INDEX INSURANCE:

INNOVATIVE FINANCIAL TECHNOLOGY TO BREAK THE CYCLE OF RISK AND RURAL POVERTY IN ECUADOR[1]

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CONTENT

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1. INTRODUCTION

During the current decade, several governments from the Andean region have prioritized the construction and strengthening of the agricultural insurance market for small farmers. The motivations for these initiatives are clear.[5] On the one hand, climate change and the perception of higher risk of extreme events, such as drought, frost and flood, which affect large numbers of vulnerable rural inhabitants, represent a strong pressure on the public budget via *ex-post* disaster management. Andean countries such as Colombia, Ecuador and Perú are particularly vulnerable to agricultural disaster due to the prevalence of El Niño and La Niña events. Investing in the development of a strong market for agricultural insurance represents an *ex-ante* mechanism, potentially more efficient from the point of view of the public budget, of managing risk associated to these type of disasters.

On the other hand, there is a larger acknowledgment that productive risk, if it is not accompanied by an insurance market, represents a strong limitation to rural development. Without agricultural insurance, financial institutions are less willing to lend to agricultural households. As a consequence, households are less willing to invest the necessary resources to adopt new technologies or intensify production. The result is a vicious cycle of low investment and persistence of poverty traps.

While the logic of strengthening the agricultural insurance market is clear, the way forward is not. The challenges of creating an insurance market for small farmers that is massive, effective and sustainable based on conventional insurance policies (named perils) are very strong. The clearest example is the need to carry out multiple field inspections in order to evaluate losses and determine if they were caused by insurable losses and out of the control of the farmer or if they were caused by the farmer's negligence (moral hazard). In the context of small farmers, who are in many cases in hard to reach areas with little infrastructure, the costs of overcoming information asymmetries between the farmer and the insurance company can be so high that they can put in doubt the viability of the market, unless that it counts with high subsidies.[6]

Index insurance represents an attractive alternative, especially in small farmer contexts.[7] Because indemnity payments depend on and external index, such as a climatic event or the average yield of a specific area, instead of depending on inspections of the insured parcels, index insurance is less susceptible to asymmetries of information and has the potential to be offered with much lower transaction costs. Nonetheless, despite its clear advantages, index insurance also faces important challenges; mainly the lack of information required in order to build an effective index that offers real protection for farmers.[8]

[5] Iturrioz and Arias (2010) offer a summary of the development of agricultural insurance markets in Latin America.

[6] Skees et. al. (2006) offer a detailed description of the costs and challenges of conventional contracts (multi-peril) associated to the lack and asymmetry of information.

[7] See Hazell et. al. (2010) for a detailed summary of the evolution of index insurance in developing countries. Barnett et. al. (2008) present a summary of the pilots of index insurance in the third world in the 1990's and 2000's.

[8] Binswanger-Mkhize (2012) present a rather pessimistic position about the potential of index insurance to mitigate risk for small farmers due to a lack of good quality indices.

The main goal of this research is to compare those two alternatives – conventional versus index insurance – in the specific context of Ecuador. Ecuador offers a particularly interesting context due to several reasons. First, starting in 2010, the government of Ecuador introduced the policy of strengthening the agricultural insurance market for small and medium farmers through subsidies to the premium of a conventional insurance contract. This policy created the possibility of gathering data that would allow us to evaluate the functioning of conventional insurance. Second, besides the agrarian census (year 2000), starting in year 2002 Ecuador counts with a national survey of agrarian production (ESPAC) which has allowed us to design a "shadow" area yield index insurance contract. We compare the hypothetical functioning of this "shadow" contract with the real functioning of the conventional insurance for the years 2011 and 2012 for a sample of rice and feed corn producers in three cantons of the country. The main criterion that we use for the comparison is the efficiency of the insurance contract in stabilizing income through the transfer of indemnity payments to farmers who suffered larger losses.

