Concept and Design of Weather Index Insurance:

The Case of Mexico

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Recently, Weather Index Insurance (WII) became of increasing interest as a tool to insure farmers of weather related risks, particularly in developing countries. Donor organizations, local governments, insurance companies, development economists as well as agricultural economists are discussing about the costs and benefits of WII. So far, most of the debate has centered around the WII implemented in Asian and African countries. In this article we present one more case: the WII program of Mexico which is one of the largest WII programs worldwide. We argue that the Mexican program is sufficiently different so that an additional analysis promises to be beneficial in order to learn about the potential problems, impacts and design of WII. Furthermore, we extend some of the previous arguments of the WII literature.

Background

The performance of agricultural production is highly influenced by the conditions of the natural environment. In particular, fluctuations in climatic and weather conditions impact farmers yields, and in developing countries—where a high percentage of the gross domestic product is generated by agricultural income—unfavorable conditions can severely affect the overall well-being of an entire region. Traditionally, farmers have developed several coping mechanisms to mitigate the potential negative impacts of their exposure to natural risks, namely by investments in:

- crop diversification (planting multiple crops with several degrees of vulnerability to weather events),
- irrigation systems (to increase the farmers independence of draughts)
- the generation of off-farm incomes
- formal and informal banking systems (either by accumulating savings or access to credit markets).

Today, despite the existence of these risk mitigating mechanisms, in developing countries a large portion of weather shocks' negative effects are still not entirely absorbed, which in some cases can lead to humanitarian catastrophes such as famines or civil wars over access to important resources (Barnett and Mahul, 2007, Alderman and Haque, 2008). More generally, the lack of tools to insure sectors against weather shocks leads to an underinvestment in the agricultural sector (Rosenzweig and Binswanger 1993, Morduch 1995).

Historically, governments have used disaster relief funds to quickly respond and stabilize affected areas of floods or droughts. However, the volatility of disaster funds over time—and the often associated strains on other governmental budgets, i.e. education, security, of which the resources are taken from—pose difficulties. Furthermore, disaster relief is an "ex-post" strategy only. In recent years efforts increased at designing "ex-ante" strategies. In theory, under the assumption of risk aversion, an optimally designed WII facilitates overcoming credit constraints, mitigates chronic underinvestment, increases productivity and could potentially relieve poor farmers from poverty traps as discussed in Barnett, Barrett and Skees (2008).

Weather Index Insurance Literature and Challenges

Although weather index insurances are currently considered to be an effective tool for the agricultural sector in developing countries (i.e. Sakurai and Reardon 1997; Skees 1999 and 2000, Skees and Enkh-Amgalan, 2002, Barnett and Mahul 2007, Barnett, Barrett and Skees 2008) the first successful implementation has been realized in the U.S. in 1997: after the deregulation of the energy sector, energy providers increasingly insure themselves against particularly mild winders to circumvent the loss of foregone revenue due to lower heating requirement (Cao et al. 2003). Since then stakeholders in the hotel industry, the agricultural sector, travel or event organizers engage in the trading of weather derivatives which became a 40 billion dollar business for the Chicago Mercantile Exchange alone in 2006 (Ginocchio, 2008).

The basic concept of WII is simple: if a certain measured weather index (i.e. precipitation) is above (flood) or below (drought) some pre-defined threshold then the insurance pays indemnity payments to the insurance holder (farmer). While we will discuss the challenges of this mechanism in more detail below, the perceived advantages of WII are that it circumvents both moral hazard and adverse selection which are problems in traditional insurance schemes that are based on actual losses of harvest. Furthermore, it is often argued (Barnett and Mahul 2007, Barnett, Barrett and Skees 2008) that WII is cost effective because no harvest damage assessment has to be made.

