevalent

compared to individuals, in addition to having access to other financial means to offset potential losses.

- **Protect against the broader economic consequences of weather risk, not just crop losses.** Most contingent claims products, index insurance in particular, developed to date have been designed to insure rural smallholder producers against reduced yields for a single crop. However, yield losses are only one indicator of household well-being, and they fail to represent the diversity of livelihood portfolios. Yield outcomes may even be a poor indicator of certain types of weather risk against which significant coping costs are incurred. Likewise, many risk aggregators have weather risk exposure that extends well beyond the impact of a single year's yield outcome on their clients. Products that protect against the broader consequences of catastrophic weather apply to a larger, more heterogeneous market and offers greater flexibility to the purchaser in adapting their business strategies as conditions warrant.
- **Protect against low-frequency catastrophic risks.** It is almost always more economical to manage the financial consequences of frequent and less severe risks through savings, borrowing, diversification, risk mitigation, and various types of informal family and community reciprocity obligations. In addition, attempting to protect against small to moderate losses using a parametric trigger is likely to be accompanied by higher basis risk because the spatial covariance of many weather events increases with the severity of the event (GlobalAgRisk, 2010). This suggests that the spatial specificity of data required for low basis risk protection against small to moderate loss events is greater than that required for developing protection against catastrophic loss events.
- **Reduce transaction costs and add value through innovative design and delivery features.** Contingent claims products targeted to smallholder households must obtain a high level of efficiency and value to achieve viable scale. Technologies such as ATMs or mobile phones provide one mechanism for low-cost delivery of products. Linking, or bundling, the insurance to other products or services such as banking can reduce costs by utilizing an existing, and often extensive, distribution channel. Some pilots have taken advantage of existing aggregators in the value chain to lower the cost of distribution, though most of these serve a rather narrow group of producers in concentrated areas, such as cotton producers who all sell through a commodity marketing board.

Forecast Insurance — Changing the Nature of Risk Transfer

Forecast information of extreme regional climate events has the potential to allow those who would otherwise be adversely affected to modify their activities to compensate for, or take advantage of, knowledge of future conditions.[12] Even when forecasts are imperfect, and therefore imperfectly applied, the value of adaptive management can be considerable. For example, the value of ENSO prediction from various studies of U.S. agriculture is hundreds of millions of dollars (Weiher, Houston, and Adams, 2011).

Several different factors influence the value of a forecast, including lead time, uncertainty of the prediction, management ability to assimilate and respond, risk perceptions, cost of adaptive management, and effectiveness on adaptive strategies (Teisberg and Weiher, 2009; O'Conner et al., 2005). In addition to these considerations, the fact that climate forecasts will always involve local variation in eventual weather outcomes suggests there will remain a role for weather risk financing. That is the short view.

A different approach is to bundle forecast information with a contingent claims contract that makes payments on the basis of the forecast itself. The immediate implication is that the claim can be made before the occurrence of the predicted severe event. Doing so addresses some of the important constraints to adaptive management and disaster preparedness. Adaptive management and insurance should be considered broadly in light of the previous principles for contingent claims. For a risk aggregator such as a microfinance organization, a forecast with insurance providing it with an early injection of liquidity could give it an enhanced ability to adapt and adjust to emergency lending needs, deposit withdraws, and the evolution of portfolio non-performance. Liquidity and information before the fact can help the financial institution maintain viability more easily than liquidity alone after the fact. Similar financial arguments can be made for businesses that maintain high opportunity cost liquid reserves to protect themselves from anticipated future shocks. To the extent that the contingent claim can be substituted at lower cost for some portion of the reserves held for that risk, funds could be freed up for productive investment.

[12] A climate prediction refers to average or extreme climate conditions for a region in the medium to long-term future (seasons to decades), versus a weather prediction which refers to the specific atmospheric conditions expected for a particular location in the short-term future (hours to days).

The study of regional climate anomalies, especially of the El Niño and La Niña phenomena, has advanced to the point where, for some locations, reasonable predictions can be made well in advance of the onset of their effects (Khalil et al., 2007; Harris and Robinson, 2001). The case study presented in Appendix H documents the development and application of an index insurance product against El Niño effects, but which is precisely done on the basis of a predictive index.

National and Regional Approaches

As part of an integrated natural disaster strategy, governments can work to ensure that basic financial services—savings, credit, and insurance—are available to households and businesses that are at risk. However, governments can also benefit from the use of financial mechanisms to transfer or pre-finance some of their food security exposure to natural disasters. National and regional approaches are compelling because they may offer the opportunity to pool and offset risks before transferring excess exposure to international markets.

Appendix D describes how the government of Malawi has used a weather derivative to pre-finance their response to food crises caused by extreme drought. As mentioned previously, the government of Mexico has used CAT bonds to pre-finance disaster relief needs caused by calamitous earthquakes or hurricanes.

The Index-based Livestock Insurance (IBLI) program in Mongolia (Appendix C) segments livestock mortality risk and then assigns roles for private sector products (more frequent, less extreme loss events) and government intervention (most extreme loss events) to combine insurance for herding households with a disaster safety net. This small-scale aggregate loss index insurance pilot has expanded to a national program and provides an example of an innovative and integrated approach that could serve as a model for public-private partnerships to support the development of weather risk management markets.

A non-governmental yet virtually national approach to index-based risk transfer is the Haiti Catastrophic Microinsurance that provides a measure of protection against natural disaster risk exposure of households borrowing from the nation's dominant microfinance organization (Appendix E). It combines loan default protection to individuals and the microfinance lender with limited lump-sum payments to individuals based on a parametric trigger for earthquake and excess rainfall risk.

Regional and supranational approaches to risk pooling and financing natural disaster risk for government financial exposure are exemplified by the Caribbean Catastrophe Risk Insurance Facility (CCRIF) and the startup African Risk Capacity (ARC) project (Appendixes F and G). These are meant to enhance a country's ability to respond to food or humanitarian crises following a specified natural disaster at lower cost through risk pooling. It is notable that these regional and multicounty approaches have avoided the temptation to provide microinsurance for affected populations, relying instead on established distribution channels of government assistance. However, the value of these regional facilities can extend beyond the intended purpose insofar as it puts in place the technical and financial infrastructure that lowers the cost for others to subsequently build tailored applications that reach to lower level aggregators and even individuals. This sequence is precisely the case of the Haiti Catastrophic MicroInsurance project, which built upon the parametric infrastructure established by the CCRIF that then exploited an alternative delivery channel to directly add value for individuals and microfinance.

Section 5 Conclusions and Recommendations

Commodity price and weather risks have both direct and indirect negative impacts on economic development and poverty alleviation in developing economies. These impacts have also exacerbated concerns about food security. When commodity prices are lower than anticipated in a given year, farmers suffer; when they are higher, food security issues emerge. The indirect effects can be equally devastating, limiting investments in the agricultural sector, including those for research and for productivity-increasing technologies. Finally, extreme natural disasters have effects that extend beyond agriculture (e.g., catastrophic flooding), further weakening the financial sector and increasing poverty trap vulnerability for millions of smallholders.

In the absence of well-functioning risk management markets, governments must assume a large part of the fiscal burden, adding another element of instability that stifles private investment and growth. Where risks are left unmanaged, financial institutions that dare to extend credit for important investments in agriculture become burdened with loan non-performance. Banking institutions either ration credit or impose higher interest rates to compensate for the higher probability of creditor default. Skees and Barnett (2006) were among the first to recommend that financial institutions themselves should be using event-based insurance products to protect their lending portfolio.[13] The same arguments for creating market-based risk transfer mechanisms can be extended to firms in the value chain. Agribusinesses also practice credit rationing or simply become reluctant to make investments in risk-prone areas where there are few effective risk transfer markets.

Making governments work well. Government responses to price shocks and extreme weather events have a tendency to create more problems than they resolve. Agricultural policy is full of failed policy actions on the part of governments to protect prices. These can become quite expensive and create incentives for greater production even in times when markets are signaling for other adjustments. The LAC region is full of cases of abandoned agricultural insurance programs that were supported by subsidies until costs rose to unacceptable levels.

Government action to reduce the immediate suffering created by extreme weather events is needed. Yet, these actions must be designed so as to not slow adjustments to anticipated

[13] Collier, Katchova, and Skees (2011) demonstrate how the extreme El Niño of 1997–1998 created non-performing loan problems for microfinance institutions operating in the northern regions of Peru. Boucher, Carter, and Guirkinger (2008) demonstrate that reducing the constraints to lending in the same region (Piura, Peru) could increase regional growth by as much as 26 percent.

climate risks. Government and donor intervention for addressing commodity price and extreme weather risks must be carefully engineered so as to "crowd in" rather than supplant risk management markets.[14] Several case studies and a review of projects in this report provide some optimism.

Safety nets and emergency assistance, critical functions that can address the needs of the most vulnerable, must be carefully structured to provide targeted assistance so as not to undermine best practices that encourage risk reduction. To mitigate risk for the long term, however, governments and donors must consider ways to facilitate improved risk management at individual, industry, and national levels, incorporating both financial instruments and physical mechanisms (e.g., privately owned warehouse storage systems).

Making markets work better. Addressing market failures that hinder the development of risk management markets and determining where market-based approaches can succeed and where government involvement is needed involve careful examination of the incentives provided and the unintended consequences of various policy actions. In an ideal world, government actions would work to ensure that there are integrated policies and sound, accessible market mechanisms in place for use by various stakeholders to manage their risk exposure.

Public goods such as creating improved data and information systems, capacity building for stakeholders, basic education about the value of risk management, and the enabling environment for risk markets to emerge are all appropriate roles for government. Investments in broader market development and support will contribute to long-lasting benefits that extend beyond an emerging market for a specific risk transfer product to create a foundation for improving risk management capacity. Important areas for investment in market development include the following:

- Educational initiatives to build awareness and understanding of risk and strategies for managing different types of risk;
- Risk assessment to guide policymakers and other stakeholders in developing appropriate strategies and prioritizing risk management investments;

[14] The Mongolia case is one of few examples where the commercial market is being "crowded in" with government subsidies for only the most extreme mortality of animals. This public-private partnership merits consideration in other sectors as it can serve as a model to create viable insurance markets that may persist even if the government changes the support in later years.

- Technical capacity building to help stakeholders develop, implement, and maintain integrated risk management planning that includes risk assessments, investments in loss prevention, and financial mechanisms for risk coping and risk transfer; and
- Review of the legal and regulatory frameworks governing potential products to ensure that compliance and adequate protections are in place.