Research results suggest that area yield index insurance could offer a viable alternative and, in some contexts, with better effective protection for small Ecuadorian farmers than the conventional insurance. Specifically, our research finds that index insurance represents a superior alternative for feed corn farmers because this crop, which depends on the rain, is highly vulnerable to covariant climatic risks such as the strong drought that affected Ecuador in 2011. This conclusion is based on the finding that, for the same value of the premium, the "shadow" index contract would have paid larger indemnities to corn farmers that suffered larger losses and, therefore, that needed most the income stabilization role of the insurance. In contrast, rice is a crop that counts with important irrigation infrastructure in Ecuador and, hence, is affected mostly by idiosyncratic risk. Even so, the hypothetical performance of the index insurance for this crop would have been very similar to the performance of the conventional insurance. These findings, together with the privileged situation of Ecuador in terms of the existence of systematic data of agricultural production thanks to the ESPAC, take us to conclude that this is a favorable time to try index insurance, not as a substitute but as a complement of conventional insurance, through a pilot project.

The rest of the report is organized in the following sections. Section 2 describes the context of the agricultural insurance policy in Ecuador and the sample of producers in which we base the analysis. Section 3 offers details about the named peril conventional contract and develops an initial evaluation of its performance. Section 4 offers a brief summary about index insurance and describes the construction of the "shadow" area yield index insurance in Ecuador. Section 5 develops a comparative evaluation of the performance of the conventional versus the index contract. Finally, Section 6 offers some recommendations for the way forward to the strengthening of agricultural insurance markets for small farmers in Ecuador.

2. RESEARCH CONTEXT: AGRICULTURAL INSURANCE IN ECUADOR AND THE SAMPLE

2.1 Background: Support policies for the agricultural insurance market in Ecuador

The governmental policy of supporting the access of small and medium farmers to agricultural insurance, so that their crops are protected, was born in 2010. This policy has two main components. First, the Ecuadorian State offers a 60% subsidy of the premium for small and medium producers of specific crops. Second, the Agricultural Insurance Unit (UNISA in Spanish) was created within the Ministry of Agriculture, currently under the name of Agroseguro Project. Agroseguro's main responsibilities include: to execute the transference of the subsidy to insurance companies; to design and carry out educational campaigns about this kind of insurance, and to make sure insurance companies respect policyholders' rights.

Until 2012, the only insurance company that offered agricultural insurance to the market was QBE-Seguros Colonial (QBE from now on), which was also the only insurance company with international reinsurance for this type of product.[9] That is why the Government began its subsidy policy through this company's contracts. However, from March 2013, the Ecuadorian State decided to stimulate the participation of the public insurance company, Seguros Sucre S.A., in the agricultural insurance market. From that date on, only policies issued by Seguros Sucre are eligible to receive the subsidy. Since data for this research was collected in 2011 and 2012, our analysis is based on the performance of the conventional insurance offered by QBE.

The subsidy policy is applied to small and medium-sized producers of specific crops.[10] There were four covered crops in 2010 (feed corn, rice, potato and wheat), but this number increased to 10 since 2011 (field corn, sweet corn, rice, potato, wheat, beans, peas, tree-tomato, banana and sugar cane). Table 2.1 shows the evolution of issued policies and number of covered hectares, as well as loss rates since 2010. According to Agroseguro, total amount of paid insurance claims up to date reaches over USD 5 million. Because of an extreme drought, 2011 was the year with the highest loss percentage, reaching 173% of premiums received. The main covered crops during the mentioned period have been rice and feed corn (Table 2.2), precisely the crops analyzed in this research.

Table 2.1. Evolution of Policies and Insured Hectares

Year	Policies Issued	Insured Hectares	Loss Rates
2010	1,893	9,885	143%
2011	5,157	23,861	173%
2012	9,870	52,133	42%
2013	10,932	43,982	61%

Notes: Loss rates are obtained by dividing total amount of paid inssurance claims by total amount of premiums earned by the insurance company. Source is AgroSeguro, MAGAP.

Table 2.2. Percentage of Policies Issued and Insured Hectares for Rice and Feed Corn

	% Policies Issued		% Insured Hectares	
Year	Rice	Feed Corn	Rice	Feed Corn
2010	43%	41%	53%	41%
2011	35%	49%	48%	41%
2012	22%	54%	28%	51%
2013	23%	58%	30%	57%

Source: AgroSeguro, MAGAP

[9] QBE designed and began to offer agricultural insurance to the market since approximately the year 2000 to a small but growing number of small, medium and large farmers.