Regarding the economics and feasibility of the insurance program, important recent insights have been gained in the case of India, Malawi and China. The main empirical problem is low take-up rate of farmers purchasing WII, ranging (depending on the study) in 2004 by 4% to 5% as analyzed by Giné, Townsend and Vickery (2008) in India, whereas Cole et. al. (2008) find take-up rates of about 27% for the same sample of Indian farmers in 2006. These studies and a series of additional papers (Giné and Yang, 2009 and Cai et al. 2009) analyze the determinants of participation of WII and find, the higher the correlation between the weather index and the yield (basis risk), the higher the take-up rate. Furthermore, take-up also increases with household wealth and lower credit constraints. All of these results are consistent with the predictions of simple neoclassical models. These studies further point towards important social-psychological and peer-effect related determinants for take-up, namely trust in the insurance program, participation in village networks, and familiarity with the insurance vendors. These variables are consistently correlated with the take up decision. Furthermore Giné, Townsend and Vickery (2008) performed experiments with farmers to measure their degree of risk aversion. The authors find—contrary to the theoretical predictions from the neoclassical model—that risk averse farmers are *less* (not more) likely to participate in WII, which may reflects their uncertainty about the WII program itself.[i]

Based on these experiences a debate evolved whether WII is an efficient tool and whether WII is self-sustainable and—due to the low take-up rates—some donor organizations are now understandably more hesitant to further invest resources into WII. For example, after a workshop on WII at the Headquarter of the Bill and Melinda Gates Foundation in Seattle, the Foundation decided not to support and engage further in the programs of weather index insurance (Wolff 2010).

However, the design of the Mexican insurance program is different from the other programs in important aspects. Therefore, we think it is worth looking at this in more detail in order to have a better understanding of the potential role, costs and benefits and effectiveness of different WII design options.

In the following we will go through some of the main problem areas of weather index insurances. Barnett and Mahul (2007) and Barnett, Barrett and Skees (2008) contributed papers which conceptually discuss the main challenges. The main challenges can be categorized into (i) basis risk (ii) data quality, (iii) low positive willingness to pay. We further discuss the problem of diversification, technology inertia, and other aggregate equilibrium effects.

Weather Index Insurance in Mexico

Agricultural Background of the Insurance, Coverage and Expansion

Mexico's WII is designed to insure against draughts in non-irrigated agricultural production and currently covers four crops: maize, barley, beans and sorghum. The total production value insured is 1.5 billion U.S. dollar, as of 2008. The main focus of the insurance is on maize, currently insured with over 1.2 billion U.S. dollar. In terms of hectares, of the total 1.9 million hectares insured, 81% (or 1.5 million hectares) is devoted to maize. In Mexico, maize is the most important crop, and its relative dominance is even higher in the non-irrigated agriculture: 90% of all maize is grown on rain-fed agriculture and the remaining 10% of all maize is grown on irrigated land.[ii] Therefore, the majority of land destined to produce Mexico's main crop depends exclusively on rain which makes the maize harvest vulnerable to adverse weather events.

80% of all agricultural catastrophes in Mexico are caused by droughts. This situation is exacerbated in the years in which El Niño phenomenon is present. According to the Ministry of Agriculture (2009), Federal and States Governments spent around a third of a billion U.S. dollars in disaster relief due to agricultural catastrophes between 1995 and 2003. Moreover, access to private agricultural production insurance in Mexico is insufficient since land fragmentation (more than 60% of the farmers own less than 5 hectares), large administrative costs and systemic risk discourage private insurers. Due to the lack of private insurers and the high budgeting uncertainty of disaster relief funds, the Mexican Government, through the Ministry of Agriculture, introduced rainfall index insurance in 2003. The insurance's objective is to support small-scale producers (i.e. owning no more than 20 hectares) that "suffer atypical climatic contingencies --in particular droughts-- get reincorporated into their productive activities".

Regional Enrollment versus Private Take-Up

While in 2003 the insurance was available in five counties only, in 2008 the insurance covers over 656 counties with a total of 1.9 million hectares. In particular, every year since 2003 state level officials suggest their federal counterpart the area to be insured (number of hectares and counties considered) within the first three months of the year (i.e. before the beginning of the season). The federal government pays 70% of the cost of the insurance premiums and the state governments cover the remaining 30%. However, for counties that have high poverty levels (defined by the National Population Council), costs are split by 90%-10% for federal and state governments, respectively. In Mexico, "Agroasemex" a governmental agency formed in 2001, exclusively provides coverage.

Therefore, although WII is in Mexico a production insurance for small-scale farmers, Agroasemex, essentially insures the federal government budgets. In other words, it serves as a budget risk management tool since it allows annual budget planning minimizing catastrophic ex-post expenditure due to droughts. Agroasemex itself reinsures their risk with the American North Carolina re-insurance company Re, hence spreading the covariate risk on an international level, where reinsurers regard a country's risk as a idiosynchratic risk if investing in multiple countries itself.