Framework for Action by International Financial Institutions

International financial institutions (IFIs) have participated extensively in developing economies, through project financing, capacity building, and technical assistance, predominantly via loans, grants, and guarantees. In some cases, IFIs have facilitated improvements in the risk management capacity of various sectors to enable greater resilience in the face of shocks and to protect productive investments. However, there is still a great need and an opportunity for international organizations to provide financial technology transfer (education, creation of regulatory and institutional frameworks), links between credit organizations, and market development support for different types of risk management products.

Perhaps one of the comparative advantages that IFIs have over other sources of funding or development agencies is that such organizations have access to worldwide capital. Their lower cost of capital can serve an important function in funding projects that support development when emerging economies cannot access capital in other ways that match the cost. The core question is how the limited capital from IFIs can be used with proper buy-in from the sovereign nations they are trying to serve. The typical path is country-focused lending. Country-focused lending has an important role in many of the public good investments discussed above. However, given the highly correlated nature of weather and price risks, country-focused lending has its limits.

The next two sections outline several country-focused investments that can be made by IFIs and then present a core recommendation: a novel integrated approach that draws on many of the recent innovations for multilateral risk financing and risk pooling. The novelty of the approach lies in considering how to combine asset risk management with asset funds that integrate a portfolio approach to manage risks of both price and extreme regional climate anomalies. This may offer new opportunities for the IDB to contribute to, and expand, the range of financial products and services available to the developing LAC economies.

Investments and Technical Assistance at the Country Level

As price and weather shocks are ongoing risks to LAC countries, it is recommended that strategies and mechanisms be devised to manage the immediate consequences of these risks (through both risk coping and ex ante risk management tools), as well as to address the underlying risk exposure through enhanced risk management (Table 3).

During an immediate crisis situation, both ex post coping mechanisms and ex ante financing may be needed to manage the immediate impacts while longer-term strategies for risk reduction and ex ante financing are developed, implemented, and gain participation. However, to the extent possible, risk management mechanisms, particularly safety nets and other forms of disaster assistance, should be carefully structured to minimize market distortions and avoid increasing future risk exposure.

For longer-term risk management, strategies are needed that incorporate risk reduction and ex ante financing mechanisms to facilitate greater economic stability, resiliency, and adaptation. As discussed, market uncertainty limits investment for greater productivity. Long-term strategies must focus on improving productivity and supply (whether by production or import), risk management education and financial tools to help better manage volatility and shocks, and contingent financing to cover additional expenses (of consumption or imports) or to offset losses (yield/revenue losses, export declines).

Table 3. Immediate Crisis Response and Risk Management Development

		Risk management development	
	Crisis response	Short-term	Long-term
Public Sector	Ex post coping mechanisms (safety nets, food aid) Ex ante public debt financing	Enhance extension services to diffuse best management practices Infrastructure maintenance (e.g., of irrigation and flood control) Risk assessment, contingency planning Incentives for mitigation	Productivity-enhancing and risk adaptation incentives (technology, input supply, research and development) Strengthen financial markets and regulation (savings, credit and insurance for extreme events) Infrastructure development
Private markets	Existing ex ante conditional financing (emergency liquidity funds, credit guarantees, insurance)	Ex ante financing (linked to lending, hedging and options, contingent financing for consumption or imports) Insurance instruments (weather index, natural disaster insurance, lending and livelihood linkages)	New instruments: production loans, hedging and options, insurance products, warehouse receipts) Risk adaptation in response to market signals
Source: Authors' elaboration.			

Addressing food security concerns requires a broad examination of the drivers and consequences of risk to prioritize needs and implement appropriate strategies for the near and long term. In volatile price environments, there is a need to strengthen financial markets (savings, credit, and insurance against extreme events) so that farmers can make longer-term productivity-enhancing investments.

The development and poverty trap literature both demonstrate that farmers exhibit risk-averse behavior largely due to the lack of strong financial systems. Microfinance institutions in Bolivia and Peru are good examples of successful development that strengthens productive risk taking. Yet, even these successes are tempered by lack of efficient ways to transfer highly correlated price and extreme weather risks.

Production loans coupled with weather or price hedging mechanisms can reduce the risks of default and loss of collateral by paying the balance of the loan should adverse weather or market conditions emerge. Access to technical assistance or extension services is also critical to provide producers with guidance in adjusting their production strategies. Insurance can also improve the resiliency of producers and others in the value chain to price and weather shocks.

> *Price volatility for major commodities is driven by global market interactions. For this reason, even a domestic policy concern — price stabilization — can also be considered a public good requiring the action and coordination of national and international actors (Timmer, 2011).*

Price risk management at the country level can include structured liquidity funds, supported by clear rules and good governance. IFIs can participate, as the cost of capital for some countries can be so high as to make these types of strategies inefficient. Furthermore, many countries do not have the credit rating that would facilitate these types of interventions.

For example, coffee is an internationally traded product that is mostly exported from LAC countries. If a group of coffee growers wishes to create a liquidity fund that would be used with carefully organized trading strategies to protect prices, this may merit consideration. The country where the coffee growers are located may decide to pursue creation of a fund for this purpose.

However, developing these mechanisms entails upfront costs and technical expertise that often demands external support. The IDB can assist in these types of efforts. In principle, producers would contribute a portion of their profits to the fund and the government may provide

an initial contribution to jump-start the initiative. International technical assistance would be needed to provide capacity to implement strategies to properly use the fund in a sustainable fashion. The government provides initial capital to the fund and commits itself to absorb extreme and less frequent losses through a contingency fund that would make loans in the worst conditions.

Box 4 lists several country-level approaches to managing price and weather risk that have been implemented at the micro, meso, and macro levels. More detailed descriptions of these efforts are included in the appendices.

Box 4. Examples of Country-Level Approaches to Risk Management

- The use of parametric index products in Mongolia (Appendix C) includes elements of a public-private partnership that layers risk and provides contingent credit for extreme risk. The program has also carefully incorporated a social safety net for the most severe losses within the framework of a market-based insurance product.
- The World Bank intervention in Malawi (Appendix D) represents a unique, though possibly difficult to replicate, case of using an exchange market for the government to hedge against high maize import prices. But it also includes a country drought index much in the spirit of the 2006 WFP drought index to provide funding when weather conditions signal an extremely low crop yield.
- The Extreme El Niño Insurance in Peru (Appendix H) demonstrates the possibility of using index insurance for microfinance institutions that function as risk aggregators to explicitly strengthen financial entities focused on the poor.

A Multicountry Approach — Supporting a LAC Regional Asset Management Platform

At a multicountry level, recent innovations in risk management in developing economies show outstanding efforts of coordination among countries within regions (see Box 5). These efforts demonstrate that the technical aspects of risk assessment are fundamental to sound investments that involve improved risk management. Risk assessment is also a first step in supporting market-based instruments that take advantage of the inherent pooling structure of a common geographical region.

In reviewing the innovations that are being tested in the LAC region and around the world, what is striking is that they appear to be disparate and largely piecemeal solutions to address any number of issues that relate to problems of price and natural disaster risk management—they are not integrated solutions.

Box 5. Examples of Multicountry Approaches to Risk Management

Recent innovations in regional risk management are focused on risk pooling approaches:

- The Caribbean Catastrophe Risk Insurance Facility (CCRIF; see Appendix F) functions as a mutual insurance company of 16 participating Caribbean governments for catastrophic tropical hurricane and earthquake risk using index insurance. The CCRIF helps lower the cost of insurance by pooling the group's risk exposure before transferring it to international markets.
- The Africa Risk Capacity Project (ARC; see Appendix G) is a multilateral approach within the African region, using CCRIF as an initial template, to model, pool, and finance extreme weather conditions, beginning with drought risk.

There are important differences between the ARC and the CCRIF. In the case of the risks protected by the CCRIF, the events are less frequent and lend themselves more readily to insurance-like solutions. Severe droughts in Africa are more frequent and may need stronger contingent credit for these layers of risk.

In both cases, the value of regional cooperation, pooling, and rapid response for government liquidity post-disaster are principles that the IDB must adhere to if it is to lead innovation in the LAC region.

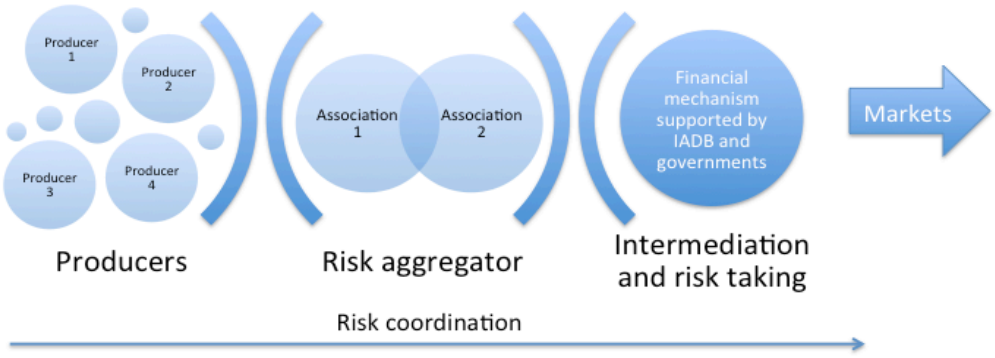
To find more efficient and holistic solutions to the core problems, one is motivated to think big and draw from the many innovations tested up to this point. The importance of risk aggregation and pooling, combined with the comparative advantage of IFIs to work in a regional context, suggests a strategy to develop a fully multicountry approach to risk management. This strategy calls for establishing a **Regional Asset Management Platform** (RAMP) that integrates central stakeholders and develops pricing and measurement tools for extreme weather risk management and price volatility hedging.

The aim is to create an efficient market-based facility that manages regional risk through multiple channels including reserving, access to contingent credit, futures exchange markets, and

recent innovations in risk pooling for natural disasters. To be effective, the RAMP must be large enough to have the required resources and capacity to manage a diverse portfolio of risks, and to operate well beyond existing contingency lines or facilities like the CRIFF or ARC.

The proposed structure, shown conceptually in Figure 7, implies education and coordination among sovereigns, regional governments, and the financial sectors in the LAC region. The RAMP will create an efficient long-term solution, particularly resistant to institutional changes in the framework of risk management in the region.

Figure 7. Regional Asset Management Platform Structure for Linking Producers to Asset Funds Supported by Governments and IFIs



Source: Authors' elaboration.