[10] The characteristic of small (or medium-sized) producer is related to production costs per hectare for each crop. Total subsidy to premiums for a farmer cannot surpass the established limit of USD 700, with the exception of bananas (USD 1,500 limit) (Agroseguro, MAGAP).

2.2 Primary data collection and sample size

Primary data collection was carried out in three cantons (local administrative regions) of importance for rice and feed corn crops: Celica, Loja Province (feed corn); El Empalme, Guayas Province (feed corn), y Daule, Guayas Province (rice). These cantons were selected given not only their importance in the mentioned crops production at the national level, but also because of convergence of a high number of corn and rice farmers polled by ESPAC national survey, which is described in Section 4, and a high number of policyholders. Data were collected twice, between October and December 2011, and between October 2012 and January 2013. The sample was chosen by convenience: starting from the list of insured farmers from selected cantons, those with a more specific address were polled, looking that they be as close as possible to the sample units of ESPAC. During the first round, output information of 2011 rainy and dry season cycles was compiled. A total of 1,000 both rice and corn farmers were polled, all of them mandatorily insured through loans from the public Banco Nacional de Fomento (BNF) and/or from the private Banco de Loja. Other 2011 data collected in the survey were experience with agricultural insurance, shocks endured during the year, and farm and household assets.

During the second round (October 2012 - January 2013), output information of 2012 rainy and dry season cycles was compiled, as well as information on experience with the insurance, shocks and net worth, in a similar fashion as 2011. Survey respondents in this round were the same farmers as in the first round; however, due to a noticeable decrease in the percentage of survey respondents who were again insured in 2012 (53% insured), 344 new survey respondents (insured) were added to the sample. Therefore, 1,344 both corn and rice farmers were polled in 2012.

Because of the loss of observations (farmers that were uninsured in 2012 or insured farmers that did not know their insured area), the number of observations of insurance policies used in the end for the analysis was 1,100 in 2011 and 819 in 2012.

Additional to the survey, focus groups were carried out at the beginning of 2012 with small groups of farmers in each canton in order to deepen our knowledge of their perceptions and experiences with the conventional agricultural insurance.

2.3 Characteristics and situation of surveyed farmers

Insured survey respondents are small corn and rice farmers with access to formal credit (financial institutions). Between 50% and 60% work their own land, though not necessarily with property deed, and there are some who rent one or two additional plots for their crops. In general, 55% rents at least one of the plots in which they work. Corn producers are farmers with limited access to irrigation, the contrary being true for rice producers, who sow in the dry season more frequently than corn producers and are able to accomplish up to three plantings during the year according to Table 2.3. Average sown area ranges between 0.8 and 6 hectares depending on the productive cycle and the canton, as shown in Table 2.4.

Table 2.3. Percentage of the Sample who Planted in 2011 and 2012

	Celica (corn)		El Empalme (corn)		Daule (rice)	
Cycle	**2011**	**2012**	**2011**	**2012**	**2011**	**2012**
Rainy	99%	100%	99%	100%	43%	48%
Dry I	1%	3%	15%	40%	99%	88%
Dry II	0%	0	0%	1%	43%	53%

Tabla 2.4. Average Sown Area by the Sample in 2011 and 2012 (Hectares)

	Celica (corn)		El Empalme (corn)		Daule (rice)	
Cycle	**2011**	**2012**	**2011**	**2012**	**2011**	**2012**
Rainy	6.0	6.0	4.8	5.4	4.4	4.7
Dry I	1.9	1.5	1.7	1.7	5.4	5.0
Dry II	-	0	-	0.8	4.4	4.6

The two analyzed years had a very different behavior, especially for feed corn producers. Year 2011 was noteworthy for an acute drought that caused losses for 45% of polled producers. 2012 in turn was a year of small losses; only 19% of survey respondents suffered losses. This can be seen in the difference of average yield between the two years (Table 2.5). Rainy season average yields in Celica were doubled in 2012 compared to 2011; increased more than 50% during rainy season in El Empalme and grew during the dry season in Daule (20% in the first dry cycle and 10% in the second dry cycle).