Importantly, in Mexico individual producers do not pay premiums to obtain coverage under the WII. Instead the WII is jointly contracted by federal and state governments that provide resources from their annual budgets to purchase insurance premiums. The automatically insured farmers get informed about their coverage status through state officials.[iii] Whether the farmers however are aware of this coverage, hover, may not be certain. In order to evaluate WII information channels, the Ministry of Agriculture hence required that the program is externally evaluated. The latest 2009 external evaluation describes that a subset of randomly selected farmers are surveyed and asked about their knowledge and willingness to pay for the insurance. According to the Ministry of Agriculture (2009) the external evaluation showed that (i) almost 100% of the farmers know about the existence of the insurance, and (ii) over 80% of the farmers reveal a positive willingness to pay for the premium (in order to obtain the insurance in case the government would not provide it for free). However, it is important to point out that this study—although classified as external to the interests of the government—was still contracted by the Mexican government and may not satisfy strict scientific criteria. In particular the result that there exists a positive willingness to pay among Mexican farmers is in stark contrast to the results found by Giné, Townsend and Vickery (2008), Cole et. al. (2008) in India, Giné and Yang (2009) in Malawi 2008, and Cai et al. (2009) in China. Given the importance and academic interest of this issue, this issue should be analyzed further.

Data Quality

To obtain the weather information, the government takes advantage of existing and publicly available weather data. Although there are more than five thousand weather stations in the country, Agroasemex however only uses a subset since only few attain international standards and have more than 25 years of daily information. The 25 year requirement was introduced because it was regarded necessary to obtain a long enough time series to statistically predict the rain-yield correlation pattern.

Basis risk Modeling and the problem of non-moving thresholds

"Basis risk" is often discussed as the number one problem about the design of WII (basis risk describes how well the index is correlated with crop yields). To model the relationship between weather conditions and and crop yields, in Mexico the "*Agricultural Insurance Simulation Model*" was developed. This model is important as it is used to determine the critical threshold values of the index below which the indemnity payments are triggered (Agroseamex, 2006). The model consists of a system of equations representing the crop-soil-weather relationship taking into account the specifics of each agronomic climate region. As a result, the growing season is separated into three phases (seeding, flowering, harvest) and for each of these three phases for every agro-climatic zone by crop different thresholds are established. The agro-climatic zones are referred to as Agro-Climatic Zone of Homogeneous Response (ACZHR). Indemnity payments are provided if rainfall is below the pre-established threshold measured in millimeters by weather stations in the ACZHR. As an example, we look at the cases of a zone in the state of Guanajuato in Figures 1 corresponding to the rainfall of the year 2005. Agroasemex offers the following contract for insuring maize in the counties "Apaseo el Alto" the first period, also known as the sowing period, runs from May 15 to July 5; the second period, or flowering period, from July 6 to August 20; and the third, or harvesting period, from August 21 to October 31. The minimum amount of cumulative rain above which Agroasemex does not provide indemnity payments (known as the trigger threshold) equals 43, 80 and 60 millimeters for the first, second and third periods, respectively. There were no indemnity payments in Apaseo el Alto, since cumulative rainfall was higher in each of the three periods than the minimum thresholds. Figure 2 shows the rainfall pattern for the county Leon in 2005. Indemnity payments were provided in 2005 for maize production in Leon since cumulative rainfall was lower than the sowing period minimum threshold (see Figure 2).

Given the importance of the thresholds for WII, in our opinion it is problematic that these thresholds stay constant over time. In Mexico since the start of the program in 2003 the defined thresholds were note re-adjusted although currently a substantial amount of research has been devoted to the development of drought resistant corn and maize types. Non-moving thresholds can inhibit important incentives to invest into research and development of drought-resistant seeds. Hence we suggest a model re-calibration and that appropriately moving thresholds over time are considered.

In addition, we consider that not only the minimum amount of cumulative rain in each period is important, but its variance within the period. In other words, attaining the minimum amount of cumulative rainfall in one or two days (potential flood) has very different consequences compared to the same amount of cumulative rainfall but dispersed over a larger number of days. Therefore, we suggest to include a minimum number of days with rain, or similar criteria.

Risk of non-diversification: monoculture, off-farm income and inertia in technology

In Mexico 22% of all current rain-fed maize production is currently insured (and it is intended to scale up the program to the entire nation). We see here a risk of overspecialization because incentives are missing to diversify (i.e. into crops which are not insured). Maize monoculture has potential negative effects on the environment and long term sustainability (Berzsenyi, 2000).