The rationale for the RAMP takes into account an initial set of "stylized stakeholders" and leads to a recommendation for a market-oriented and more holistic approach to the fundamental issues of price and extreme weather risk management in LAC countries. The RAMP would target its services to six primary stakeholders with the following assumptions:

1. Mid- to large-scale farmers, producing the bulk of primary commodities in the region;
2. Small-scale farmers, representing a smaller proportion of the population in this region than many other areas in the world, such as Africa;
3. Consumers, primarily the poor;
4. Financial institutions, with risk-exposed portfolios;
5. Value chain firms, underinvested in risk exposed agriculture; and

6. Government, with budgets burdened by commodity price support policies that permeate the region and consumer price protection.

Among these stakeholders there are multiple offsetting interests that can be exploited to organize, pool, and transfer risk. Higher than expected prices in any given season benefit mid- and large-scale farmers, financial institutions, value chain firms, and government budgets. Lower than expected prices in any given season benefit consumers, government budgets, and, in many cases, small-scale farmers who suffer proportionately less from lower prices for farm products given the large share of household income dedicated to food consumption.

To sharpen the focus on the search for solutions and the role of the RAMP, one can consider two primary drivers of higher or lower than expected prices within any of the countries in the region. The first driver comes from global influences on world prices. While this driver can be highly important, in many of the countries in the region a direct use of global exchange markets to hedge against these risks has met with limited success, particularly among countries that are not exporting large amounts of these commodities. Regional climate anomalies are a second driver that can dominate price and supply conditions within a country or region. For instance, when world prices are low, a major drought or flooding event in the region can create local food shortages resulting in locally higher prices. By contrast, excellent weather conditions in some of the countries in the region may result in lower prices even if world prices are high. A RAMP can take advantage of these many offsetting interests—potentials for natural swaps—of stakeholders and risks to offer greater efficiencies for protecting the positions of the key stakeholders in the region.

> *Extreme El Niño events and extreme La Niña events are 100 percent negatively correlated. Yet, both have regional effects on crop production that create regional food security problems. Having regional forecast insurance creates more opportunities to find market solutions that work on both the price and yield risk problems in the region.*

The IDB could play a major role in finding an integrated solution such as a RAMP. With sound governance, timely market positions could be taken to protect against global conditions that create price spikes that hurt consumers or that create low prices that hurt mid- to large-scale farmers and slow investments in agriculture. Having experts in global exchange markets work alongside climate experts to create a suite of parametric forecast-based risk transfer solutions

will enhance both the price risk management and the weather risk management solutions in the region.

To create an effective RAMP, IFIs and regional governments would need to seed the capital and support the capacity to manage a large portfolio of offsetting risks using a wide range of market-based solutions that have been reviewed in this report. IFIs in particular are able to provide lower-cost risk capital. The RAMP would achieve the economies of scale and the critical mass to pool a diverse portfolio of risks using capital markets as a means of "crowding in" market solutions, and it must be carefully designed with that objective in mind. It must enhance markets.

The financial mechanism would be similar to special purposes vehicles developed for structured financial transactions, which protect capital resources for stated objectives. It should feature a governance board composed of representatives of participant countries, industry members, and experts on risk management—governance structures not unlike the CRIFF or ARC.

A sketch of a RAMP must have at least three components:

1. Strong asset base to access financial markets;
2. Origination professionals with strong relationships in the global capital markets and with stakeholders in LAC countries; and
3. Highly technical professional staff that understand global financial exchange markets and climate relationships to regional outcomes.

The asset management company would be a legal private company with equity provided by a consortium of countries and IFIs led by the IDB. Working capital of the RAMP could be structured following a multilayered scheme. The first layer corresponds to a retention layer which works as a solid base for several other layers that focus on risk transfer, such as contingent capital, derivative contracts, weather derivatives or weather index insurance, and insurance forecast products. The structure of revenues would be comprised of the following main sources:

1. Income payments made by hedging contracts;
2. Premiums paid by producers, other risk aggregators, and member countries; and
3. Sufficient support in the initial capital endowment (donors).

The basic ingredients are emerging for the IDB and perhaps other donors to assist in creating a highly effective RAMP—a robust financial platform that would provide the LAC countries with access to financial engineering and management not only of prices but also of those regional conditions that contribute to situations of food insecurity. Indeed the benefits could be enormous for the region. However, experience with the CRIFF and ARC demonstrates that there are many political challenges to overcome to make such an asset management and trader-based institution effective in the region. The IDB is uniquely positioned to play a formative role in launching a RAMP given its experience and expertise in the region. The next step would involve developing a careful plan of the sequence of activities and stakeholders needed to create such an institution.

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Appendix A Financial Instruments for Price Risk Management

If a developing country has a significant export and import structure, it can be exposed to commodity price risk. This paper describes diverse instruments such as forwards, futures, options, and swaps, among others, that can be used to manage price risk and reduce volatility due to movements in commodities prices.

Based on international experience in developed markets, hedging instruments require an appropriate legal and regulatory framework, limited government intervention that might crowd out these types of transactions in the private sector, and appropriate credit quality rating to reduce operative and counterparty risks. The use of commodity derivative instruments in developing countries to manage commodity price risk is an increasingly common practice. In countries in Asia and Latin America, commodity futures and options have been used for some time; and recently, the use of commodity derivates has increased in Africa and in many other transition economies.

However, it is important to emphasize that the liquidity of these markets is scarce and only large-scale producers can access them. While there are many lessons to be learned from developed economies with efficient markets, in most developing economies there is still a great deal to be done. The technology (financial instruments) is already there; nevertheless, using these instruments in developing economies implies a regulatory framework, appropriate deepening of the financial system, and favorable macro and micro economic environments, among other factors that would allow the orderly development and use of hedging instruments.

The next section describes the main financial instruments for price risk management, particularly, to manage price risk of agricultural products.

Derivatives

Derivatives are financial contracts used in capital markets that "derive" their value from an underlying asset, rate, or index. Derivatives may be exchange-traded or traded privately "over the counter" (OTC). The value of a derivative can be based on a weather index—such as temperature, rainfall, snowfall, wind speed, or sea surface temperature—, or a non-weather index—such as area yields or commodity prices (Carpenter and Skees, 2005). Derivatives have been used to transfer both price (e.g., futures and options contracts) and weather risks. The function of a derivative is very similar to an insurance contract, involving the payment of a sum

of money from one party to another, the transfer of risk, and a defined contract term. There are important legal and regulatory distinctions that offer different advantages and limitations. The advantage of derivatives is that they offer a large degree of flexibility in that the terms of OTC contracts may be customized to needs of the parties involved. However, derivatives often fall outside the realm of regulation and therefore lack many of the protections offered by insurance regulations.

Subject to the laws of a particular jurisdiction, a common legal requirement of insurance contracts is that the purchasers have an insurable interest and that the payouts are compensation for incurred losses (Carpenter and Skees, 2005). Derivative contracts have no such requirement and consequently may be purchased and even traded quite freely. Because of the lack of regulatory oversight for OTC contracts, derivatives are not recommended for farm-level applications where individual purchasers are unlikely to have the requisite financial knowledge and expertise.

Under some jurisdictions an index insurance product will not be considered a legal form of insurance based on the legal definitions and their interpretation by the insurance supervisor. In such cases, the same product may be considered a derivative. However, this has significant implications for how the product is used and regulated. A thorough legal review is required to determine the legal classification and acceptance of any proposed risk transfer product within a particular jurisdiction.

Forward Contracts

The owner of a forward contract agrees to the purchase or sale of an asset at a future date at a specific price; it differs from a spot contract in which the asset will be bought or sold in the moment. The purchase/sale date is called maturity and the agreed price is known as the delivery price. Forward contracts are traded on the OTC market, not in the exchange market, which is the market for standardized contracts. A forward contract can be one of two types: a long position or a short position. The party that assumes the long position will buy the underlying asset at maturity of the contract for the delivery price. The party that has a short position will sell the asset on the same date and at the same delivery price.

An instrument such as a forward contract can be used to hedge price risk. For example, suppose that on January 15, 2012, an importer knows that in four months (May 15, 2012) he will

need to buy a certain amount of rice and he wants to hedge against a price increase. The importer can agree to buy a ton of rice four months forward at a price of 300 dollars. If the importer agrees that on May 15, 2012 he will buy a ton of rice from the seller, then the importer has a long forward contract and the seller has a short forward contract. Both sides have made a binding commitment.

Effective use of Forward Contracts

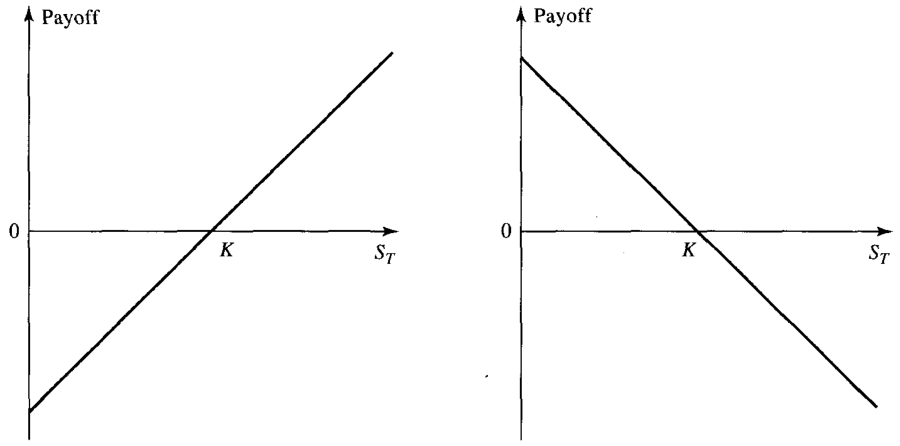
In the example above, what can happen? The spot price can go up or go down or stay the same. The forward contract obligates the importer to buy a ton of rice for $300. If the spot price rose to, say, $350 at the end of four months, the forward contract would be worth $50 (=$350 - $300) to the importer. It will allow him to buy a ton of rice at $300 and not at $350. In the other possible scenario, if the spot price fell to $250 at the end of the four months, the forward contract will represent a loss to the importer of $50 because per one ton of rice that can be bought at $250, the importer will be required to pay $50 more than the market price for the rice.

For the long position of any forward contract, the payoff is the difference between the spot price of the asset at maturity of the contract and the delivery price. For the short position, the payoff is the opposite of the long position, that is, the difference between the delivery price and the spot price of the asset at maturity of the contract.