Table 2.6 summarizes for each year the main causes that survey respondents pointed for "poor harvest". In 2011, corn producers were severely affected by drought, whereas rice producers were affected by pests. In 2012, crop damages were caused mainly by excess humidity and pests.

Table 2.5. Sample Average Yield (ton/ha.) in 2011 and 2012

	Celica (corn)		El Empalme (corn)			Daule (rice)	
Cycle	**2011**	**2012**	**2011**	**2012**	**Cycle**	**2011**	**2012**
Rainy	1.43	2.89	3.42	5.20		4.61	4.67
Dry I	3.49	3.11	4.19	3.96		4.64	5.59
Dry II	-	-	-	3.71		4.71	5.19

Table 2.6. Main Causes of "Poor Harvest" Reported by Sample

	Celica (corn)		El Empalme (corn)		Daule (rice)	
Cycle	**2011**	**2012**	**2011**	**2012**	**2011**	**2012**
Rainy						
Flood	0%	12%	0%	7%	4%	28%
Excess Humidity	0%	62%	0%	80%	11%	23%
Drought	100%	1%	98%	2%	4%	0%
Pests	0%	58%	1%	58%	81%	85%
Dry I						
Flood	-	0%	0%	0%	0%	0%
Excess Humidity	-	17%	0%	0%	0%	2%
Drought	-	17%	100%	92%	0%	6%
Pests	-	67%	0%	12%	100%	96%
Dry II						
Flood	-	-	-	-	0%	0%
Excess Humidity	-	-	-	-	0%	6%
Drought	-	-	-	-	0%	9%
Pests	-	-	-	-	100%	91%

Notes: Figures represent percentage of farmers in the sample who reported having had "poor harvest" during the cycle.

3. CONVENTIONAL INSURANCE CONTRACT: DESCRIPTION AND PERFORMANCE

In this section we will describe the details of the conventional insurance contract offered by QBE in 2011 and 2012. We highlight several elements that have reduced the real coverage of this insurance and we analyze the level of protection offered to policyholders.

3.1 Conventional contract features

QBE's contract is an agricultural multi-peril insurance contract that covers individual losses caused by climatic risks. Since agricultural insurance has been distributed mainly through financial institutions, such as Banco Nacional de Fomento (BNF) and Banco de Loja,[11] the insured value used to be the amount of the loan, instead of production costs; however, by 2012 the insured value was established based on average production costs per zone, according to QBE's definition.[12]

QBE contract's main characteristics are summarized as follows:

- Covered risks: drought, flood, strong winds, frost (in the Sierra region), excess humidity, uncontrollable pests and diseases, and fire

- Coverage period: 120 days from the sowing of the crop

- Procedure in case of loss:

[11] More than 80% of subsidized policies are channeled through financial institutions (AgroSeguro, MAGAP).
[12] Average production cost per zone is defined by QBE based on a sampling of costs in the field, which includes labor costs, soil preparation, and a kit of supplies needed for each crop.

- Notice of loss: A loss claim form must be sent to the insurance company within 10 days after the loss occurrence. This form is usually channeled to the insurance company through the intermediary Bank. Once the form is received, the insurance company plans a visit to the policyholder's crop.

- Total loss (85% of crop loss): in the case that the appraiser or adjuster sent by the insurance company establishes a total loss, the subsequent payment is the invested amount until the occurrence of the loss (as long as it is lower than the insured value), minus a deductible.

- Partial loss: if the adjuster declares partial loss, he/she must carry out additional visits to the plot (at least one additional visit). The policyholder has the responsibility of sending a harvest notice form to the insurance company, which must be sent 10 days prior to harvest. Once this form is received, the adjuster visits again the plot and carries out a sample to estimate the yields to be obtained. In the case that the harvest value is lower than the insured amount, the subsequent payment equals the difference between both figures, minus a deductible.

- Deductible: 30% of loss value.

Covered amount, premium rate and reference price for loss setting, all varied during the two analyzed years, as seen in Table 3.1.