Related, more generally, a strong WII creates disincentives to invest in other important agricultural technologies. For example WII may decrease important efforts to invest in the development of irrigation systems because farmers are insured only if crops are planted on rain-fed land. Similarly, the structure of the rural work-force can be affected by reducing off-farm income, which prior to the WII program was one of the major risk coping mechanisms in Mexico.

Aggregate equilibrium effects of disaster prevention

The Mexican WII program was initially designed by the government for budget planning purposes to produce an ex-ante disaster prevention strategy which has no volatility in budget size. There is considerable work on WII as a tool to prevent disasters and famines (Barnett, Barrett and Skees 2008, Chantarat et al. 2007). For a WII program with such large coverage as in Mexico, however, the problem is that under food shortages sudden indemnity payments can lead to rapid food price increases. This may be particularly true in rural areas which are not well integrated into larger markets and where a food commodity such as maize is a necessity with very low own price elasticity of demand. Particularly vulnerably (due to the local inflation) are those households that are not covered under the WII (poor non-farming population or firms that produce other crops than those that are insured).[iv]

Conclusion

In this paper we outline the rapidly growing Mexican weather index insurance program and discuss some associated challenges. In particular we suggest that the thresholds of the weather index should be (continuously) re-calibrated in order to adjust for the development of drought resistant seeds. Secondly, the index could be relatively easily extended to account for precipitation variances. Thirdly we point out towards potential spill-over effects on related markets: WII creates disincentives to invest in other non-insured crops leading to potential overspecialization and monoculture. WII further generates disincentives to invest in irrigation systems because farmers are insured only when producing on non-irrigated land. Finally, in case of catastrophic events food prices can inflate with indemnity payments at the expense of the uninsured poor. Clearly further research is necessary, in order to evaluate the magnitude and the potential importance of these second order effects.