The holder of the long position is obligated to buy an asset worth the spot price for the delivery price agreed in the contract, while the holder of the short position is obligated to sell an asset worth the spot price for the delivery price agreed in the contract.

Figure A1 shows the payoffs of both positions; K denotes the agreed delivery price and S_T the spot price of the asset at maturity. The value of a forward contract depends on the spot price relative to the delivery price. In both cases, when the delivery price and spot price at maturity coincide, the payoff from the hedge is zero.

Figure A1. Payoffs of Long and Short Positions of a Forward Contract



Long position ***Short position***

Source: Author's elaboration.

Futures Contracts

Futures contracts are very similar to forward contracts; they are also an agreement to buy or sell the asset at a future date for a specific price, but as distinct from forward contracts, futures contracts are traded on an exchange, where the features of the contract are established, such as the amount of the asset to be delivered for one contract and how the futures price is to be quoted. Another difference from the forwards is that they do not specify an exact date for delivery, but a delivery month and the exchange specifies a month period for the delivery.

Underlying assets of futures contracts are a wide range of commodities and financial assets. In the case of commodities as underlying assets, delivery time is generally a month. Within the delivery period, the one that has the short position has the right to choose the time when it will make the delivery. The exchange also specifies the product quality and the delivery location.

Consider, for example, a wheat futures contract traded on the Chicago Board of Trade. The size of the contract is 3,000 bushels. Contracts for five delivery months (March, May, July, September, and December) are available for up to 18 months into the future. The exchange specifies the grades of wheat that can be delivered and the places where the delivery can be made. Futures prices are regularly reported in the financial press. Suppose that on July 10, the

September futures price of wheat is quoted as 7.69 dollars a bushel. This is the price, exclusive of commissions, at which traders can agree to buy or sell wheat for the September delivery.

Options

Options are traded on the exchange market as well as in the OTC market. There are two types of options: call and put. A call option gives the holder the right to buy the underlying asset by a certain date for a certain price. A put option gives the holder the right to sell the underlying asset by a certain date for a certain price. The price established in the contract, whether call or put, is known as exercise price or strike price, and the date is known as the expiration date or maturity. In turn, there are two types of options within the calls and puts, European and American options, depending on the time when they can be exercised. European options can be exercised only on the expiration date itself and American options can be exercised from the agreement date to the expiration date or maturity.

Unlike the two previous instruments, forwards and futures, in the options the holder is not obligated and has the right to exercise the option or not. Also, unlike forwards and futures that do not have a commission, purchasing an option comes at a premium.

Option Positions

There are two sides to every option contract, the long position and the short position, the party who buys the option and the party who sells or writes the option, respectively. The writer of an option will have an initial income (price of the option) in return for potential liabilities later. The writer's profit is the loss of the purchaser of the option, and the writer's loss is the profit of the purchaser of the option.

There are four types of option positions:

1. Long position in a call option;
2. Long position in a put option;
3. Short position in a call option; and
4. Short position in a put option.

Call Options

To characterize a European call option in terms of the payoff to the investor at maturity, consider a call option bought by an investor with a strike price of $50 to purchase an amount of corn in six months. Suppose that the price of the option is $5. The initial investment is $5 and the investor can only exercise the option on the expiration date. If the price of corn on this date is below $50, the investor will not to exercise the option because there is no point in buying for $50 an asset that is worth less in the market. Thus, the investor loses $5, the whole price of the option.

Now, suppose that the corn price goes up to $70. The investor will exercise the option and he will be able to buy the corn for $50. If the amount of corn is sold immediately, the investor makes a gain of $20 (=$70- $50), ignoring transaction costs. The net profit is $15 when the initial investment of $5 is subtracted because of the price of the option (the time value of money is ignored in the profit).

There are some circumstances in which an investor exercises an option and still incurs a loss overall. Suppose that in the example the price of the corn is $53 at the expiration of the option. The investor would exercise the option for a gain of $3 ($53 - $50) and realize a loss overall of $2 when the initial cost of the option is taken into account. If the price at maturity is above the strike price, in general, call options should always be exercised.

In the example, the investor holds the long position, the writer of the option the short position, who would have an initial gain of $5 and a loss whenever the price of the corn is above $50. If the price rose to $70, he would lose $20 (profit of the investor) and realize a loss overall of $15 ($20 - $5) when the initial cost of the option is taken into account.

Put Options

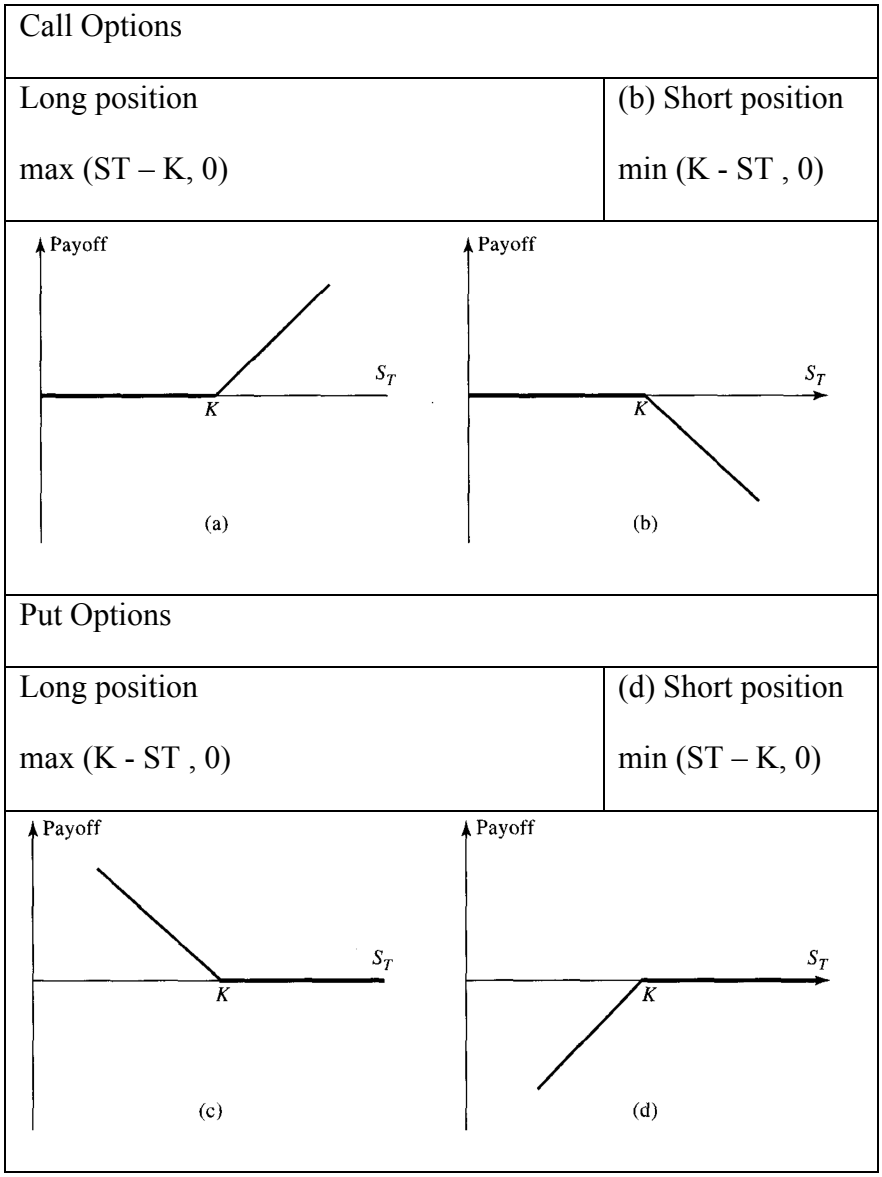
Put options are usually purchased as an insurance against price declines, whereas call options are usually purchased as insurance against price increases.

Consider an investor who buys a European put option to sell soybeans with a strike price of $100. Suppose that the expiration date of the option is in five months, and the price of the option to sell is $6. The initial investment is $6. If the option is European, it will be exercised only if the price of soybeans is below $100 at the expiration date. Suppose that the soybeans price is $75 on this date. The investor can buy the soybeans for $75 at the market and then exercise the put option selling the same soybeans for $100 to realize a gain of $25 (again

transactions costs are ignored). When the $6 initial cost of the option is taken into account, the investor's net profit is $19. If the final price of the soybeans is above $100, the investor will clearly choose not to exercise the put option and thus, he loses his investment of $6.

If K is the strike price and S_T is the final price of the underlying asset, the payoffs from all four positions are the ones shown in the Figure A2.

Figure A2. Payoffs of Short and Long Positions of Call and Put Options



Source: Authors' elaboration.

Swaps

A swap is an agreement to exchange cash flow on or before a specified future date based on the underlying value of commodities exchange, currencies exchange rates, stocks or other assets. The dates when the cash flows are to be paid and the way in which they are to be calculated are also defined in the swap.

Commodity Swaps

A commodity swap is a kind of swap in which exchanged cash flows are dependent on the price of an underlying commodity. Commodity swaps involve two participants, called counterparties. On predetermined settlement dates, or dates on which the commodity price is recorded, the floating, market or spot price of the underlying commodity, such as oil, sugar, or grains, among others, is exchanged for a fixed price. No commodities are exchanged during the trade.

The type of commodity swap entered will depend upon the investment strategy, specifically whether a party is an end-user, such as a producer or consumer of the commodity, or a speculator attempting to make money from price fluctuations.

For example, a bakery chain may be an end-user of wheat; the bakery chain's executive management may want to enter into a swap in order to avoid volatility in the price of wheat bushels. By contrast, a manager of a fund based on commodities may see an advantage in the difference between wheat prices and current money market rates. In addition, both of the above-described situations may offer the possibility to hedge, or limit, future risk. The bakery chain sees the opportunity to lock in a wheat price at an affordable rate. The fund manager may view a commodity swap as a hedge against future inflation.

Typically in a commodity swap in which a party is an end-user of the commodity, the user would secure a maximum price and agree to pay a financial institution the fixed price. In return, the user would get payments based on the market price for the commodity involved. On the other side, a producer wishes to fix his income and would agree to pay the market price, in return for receiving fixed payments for the commodity.

Also a company that uses commodities as input may find its profits becoming very volatile if the commodity prices become volatile. This is particularly so when the output prices may not change as frequently as the commodity prices change. In such cases, the company

would enter into a swap whereby it receives payment linked to commodity prices and pays a fixed rate in exchange.