Table 3.1: QBE Contract Variables in 2011 and 2012

Variables	2011	2012
Insured amount	Loan amount	Standardized amount based on average production costs per zone.
Premium Rate	Feed corn: 6.9% Rice: 5.3%	Feed corn: 9.5% Rice: 5.3%
Reference Price used to set losses	Feed corn: \$12.5 - \$14.5/qq Rice: \$15/qq	Feed corn: \$14.5/qq Rice: \$16/qq

Since this type of contract is conventional and the insurance company visits the plot to verify real damages, policyholders should be 100% covered in case of losses due to covered causes and, therefore, should receive payments according to their losses (minus the deductible). Nevertheless, because of problems that will be detailed in the next sub-section, the coverage does not reach the expected levels.

3.2 Problems limiting effective coverage of conventional insurance

Before going on, let us define the measure we will use from now on in order to determine if a farmer experienced loss. In general terms, the insurance company would make a payment if the harvest value is lower than the insured amount per hectare, i.e., if the condition of the equation (1) is met.

$$pR_E < M \tag{1}$$

Where, R_E is the yield estimated by the adjuster (QQ/ha); p is the reference price set in the insurance contract ($/QQ), and M is the insured amount per hectare ($/ha). In other words, in terms of the insurance, there would be a loss when the yield (R_E) is under (M/p). This value, denominated in quintales, is called the "trigger" of the conventional insurance, or D_{SC}. In order to calculate the numerator of this trigger, we used the median of the insured amounts (per hectare) distribution, as reported by QBE, for each canton and each year. In this research, losses have been defined comparing yields reported by the sample respondents (i.e., yields actually obtained, instead of yields estimated by the insurance company) with the aforementioned trigger.

As it can be deduced from the contract characteristics, in many cases its complexity leads to misunderstandings of its functioning by the policyholder. Five common reasons of confusion are stated next, as well as evidence resulting from our research.

The first motive of confusion is that *the policyholder did not file a loss claim* and therefore the insurance company was never aware of his/her loss, despite it had been a covered loss. Failure in filing a claim may be due to lack of information. This has been the case of farmers that were unaware that they were insured, or whose insurance policies were received by them after the relevant period. Some reasons for these situations have been failures from the intermediary banks to let the policyholders know the information of the agricultural insurance, or delays in processing with the insurance company the documents of the insurance policy, as well as delays in the transfers of subsidy funds by the Government to the insurance company, which in some cases delayed the issuing of the policies. From survey respondents who gave reasons for not having made a claim despite having their crops damaged (107 policies), 45% point to lack of knowledge of their condition of policyholders or about the process of filing a claim to the insurance company.

Another reason that limits the percentage of loss claims is high transaction costs. Many times the policyholder must spend time and incur expenses in transport and telephone in order to make sure their claim forms have been received by the insurance company; in order to make the adjuster visit the farm, or in order to have the payment made. All this implies visits and calls to the intermediary bank, as well as calls to the insurance company, representing efforts and expenses that not all insured farmers are willing to assume. From the 107 cases of producers who suffered losses without making a claim, 34% were due to lack of time or to the perception that making a claim meant a waste of time since there is no trust in the insurance company's (or bank's) capacity to deal with the claim, or because it was foresaw that the amount of the indemnity payment would not compensate transaction costs. As a result, despite 34% of policies in the sample had losses (45% in 2011 and 19% in 2012), only 25% made a claim (37% in 2011 and 10% in 2012), whereas the remaining 9% did not.

The second motive of confusion is that, in many cases, *the policyholder did not understand that he/she had only up to 10 days after the loss occurrence to send the loss notice*. In this case, the insurance company rejects the claim or applies a penalty to the insured amount, depending on how late the claim was made. According to our sample, 54% reported that the deadline to send the loss claim was between 1 and 10 days; however, only 19% was right on the maximum number of days to send the claim (10 days). The remaining 46% stated that the deadline was between 12 and 120 days.

The third motive of confusion is that the policyholder sent successfully his/her loss notice but it was a partial loss and later failed in sending the harvest notice form. In this case, all rights of receiving a payment are lost.

The fourth motive is that the insured area the farmer assumes may differ from the effectively insured area, which might make the payment differ from what the farmer expects. For 57% of cases from the sample, the insured area as reported by the farmer was different from the effectively insured area

(34% of cases thought their insured area was larger than the effectively insured, while the opposite happened for 23% of the cases).