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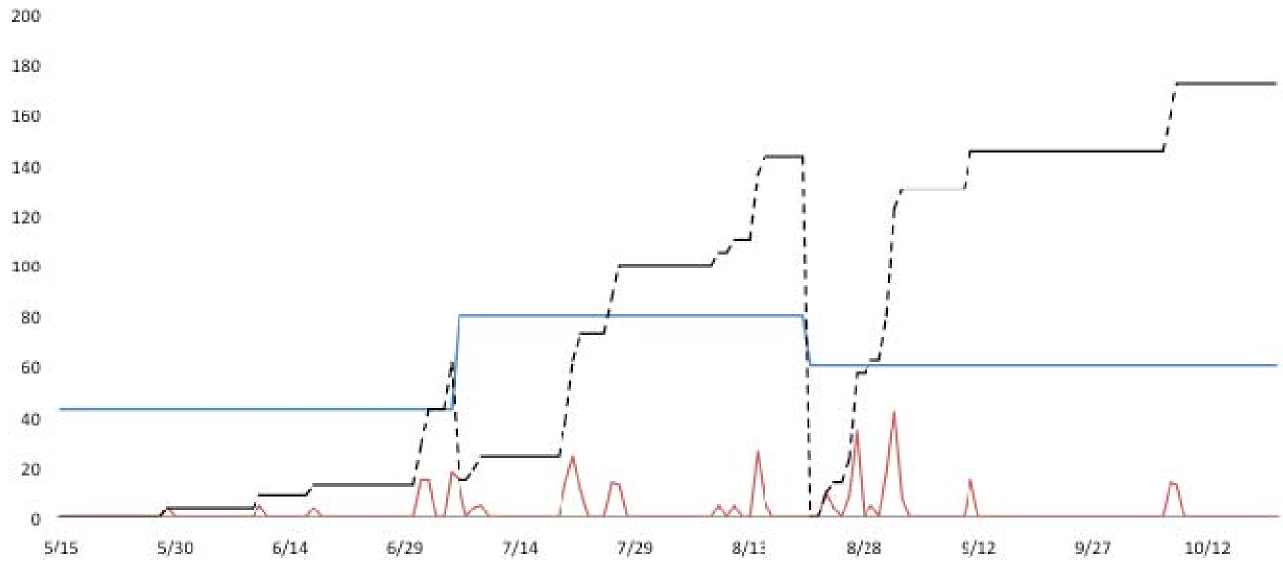
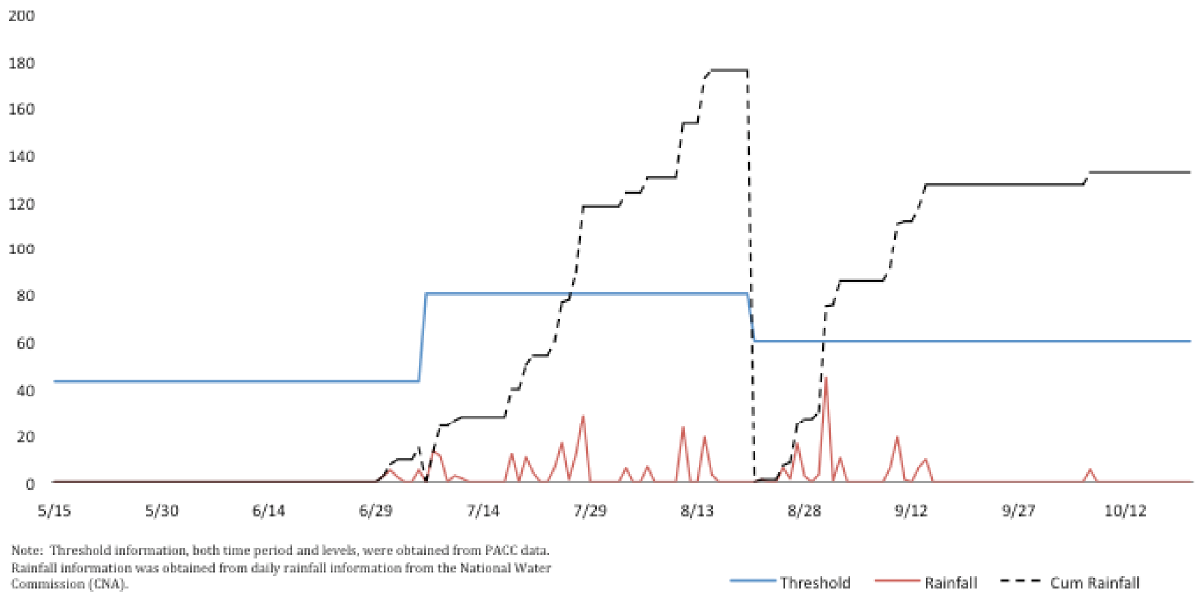
Figures 1: Weather Insurance Thresholds and Actual Rainfall: Apaseo el Alto, 2005



Note: Threshold information, both time period and levels, were obtained from PACC data. Rainfall information was obtained from daily rainfall information from the National Water Commission (CNA).

Figures 2: Weather Insurance Thresholds and Actual Rainfall: Leon in 2005



Endnotes

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[i] In randomized field experiments in Malawi, Giné and Yang (2009) study the interaction between access to credit and access to WII, which is important given that one argument in favor of WII is that it facilitates farmers to overcome credit constraints. Their finding however is that farmers who were offered a credit were less likely to adopt the credit if simultaneously the farmer was also offered a WII (compared to the control group of farmers that were offered a credit only). Giné and Yang interpret this result with limited liability of the loan contract. Another potential interpretation is psychological, in the sense that by offering both credit and WII, those farmers just got reminded about the risks of defaulting the credit and hence decide to rather accept neither. Finally, one other

interpretation (not described in their paper) is that the offer of a credit and an insurance program simultaneously is simply too complicated to understand for the average Malawi groundnut and maize farmer. Suggestive evidence for this hypothesis is that Giné and Yang (2009) find that the adoption of both offers increases with education, income and wealth.

[ii] In Mexico non-irrigated farming still clearly dominates. In 2008, agricultural production added for up to 20.5 million hectares of which 73.6% depended exclusively on rain. Maize production covered 7.8 million hectares of which more than 6.9 million (90%) was non-irrigated land (Ministry of Agriculture, 2009).

[iii] The announcements are made through the regional offices of the Program for Direct Assistance in Agriculture or through the “Ventanillas Autorizadas” depending on plots location and county.

[iv] In less developed African countries the effect of a local price increase may be even larger because a larger portion of the population directly depends on farm-income (and a larger percentage of the population would be hence insured) and because the agricultural markets are likely to be even less well integrated compared to the case of Mexico.