Commodity swaps have additional costs beyond the potential price paid on the settlement date. For instance, swaps may include brokerage fees as well as risk-analysis and internal administrative costs. In addition, legal ramifications of commodity swaps also affect the type of contract. Creditworthiness of counterparties, security (collateral) available, and termination rights of the parties all must be considered.

Commodity Stabilization Funds

A commodity stabilization fund (CSF) is a self-insure method to reduce exposure to commodity price risk. When access to hedging instruments linked to commodities is limited for developing countries, self-insurance is a reliable alternative.

In most of the cases, stabilization schemes of domestic commodities prices create a buffer stock. When prices fall down below a certain threshold, producers are compensated and, on the contrary, when prices increase, reserves accrue. The assets are accumulated during periods of high export earnings and when the prices of commodities are high. The opposite occurs when the prices of commodities are low. Instead of accumulating them, assets are drawn down.

A CSF aims at reducing the budgetary, macroeconomic, and fiscal impact of commodity cycles. If this is achieved it will potentially reduce the need for the government to cut public spending when the revenues of commodities become lower.

For example, Colombia created a stabilization fund called the National Coffee Fund, which had three objectives: to accumulate inventories under the country's commitments under International Coffee Organization agreements, helping to reduce the volatility in prices; to act as a buyer of last resort for coffee growers, giving them a minimum and transparent price for their coffee; and to help finance public works in coffee-growing areas, as well as investment in research and other coffee-related areas.

The effectiveness of a CSF depends on the rules for deposits and withdrawals in the different possible states of nature. Another requirement for a stabilization fund to be feasible is that the prices of the commodities tend to the median and at some moment go back to said value. If it happens slowly, over years instead of months, the CSF will have to be very large to be effective; otherwise, another option is to have access to foreign borrowing.

Warehouse Receipts

A warehouse receipt is a written document or signed receipt stating that commodities have been received and are safely stored in a warehouse, vault, or depository. The receipt guarantees the existence and availability of a commodity of a particular quantity or weight, type, and quality in a named storage facility.

There are two types of warehouse receipts: negotiable and non-negotiable. Negotiable receipts allow for the transfer of ownership of the stored commodity without physically delivering it. In most cases, receipts are negotiable. Negotiable warehouse receipts are eligible as collateral for loans when borrowing from banks or from the warehouse itself. If the loan is from a financial institution, the quality and quantity of the collateral is ensured by the warehouse, but still faces fluctuations in commodities market value. As a result, the financial institution will only lend a percentage of the value of stored commodities. However, using warehouse receipts as collateral increases credit quality, thereby reducing finance charges for the borrower. Another customary practice with negotiable warehouse receipts is not to deliver the actual commodity, but to use it to negotiate expiring futures contracts. Non-negotiable warehouse receipts, unlike negotiable receipts, must be endorsed to transfer the ownership of the commodities. In order to work well, warehouse receipts require that the receipt have a recognized basis in law so that the ownership established by the receipt cannot be readily challenged.

Commodity Notes

Commodity notes are similar to commodity swaps. Both provide price protection and no commodities are exchanged during the trade. The one who buys a commodity note in return is paid an interest that depends on the price of the underlying commodity and on the type of note: bear note or bull note. A commodity note usually differs from a swap in the maturity or term, which ranges from six months to a year. Also, a commodity note is not as credit intensive as a swap and it guarantees the principal established, although the movements on market prices are not favorable. For example, a government in a coffee-producing country may buy a commodity bear note, because it wants to protect a grower of coffee in the event that coffee prices fall. If the prices rise, the government will receive an interest payment, usually a small one; on the other hand, if the prices fall, the interest paid will be larger. For a bull note, when the prices rise, the buyer of the note receives a larger interest payment, and when the prices fall, no capital is lost. In

both kinds of commodity notes, there is the possible loss of higher interest rates when the price movements are not those expected by the buyer of the note.

Commodity-Linked Loans

A commodity-linked loan is a loan in which the interest rates, interest payments, or repayments of principal depend on the price or on an index of prices of an underlying commodity. In most cases, the interest and the principal can be equal payments that correspond to the price paid for buying a certain amount of the commodity. Sometimes the only payments that depend on the commodity are the interest payments. This instrument can be replicated when combining a commodity swap with a typical bank loan.

Specific types of commodity-linked loans are the Commodity Inventory Purchase Agreement (CIPA)-linked notes, in which the transaction involves warehouse receipts as collateral for the loan. In the note bought, the principal and a part of the interest payments, usually a small part, are guaranteed. The buyer of the CIPA note will hedge against commodity price risk without having to pay any premium. In order to work, the country willing to use CIPA-linked notes must have proper warehouse verification procedures in place.

Commodity Bonds

There are two types of commodity bonds: forward-type and option-type. In a forward commodity bond the payments of principal and coupons depend on the price or on an index of prices of an underlying commodity. When only the payment of the principal is related to the price of the commodity, the bond is the result of combining a forward contract and a regular bond, but when both payments are linked to the price of the underlying commodity, this type of bond can be replicated by combining a commodity swap and a conventional bond. If producers want to hedge against risk, they could issue a forward commodity bond.

In an option commodity bond, an option is combined with a regular bond, and the holder of the bond has the right to buy or sell, depending if the option is a call or a put, a specified quantity of the underlying commodity for a certain strike price. It is customary to use option commodity bonds to reduce financing costs by attaching long-term options to a commodity as the underlying asset. Table A1 summarizes and compares the different instruments described above.

Table A1. Summary and Comparison of Financial Instruments

Name		Definition		Market type	Position		Holder is obligated	Payoffs	
Forward		Agreement to buy or sell an asset at a certain future time for a specific price. The price agreed in the contract is known as the delivery price.		OTC	Long	Buy	Yes	Spot price minus delivery price	
					Short	Sell	Yes	Delivery price minus spot price	
Futures		Agreement to buy or sell the asset at a future date for a specific price. The amount of the asset to be delivered is established for one contract, but it is not specified an exact date. In the case of commodities as underlying assets, delivering time is generally one month. The exchange also specifies the product quality and the delivery location.		Exchange	Long	Buy	Yes	Spot price minus delivery price	
					Short	Sell	Yes	Delivery price minus spot price	
Options								**European Options**	
								If the spot price is below the strike price	If the spot price is above the strike price
								Call option *not* exercised	**Call option exercised**
	Call	A call option gives the holder the right to **buy** the underlying asset by a certain date for a certain price.	The price established in the contract is known as exercise price or *strike price*, and the date is known as the expiration date or *maturity*. There are two types of options within the calls and puts: **European** options, which can be exercised only on the expiration date itself and **American** options, which can be exercised from the agreement date to the expiration date or maturity.	Both	Long	Buy the right to buy	No	Zero	Spot price minus strike price
					Short	Sell the right to be bought from	Only if the long position exercises the option	Zero	Strike price minus spot price.
	Put	A put option gives the holder the right to **sell** the underlying asset by a certain date for a certain price.		Both				**Put option exercised**	**Put option *not* exercised**
					Long	Buy the right to sell	No	Strike price minus spot price	Zero
					Short	Sell the right to be sold to	Only if the long position exercises the option	Spot price minus strike price	Zero

Name	Definition		Holder	Holder's objective	Benefits	
Swap	Agreement to exchange cash flows on or before a specified future date based on the underlying value of commodities exchange, currencies exchange rates, stocks, or other assets.	**Commodity swap**				
		The exchanged cash flows are dependent on the price of an underlying commodity. On predetermined settlement dates, or dates on which the commodity price is recorded, the spot price of the underlying commodity is exchanged for a fixed price.	User of the commodity	Would secure a maximum price and agrees to pay the fixed price.	In return, the user would get payments based on the market price for the commodity involved.	
			Producer of the commodity	Fix income and would agree to pay the market price.	In return, the producer would receive fixed payments for the commodity.	
Commodity Stabilization Fund	Self-insure method to reduce exposure to commodity price risk. Stabilization schemes of domestic commodities prices create a buffer stock.		Government or commodity producers guild	Commodity price risk management.	**When prices go up**	**When prices go down**
					The assets are accumulated. Reserves accrue.	The assets are drawn down. Producers are compensated.
Commodity Notes	Commodity notes are similar to commodity swaps, as they both provide price protection and there are no commodities exchanged during the trade. The one who buys a commodity note in return is paid an interest that depends on the price of the underlying commodity	Bear note	Government or commodity producers guild	Protect producers of the commodity in case the prices go down.	Buyer receives an interest payment, usually a small one.	Buyer receives an interest payment; the interest paid will be larger than when prices rise.
		Bull note	Financial institution	Hedge against loses in the portfolio.	Buyer receives a larger interest payment.	No capital is lost.
Warehouse Receipts	Written document or signed receipt stating the reception of commodities that are safely stored in a warehouse, vault, or depository. In the receipt the existence and availability of a commodity of a particular quantity or weight, type, and quality in a named storage facility is guaranteed.	**Negotiable:** allow transferring the property of the storage commodity without physically delivering it. These receipts are eligible as collateral for loans when borrowing from banks or from the warehouse itself and used to negotiate expiring futures contracts.	Producer of the commodity	Be able to transfer the property of the commodity without physical delivery. Having collateral for loans.	If the warehouse receipt is used as collateral it increases credit quality and thereby leads to lower finance charges for the borrower.	
		Non-negotiable: must be endorsed to transfer the ownership of the commodities.		Minimize commodity physical risks.	The existence and availability of the stored commodity.	

Name		Definition		Holder	Holder's objective	Benefits
Commodity-Linked Loan		Loan in which the interest rates, interest payments or repayments of principal depend on the price or on an index of prices of an underlying commodity.	**Commodity Inventory Purchase Agreement (CIPA) linked notes** The transaction involves warehouse receipts as collateral for the loan.		Hedge against commodity price risk.	In the note bought, the principal and a part (usually small) of the interest payments are guaranteed.
Commodity Bonds	Forward	In a forward commodity bond, the payments of principal and coupons depend on the price or on an index of prices of an underlying commodity. It is the result of combining a forward contract and a regular bond.		Producer of the commodity	Issue a forward commodity bond to hedge against risk.	
	Option	In an option commodity bond, an option is combined with a regular bond. The holder of the bond has the right to buy or sell, depending if the option is a call or a put, a specified quantity of the underlying commodity for a certain strike price.			Reduce financing cost.	

Source: Authors' elaboration.

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Appendix B. Mexico —Agricultural Price Risk Hedging

Type of instrument: Futures.

Risk(s) covered: Upside and downside price risks for corn, wheat, sorghum, soybean, safflower, cotton, coffee, orange juice, beef, pork, and recently added coverage for cocoa and for agricultural and finishing inputs such as fertilizers, natural gas derivatives, and diesel.

Beneficiaries: Agricultural producers, small businesses, and processors.

Structure: Participants access the futures market via an intermediary institution within the Ministry of Agriculture (ASERCA). Options for corn, wheat, soybeans, pigs, and cattle are placed on the Chicago Mercantile Exchange (CME) and Chicago Board of Trade (CBOT); cotton, coffee, and orange juice are placed on the NYSE (New York Board of Trade, NYBOT). For crops that are not publicly traded (i.e., sorghum and safflower), coverage is based on similar exchange-traded commodities (i.e., maize and soybeans respectively) that experience similar movement in prices. ASERCA provides a 50–100 percent subsidy on the price of the options.

Status: The program is offered nationwide and has grown significantly from its inception with the continued increase and volatility in maize and other commodity prices. The ASERCA 2011 budget for subsidizing the price-hedging scheme is $700 million (Agribusiness Report), compared to $22.5 million for 2002.

In the wake of the North American Free Trade Agreement (NAFTA), Mexico moved to open its agricultural markets, thus exposing growers and consumers to unprecedented levels of price uncertainty. To mitigate the impact of commodity price volatility, the government launched a subsidized commodity-hedging scheme, initially to help cotton growers lock in the selling price of their crop. Since then, the program has expanded to include a total of eleven products—corn, wheat, sorghum, soybean, safflower, cotton, coffee, orange juice, beef, pork, cocoa, as well as agricultural and finishing inputs, including fertilizers, natural gas derivatives, and diesel. The scheme is administered through a decentralized agency reporting to the Ministry of Agriculture — Support and Services for Agricultural Lending (ASERCA), which acts as an intermediary, enabling producers and end users to access futures options traded on the Chicago, Kansas City, and New York Boards of Trade, and the Chicago Mercantile Exchange. The hedging program

aims to stimulate production, encourage consumption of domestic supplies, and stabilize important commodity markets by providing price certainty.

The hedging program functions as price insurance. The participant is in effect buying insurance against sharp drops in commodity prices. The minimum price is fixed using the relevant futures exchange in U.S. dollars. Growers may acquire commodity futures, futures options, and synthetic options contracts. Both call and put options are eligible. Any gains realized from exercising the option go first toward reimbursing the farmer's initial share of the option premium. ASERCA then recoups up to the full amount of the initial subsidy; any remaining profits are remitted to the farmer. The corn-hedging scheme appears to have helped obviate sharp price inflation of the national staple. In 2011, after white corn prices spiked in the wake of weather-induced crop losses, tortilla prices increased only modestly relative to the national and global price of white corn, thanks to the hedging scheme and domestic support programs. According to government officials, 60 to 70 percent of Mexico's tortilla makers purchased grain contracts before the price surge. Even small tortilla shops organized themselves into a union to lock down the price of corn for almost a year. ASERCA subsidized 100 percent of the cost of the premium.

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Appendix C. Mongolia — Index-based Livestock Insurance (IBLI)[15]

Type of instrument: Index insurance.

Risk(s) covered: Severe livestock mortality as indicated by county-level livestock mortality estimates.

Target market: Herder households across Mongolia.

Structure: IBLI is a public-private partnership that utilizes county-level estimates of livestock mortality to insure herders against correlated livestock losses. A commercial insurance product is priced to cover losses from 6–30 percent mortality. The government of Mongolia finances losses above 30 percent as an integrated disaster assistance component.

Status: Began as a pilot program in 2006 in three provinces. In 2010, IBLI was sold to nearly 7,000 herders in nine provinces. IBLI is to be implemented as a national program in all 21 provinces in 2012. The program has obtained reinsurance to finance a layer of catastrophic loss.

Catastrophic livestock losses resulting from severe winter conditions (*dzud*) threaten herders' subsistence and livelihoods, reduce supply, and give rise to the price of meat for urban and rural consumers. Extreme livestock losses in 1999 and 2002 were particularly costly and prompted the government of Mongolia and the World Bank to revisit their past efforts at insuring the country's herds. (Losses in 2010 were even more severe, with approximately 22 percent of adult animals dying.) Herding represents the bedrock of rural livelihoods in Mongolia and a major segment of the national economy. Consequently, extreme *dzud* represents a substantial liability to the country as a whole. However, given the geographic expanse of Mongolia, it is difficult to offer traditional individual livestock insurance to herders, let alone solve the loss assessment problem of verifying individual losses during the severe winter months when travel is nearly impossible. Since the livestock losses are strongly correlated within the same area, it is possible to transfer risk and provide some protection using Index-based Livestock Insurance (IBLI). Mahul and Skees (2006) describe the motivation for the design and its details. IBLI uses estimates of

[15] Much of this section is excerpted from Skees and Cavanaugh, 2012.

mortality at the country level. The design is motivated by considerations of the market and the decision making processes. There are three levels of risk that are segmented or layered:

1. For losses in the area below 6 percent, herders must self-insure via their own risk-mitigation strategies or savings and credit when possible. Having IBLI has proven to give herders more access to loans and at lower interest rates;
2. For losses in the area between 6 and 30 percent, herders can chose to purchase IBLI from commercial insurers who are now obtaining reinsurance from both the global market and the government of Mongolia using the herder premiums. These events generally occur once in five years. This layer of risk held by the private sector insurance companies is referred to as the Livestock Risk Insurance (LRI); and
3. For losses above 30 percent, the government of Mongolia pays herders who purchase IBLI based on the sum insured that they purchase. This social side represents catastrophic losses are that generally occur about once in 25 years and represent a layer of risk where herders would be unlikely to pay for the risk as it would need to be charged by commercial insurers. This layer of risk is referred to as the Government Catastrophic Cover (GCC).

This arrangement in essence divides the risk of *dzud* into three separate risks and assigns management responsibility for each risk to a distinct party. Of course households retain outright some of the moderate, frequent risk. This is true in most insurance arrangements, with, for example, deductibles on car insurance. The Mongolian IBLI program is distinct because of the arrangements for second and third layers of risk—the LRI and the GCC. In the developed world, schemes covering this type of correlated risk generally lump together risks corresponding to these second and third layers of risk, that is, those risks likely to occur with a frequency of a few years or greater (meaning less frequent). But for all the psychological and political reasons discussed above, few private insurance markets have emerged to cover this combined catastrophic risk, even in countries with well-developed insurance markets. In response to this market failure, governments have generally provided subsidies for insurance premiums, often passed through to private insurers, covering all catastrophic losses. This arrangement may include some ex post disaster assistance in the case of an event. But in any case, all catastrophic losses are treated as a single unit of risk.

The problems with the typical arrangement of government-subsidized insurance that lumps all of the risks together are myriad. Insurance companies do not have the proper incentives to manage their own risk. The upper layers of risk require extra loading that may make the subsidies more expensive than necessary. In addition, the lack of clarity about the social and market responsibilities leads to more opportunity for rent seeking. Developing countries can ill afford these approaches, as there is an open-ended call on the treasury for funding based on the level of insurance purchased.

In modeling the cost of the Mongolia program, the extreme risk (above 30 percent) would be very expensive if it were priced commercially at an individual country level. However, by making this subsidy explicit and reserving these funds, the government of Mongolia can pool these extreme risks across the country and provide a level of support at a lower amount than they could if they were providing subsidy for a public-private insurance product that paid for loss from 6 to 100 percent without creating perverse incentives.

To be sure, these problems remain present to some extent in the IBLI program. It is still true that losses from the GCC may represent a serious financial burden for the government of Mongolia. Still, the government can purchase reinsurance on the pooled countrywide risk of the GCC for less funding than if they provided a percent subsidy. Fundamentally, if the government later decides that it cannot afford to provide this form of support, which would not be uncommon in developing countries, that decision should not disrupt the commercial layer of risk (the LRI) provided by local insurance companies with international reinsurance arrangements. Thus, this special design allows the government to constructively subsidize the emergence of risk management markets without undermining the long-term sustainability of these markets. The approach "crowds in" the market, using a clearly defined social approach that addresses the various psychological quirks in regard to consumer perceptions of low-frequency, high-impact risks. In this arrangement, a government subsidy is targeted specifically at those risks that provoke the greatest psychological and economic hurdles.

The net result of all this seemingly complicated financial engineering is surprisingly simple: a robust series of insurance programs, some public and some private, that cover the full range of risks faced by herders at the local level, traditionally believed to be uninsurable. Generally, the lower levels of risk, those thought to show less deviation between consumer behavior and economic theory, are left to the herders themselves, with the support of insurance

companies. Higher levels of risk, at which consumer behavior is assumed to be heavily influenced by the collection of psychological and political complications that an economist might call "market failure," are relegated to the government of Mongolia. The government of Mongolia is now reviewing a fully social program for the extreme losses that would be available to herders who do not purchase the LRI. In 2012, the IBLI will be expanded to a national program.

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Appendix D. Malawi — Rainfall Index for Drought Relief and Food Security

Type of instrument: Index-based weather derivative.

Risk(s) covered: Insufficient rainfall during the maize production period.

Beneficiaries: The government of Malawi (GOM) purchased the derivative contract with the premium financed by the UK Department for International Development (DFID). The insurance pre-finances GOM emergency drought response. Payouts could be used to purchase a portion of maize imports required to offset domestic production shortfalls.

Structure: The underlying index is the Malawi Maize Index (MMI), which is based on October to April rainfall measured at 23 weather stations across Malawi. Payouts are triggered when the realized value of the MMI is less than a specified trigger value (e.g., 90 percent of the historical average MMI).

Status: The GOM purchased the insurance for the 2008–2009, 2009–2010, and 2010–2011 crop years. For the 2009–2010 crop year, the GOM agreed to use insurance payouts to purchase white maize call options on the South African Futures Exchange (SAFEX) thereby protecting their fiscal exposure for purchasing white maize from neighboring countries.

Almost 40 percent of Malawi's GDP is dependent on agriculture. The primary food crop is white maize, which accounts for more than 50 percent of total calorie consumption. Most maize production in Malawi is rainfed, so food security and economic growth are compromised when insufficient rainfall leads to maize production shortfalls. In response to a major drought in 2005, the GOM spent US$200 million for food aid. Such shocks to GOM finances (similar rainfall deficits and maize production shortfalls occurred in 2000 and 2004) have increased government borrowing and threatened macroeconomic stability. This economic uncertainty further limits Malawi's ability to attract investment capital.

In principle, a contingency fund could be established to address the fiscal consequences of insufficient rainfall and maize production shortfalls. Such a contingency fund would serve as a form of "self-insurance." However, given the extensive development needs in Malawi, the opportunity cost of a government contingency fund would be quite high. Furthermore it would be politically difficult to protect the contingency fund in the face of immediate constituent needs.

The government's purchase of the rainfall derivative serves to pre-finance emergency response when insufficient rainfall has generated widespread food insecurity.

Exactly how any payout would be used continues to evolve along with broader GOM drought response planning. For the 2009–2010 crop year, the GOM pledged to use payouts to purchase white maize call options on the South Africa futures Exchange (SAFEX), thereby capping the effective price of any required maize imports. Since 2005, the GOM has selectively purchased OTC call options on SAFEX to hedge the price of maize imports.

The World Bank has functioned as a market intermediary in these transactions. The World Bank sells the insurance to the GOM and then simultaneously transfers the risk to reinsurance companies and/or investment banks. Having the World Bank function as an intermediary reduces the counterparty risk for both the GOM and the market entities that accept the risk.

Contract Design

The underlying index for the rainfall contract is the Malawi Maize Index (MMI). The MMI is based on October to April rainfall measured at 23 weather stations across the country. In creating the MMI, different weights were assigned to different time periods from October to April based on water requirements during different maize growth phases.

The parameters of the contract are renegotiated each year. For example, in regard to the contract in place during the 2009–2010 crop year, payouts would have been triggered if the MMI were more than 10 percent below its historical average. The contract also specifies a "tick size" value. The tick size is the amount of payout for each percentage point that the MMI is below the threshold. Finally, the contract specifies the maximum payout for the 2009–2010 contract, which was USD 4.385 million.

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Appendix E. Haiti Catastrophe Microinsurance

Type of instrument: Index insurance.
Risk(s) covered: Damaging wind, excessive rainfall, and earthquakes.
Beneficiaries: Lending clients of Fonkoze Microfinance Institution in Haiti, representing female entrepreneurs.
Structure: Coverage is mandatory for all borrowers; premium is a 3 percent fee on the value of the loan; an additional 2 percent is subsidized. The payouts provide for loan payoff and a lump sum (U$125) for rebuilding/recovery. A peer-based loss adjustment process is used to allocate the distribution of payouts among members of solidarity groups according to need.
Status: The program was introduced in January 2011, and has since provided three payouts as a result of extreme rainfall, totaling over US$1 million to more than 4,000 clients.

In January 2011, the Haitian microfinance institution, Fonkoze, in partnership with Mercy Corp, Swiss Re, and DFID, among others, launched a catastrophic microinsurance program to benefit the 55,000 female entrepreneurs who participate in their lending and livelihoods support programs.

The insurance provides coverage against damaging winds, excess rainfall, and earthquakes by relying on index-based triggers. To minimize basis risk among individual clients, the insurance program takes advantage of the existing borrower groups (solidarity groups) as a mechanism for assessing and allocating payouts based on individual losses.

Six to ten solidarity groups form a center headed by an elected representative. The elected leaders are trained to conduct the loss assessment by visiting group members in the aftermath of a disaster to determine who has suffered losses. The distribution of the insurance payout is then decided by consensus at a meeting of the center's members.

At the start of the insurance program, program sponsors launched a re-insurance facility, the Microinsurance Catastrophe Risk Organization (MiCRO) to provide a platform for facilitating the development of index-based insurance products for low-income markets. The

goals are to use the MiCRO facility to offer insurance coverage against other types of risks in Haiti and to expand geographically to other countries.

In the first year, there have been three triggering rainfall events. Over US$1 million was paid to 4,000 clients to pay off the balance of their loans and provide cash payments for recovery. Most claims were paid within 60 days of the triggering event.

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Appendix F. Caribbean Catastrophe Risk Insurance Facility (CCRIF)

Type of instrument: Index insurance.

Risk(s) covered: Earthquake and damaging wind from hurricanes.

Beneficiaries: Sixteen participating Caribbean nations: Anguilla, Antigua and Barbuda, Bahamas, Barbados, Belize, Bermuda, Cayman Islands, Dominica, Grenada, Haiti, Jamaica, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Trinidad and Tobago, and the Turks and Caicos Islands.

Structure: CCRIF functions as a mutual insurance company controlled by participating governments. Participating countries initially capitalized CCRIF, with support from donor partners. CCRIF helps Caribbean countries lower the cost of insurance by pooling their risk exposure. A portion of the pooled risks is retained through reserves, which reduces the cost of insurance premiums. CCRIF transfers the risks it cannot retain by purchasing reinsurance and catastrophe swaps.

Status: Established in 2007 with continuous member renewal; payouts to date: 8.5 to Barbados (2010); 3.2 to St. Lucia (2010); 1.1 to St. Vincent and the Grenadines (2010); 4.2 to Anguilla (2010); 7.8 to Haiti(2010); 6.3 to Turks and Caicos Islands (2008); 1 to Dominica (2007); and 1 to St. Lucia (2007).[16] To address the problem of tropical storms bringing heavy rainfall but low wind speed, the CCRIF will offer for the first time parametric coverage for excess rainfall in 2012.

On average, one to three Caribbean countries are affected by a hurricane or earthquake each year, although during severe hurricane seasons this number can be much higher. In 2004, the region suffered a disastrous hurricane season, with 15 named storms. Hurricane Ivan, the strongest storm of that season, wrought devastation on the Cayman Islands, Grenada, and Jamaica. In Grenada, 89 percent of the country's housing stock and more than 80 percent of its public and commercial building structures sustained damage. The damage was estimated at over US$800 million, or approximately 200 percent of Grenada's GDP. The heads of government of the Caribbean Common Market and Community (CARICOM) were compelled by their

[16] Amounts are in US$ millions.

experiences during this catastrophic season to ask for World Bank assistance in improving access to catastrophe risk insurance.

The main objective of CCRIF is to provide its members with access to affordable and effective coverage against natural disasters. Small island states have difficulty absorbing the financial impacts of disasters for a number of reasons, including: i) limited budgetary capacity which prevents them from establishing sufficient financial reserves; ii) the impossibility of cross-regional subsidization of recovery efforts due to their limited size and economic diversification; iii) high debt levels, which limit their access to credit after disasters; and, iv) limited access to catastrophe insurance due to the high transaction costs resulting from the relatively small level of business brought into these markets.

CCRIF enables countries to pool their individual risks into a single, better diversified, joint reserve mechanism. Through risk pooling, CCRIF provides coverage to countries at a significantly lower cost than individual governments would incur if they had to maintain their own reserves, or if they were to independently purchase insurance in the open market.

Structure and Description

The CCRIF functions as a mutual insurance company controlled by the participating governments. Participating countries initially capitalized the company, with support from donor partners. CCRIF helps Caribbean countries lower the cost of insurance by pooling risks. A portion of the pooled risks is retained through reserves, which reduces the cost of insurance premiums. CCRIF transfers the risks it cannot retain by purchasing reinsurance and catastrophe swaps.

The coverage provided by CCRIF is parametric in nature. Unlike traditional insurance settlements that require an assessment of individual losses on the ground, parametric insurance relies on a payout disbursement contingent on the intensity of an event (e.g., wind speed, ground acceleration). In the case of CCRIF, payouts are proportional to the estimated impact of an event on each country's budget. The estimated impact is derived from a probabilistic catastrophe risk model developed specifically for CCRIF.

Insured countries pay an annual premium commensurate with their own specific risk exposure and receive compensation based on the level of coverage agreed upon in the insurance contract upon the occurrence of a triggering event.

Outcomes

CCRIF is the first-ever multicountry risk pool. Sixteen Caribbean countries joined in 2007 and have renewed their policies each year since. Eight payouts have been made to date[17]: 4.2 to Anguilla (2010); 8.5 to Barbados (2010); 1 to Dominica (2007); 7.8 to Haiti (2010); 1 to St. Lucia (2007); 3.2 to St. Lucia (2010); 1.1 to St. Vincent and the Grenadines (2010); and 6.3 to Turks and Caicos Islands (2008).[18]

The CCRIF has been well received by the reinsurance market, which has provided capacity at a low rate to CCRIF. A US$20 million CAT swap between IBRD and CCRIF was the first derivative transaction to enable emerging countries to access the capital market to insure against natural disasters.

Lessons Learned

1. CCRIF addresses one disaster risk financing need of small island states: access to immediate liquidity in the aftermath of a disaster. CCRIF does not cover all losses that a country may incur; instead, it covers estimated liquidity needs for the first three to six months after a major catastrophe. When designing a disaster risk financing strategy, it is important to understand that each country requires a tailored combination of disaster risk financing tools. There is neither a "one-size-fits-all" strategy nor a "silver bullet" disaster risk financing tool.
2. A critical mass of country participation in CCRIF is required for CCRIF to benefit from risk pooling and diversification. In order for Caribbean countries to benefit from diversification through risk pooling (e.g., joint reserves and improved reinsurance rates), enough countries must participate. Furthermore, CCRIF carries administrative costs that are shared by participants; a significant number of participants are required to maintain an affordable average administrative cost per country.
3. Dialogue on risk financing can enhance discussions with decision makers on more comprehensive disaster risk management. Risk models developed for risk financing products can provide useful information on the risk exposure of the economy analyzed.

[17] The CCRIF member countries are Anguilla, Antigua and Barbuda, Bahamas, Barbados, Belize, Bermuda, Cayman Islands, Dominica, Grenada, Haiti, Jamaica, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Trinidad and Tobago, and the Turks and Caicos Islands.
[18] Amounts are in US$ millions.

This information and related dialogue on financial protection can help sensitize decision makers to the need for more comprehensive strategies to deal with increasing losses from adverse natural events, including actions to try to avoid the creation of new risks (e.g., territorial planning, building standards) and to reduce existing risks (e.g., protective measures, strengthening of infrastructure).

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Appendix G. African Risk Capacity Project (ARC)

Type of instrument: Risk pooling and risk transfer through a contingency financing facility, using a layered approach.

Risk(s) covered: Drought (to lower the costs of disaster response, address food insecurity, and obviate humanitarian crises), with the potential for extending the facility to other risks in the future.

Beneficiaries: Food-insecure populations and governments via African Union (AU) member states and regional bodies.

Structure: Structure, size, and scope of ARC; the role of stakeholders in the pool; and the requirements for participation are in the process of being determined. ARC is envisaged as a pan-African, stand alone financial entity that will pool weather risk across the continent and, through aggregation, significantly reduce risk transfer and risk management costs for participants. Payouts will be based on transparent and objective criteria identified through a software platform, Africa RiskView (ARV), which uses satellite rainfall information to produce near real-time response cost estimates. The capital in the pool will be based on initial contributions from member countries and donors. Participating countries will pay an annual fee (coverage), based on their risk exposure as calculated by ARV.

Status: The project is under development with leadership provided by the United Nations World Food Programme (UN WFP), which is working closely with the African Union Commission and using support from the UK Department for International Development and the Global Facility for Disaster Reduction and Recovery of the World Bank.

Although weather-related food insecurity and humanitarian crises figure prominently in sub-Saharan Africa, existing mechanisms for responding to natural disaster risks are not timely, equitable, sufficiently large, or fiscally viable. As an alternative mechanism for disaster risk financing, ARC is an initiative that aims to secure cost-effective, certain, and timely liquidity to affected regions. ARC has been envisaged as a continent-wide risk pool that capitalizes on natural weather risk diversification across Africa to provide cost-effective contingency financing and fast cash disbursements in the event of drought (with the potential of extending the

mechanism to other natural disasters). Preliminary calculations indicate that the capital requirements associated with establishing a continent-wide pool are reduced by half compared to individual country reserves. The facility is to be led by the African Union Commission.

ARC is loosely modeled after the Caribbean Catastrophe Risk Insurance Facility (CCRIF), which has a track record of providing immediate liquidity to member governments affected by a disaster since 2004. ARC combines disciplines of crop monitoring and early warning; vulnerability assessment and mapping; emergency response; and financial planning and risk management. It is to be based ARV software platform, developed by the UN WFP. ARV translates satellite-based rainfall information into estimates of response costs for every first-level administrative unit in sub-Saharan Africa before an agricultural season begins and as it progresses. Frequency distributions for drought response costs are based on rainfall data over the past 15 years. It is flexible and can be customized for each country to quantify risk of drought and cost of participation, which governments can use to improve national disaster risk reduction and risk management strategies. The platform creates the basis for financing facility that employs a risk layering approach, including reserves, contingent lines of credit, and market risk transfer instruments. Rules for payouts will be determined in advance, and payouts will be based on transparent and objective criteria identified through the ARV software platform. The capital in the pool will be based on initial contributions from member countries and donors. Participating countries will pay an annual fee (coverage), based on their risk exposure.

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Appendix H. Extreme El Niño Insurance in Peru

Extreme El Niño is a cyclical phenomenon linked to major ocean currents and causes catastrophic rainfall and flooding in northern Peru, particularly in the province of Piura. Even with advance warning, communities struggle to manage the destruction of crops, property, and infrastructure brought on by extreme El Niño events. In the immediate aftermath of the last extreme El Niño in 1997–1998, roughly 200,000 Peruvians were displaced from their homes. Studies of rural communities in the region revealed that virtually everyone within high-risk communities suffered major disruptions to their economic activity, with many losing productive assets that define their livelihoods and their prospects for economic recovery.

While normal cycles in ocean currents remain the major determinates of the likelihood of an extreme El Niño in any given year, on the margin, those cycles may be affected by global climate change. In 2004, the Peruvian meteorological service, SENAMHI, predicted that global warming is likely to increase the frequency and severity of future El Niño events.

With initial support from USAID, and later, the Bill and Melinda Gates Foundation, GlobalAgRisk designed an insurance product to protect against the consequences of extreme El Niño. The insurance, offered by the international reinsurance company PartnerRe, with local support from the Peruvian insurance company La Positiva, is truly innovative, representing a number of important breakthroughs:

- the world's first regulated "forecast" insurance
- the first index insurance contract to use sea surface temperature
- the first index insurance to be framed as contingent insurance

El Niño insurance makes payouts before the onset of catastrophic weather. Extreme levels in the average November-December sea surface temperature, as measured by the U.S. National Oceanic and Atmospheric Administration (NOAA), trigger insurance payouts. NOAA monitors El Niño Southern Oscillation (ENSO) by measuring sea surface temperatures from different regions in the Pacific. Sustained high levels in ENSO 1+2, a composite of Regions 1 and 2 located off the coast of Peru, indicate a severe El Niño. When ENSO 1+2 reaches these extreme levels, it is also a forecast of impending catastrophic rainfall in Piura during the months of February to April. Thus, payouts can be made in January in time to be applied towards loss

prevention measures. In the past two extreme events of 1982–1983 and 1997–1998, rainfall amounts were in the range of 40 times normal for the early months of the year. Figure H1 illustrates the relationship between the ENSO values and rainfall in Piura.

By making payment prior to extreme flooding, this new insurance can enhance risk coping and adaptation for a wide range of stakeholders who face catastrophic flooding events and directly facilitate investment in loss prevention measures before El Niño-related flooding occurs. Educational design efforts have centered on adapting this insurance for use by governments, rural producer's associations, and individual households to facilitate adaptation to climate change and in helping these stakeholders understand how they can use the early payments to ease the problems and implement longer-term adaptation strategies.[19]

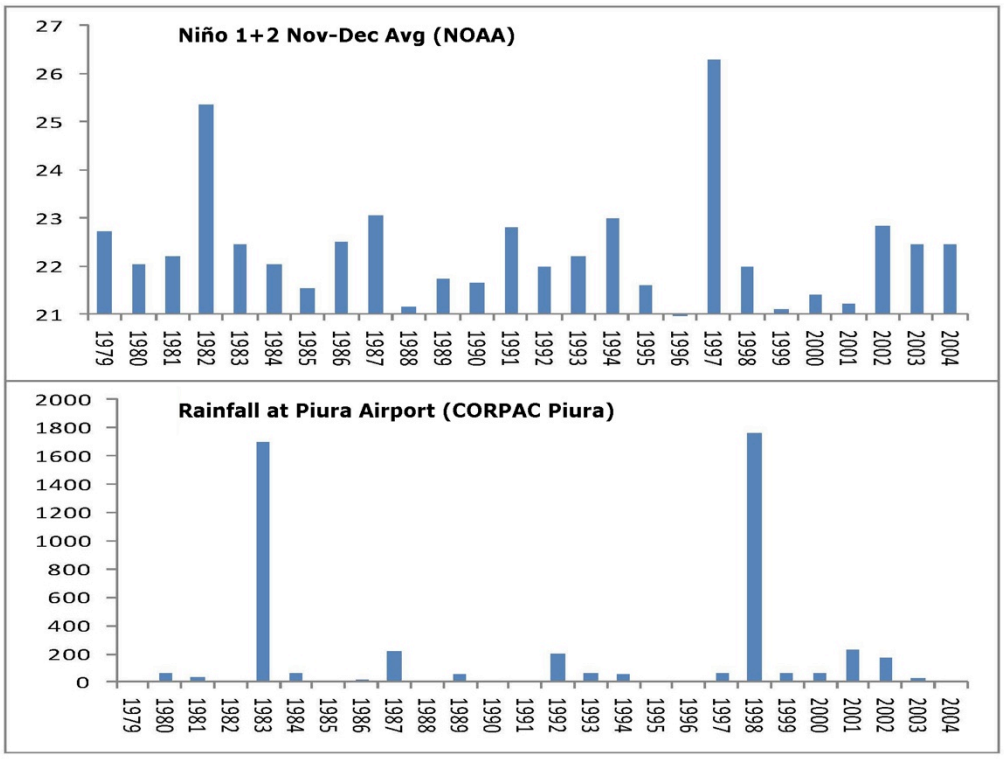
It has become apparent during this work that, despite the theoretical ease of using the El Niño insurance to cover the risks face by individual households, there are significant commercial challenges to its short-term prospects. Ultimately, commercial viability has made larger economic actors (businesses and governments) the targets for establishing a market in El Niño insurance. In particular, there is a project focused on insuring banks so that they would receive an infusion of cash that would allow them to continue lending to struggling communities, even as many borrowers in those communities defaulted due to El Niño. Because the product is structured as contingent insurance, the bank is not limited in the amount they can cover so they could offset losses within their portfolio as well as to physical property. Any payment would arrive immediately on their balance sheet, as there is no loss adjusting. Finally, the payment is a fixed percentage of their contracted sum insured, so there is every incentive still in place for the bank to discourage borrowers from rebuilding in the most vulnerable areas, as it makes loans for rebuilding.

La Positiva Seguros realized the first sale of this insurance in 2011 to Caja Nuestra Gente, a fast-growing microfinance bank with an explicit goal of expanding their lending to poor, underserved communities, which in Peru is often synonymous with communities at high risk of El Niño.

[19] Global climate change is, in some fundamental sense, uninsurable given the difficulty of establishing global forecasts of its ultimate consequences, let along reliable estimates of its regional impacts. However, global indexes like those used to monitor El Niño can serve as a proxy for climate change, covering some of the phenomenon whose frequency may be affected by sustained increases in average global atmospheric temperatures.

Under the current contract design developed for Piura, payouts are based on elevations in the average of the November and December SST from the Niño 1+2 SST index. Payments begin when this value reaches or exceeds 24C, corresponding to extreme El Niño events and intense rainfall in Piura (Figure H1). At this threshold, the insurance would have paid 45 percent of the sum insured in 1983 and 76 percent in 1998. The full sum insured is paid when the temperature meets or exceeds the limit, which is 27C.

Figure H1. Average Nov–Dec SST (°C) from Niño 1+2 and Jan–Apr Rainfall in Piura



Source: GlobalAgRisk, using data from NOAA and CORPAC Piura.

The insurance contracts can also be tailored to better fit the needs and expected loss experience of the target market by adjusting the payout threshold and limit values or imposing an alternate payout structure, such as a step function or accelerated payout. Keep in mind that changing the SST values over which payouts are made also changes the price of the insurance in relation to the expected probability of loss. The current design provides a minimum payment of 5 percent of the sum insured if the SST index measures at or just above the triggering value, above

which the payout is proportional for each incremental increase in the SST value up to 100 percent of the sum insured when the limit is met.

Working with risk aggregators and other larger-volume clients such as the regional government allows for customization of the contract design that is not possible for household-level products given the relative transaction costs. Such flexibility is needed to accommodate the different needs and constraints of the diverse applications.

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