A fifth motive of confusion is that the coverage period of the crop is limited to 120 days, which the farmer may not be aware of, and therefore think his/her crop is covered until the harvest, even if this happens further than 120 days after sowing. This was the case of many farmers in Celica canton, where the corncob is left to dry on the plant before being harvested, which may lead a 4-month crop to take even six or seven months. During focus groups, there was also mention of cases in Daule where rice pests appeared close to harvest time, when the coverage period had ended. This way, the farmer might feel unsatisfied and even uncovered against risks he/she thought to be covered.

Besides lack of understanding of deadlines and terms of contracts from the farmers side, other types of problems that may hinder the policyholder to have a complete coverage against losses from covered causes, are differences that may occur between the estimated yields made by the adjuster and actual yields. The insurance company applies a yield estimation methodology but this estimation may differ from the amount actually harvested. Moreover, there might be differences between the adjuster assessment of farmer effort and actual effort on the farm.

Lack of knowledge about the insurance contract is also evident in aspects as the insurance cost and the covered risks. This can be seen in Table 3.2.

Table 3.2. Knowledge of the Insurance by the Sample

	2011	2012	Total
Knew how much they paid for the insurance	41%	32%	37%
Knew that the Government subsidizes the premium	13%	12%	12%
Knew all covered risks	54%	53%	53%
Thought that additional risks were covered	11%	11%	11%

As it can be seen, the lack of knowledge or misunderstanding of the contract may lead the policyholder to remain unprotected against covered risks despite having paid for an agricultural insurance.

3.3 Coverage level for policyholders in the sample

In order to look at the conventional insurance capacity to stabilize farmers income, we show next an analysis of the insurance effect on different levels of gross income according to our survey respondents experience in the two years considered. Gross income means in this case the income from agricultural output resulting from the insured crops, without deducting production costs and without taking into account other household incomes.

Gross income per hectare is defined as the yield per hectare multiplied by the reference price (price defined in QBE insurance contracts). Table 3.3 shows the distribution of gross income per hectare from the entire sample (both years, both crops) and it is compared with the gross incomes modified by QBE insurance payments; i.e., considering the premium paid and the indemnity payments received. In short, the columns correspond to equations (2) and (3):

$$Y_{SS} = pR \qquad (2)$$

$$Y_{SC} = pR + I - C \quad (3)$$

Where Y_{SS} is gross income per hectare with no insurance ($/ha); Y_{SC} is gross income per hectare with conventional insurance ($/ha); *R* is realized yield (QQ/ha); *I* is indemnity payment received ($/ha) and; *C* is paid premium ($/ha).

Deciles divide the simple in 10 groups of the same size, sorting farmers from small to large according to their gross income per hectare (without insurance). Survey respondents in decile 1 constitute the inferior tail of the gross income distribution. Average gross income for this first decile was $177/ha. On the other side, average gross income from survey respondents in decile 10 was $2,630/ha.

Table 3.3. Gross Income and Percentage of Indemnity Payments by Decile: Aggregate Sample (both crops both years)

Decile	Gorss Income without insurance (US$/ha)	Gorss Income with QBE insurance (US$/ha)	% of policies that received indemnity payments
1	177	257	80.2%
2	427	502	74.4%
3	634	656	46.9%
4	857	859	42.4%
5	1,046	1,029	30.0%
6	1,251	1,208	14.3%
7	1,466	1,422	14.0%
8	1,698	1,653	9.9%
9	2,018	1,971	8.3%
10	2,630	2,573	6.1%
Total	***1,216***	***1,209***	***32.8%***

The third column in Table 3.3 shows, without changing farmers composition in deciles, gross income when the net indemnity payment (payment minus premium) received from QBE's conventional policy is added. It can be seen that, thanks to this insurance, farmers in deciles 1 to 4 were able to improve their gross income. For instance, decile 1 farmers' gross income increased by almost 50%, from $177/ha to $257/ha thanks to the insurance. In contrast, average gross income for farmers in deciles 5 to 10 decreased due to the insurance premium expense being on average higher than the indemnity payment received. Average costs of sowing a hectare of feed corn or rice range between $800 and $1,000, which suggests that, as expected, indemnity payments for this contract have benefited mainly farmers with gross incomes lower than their production costs, i.e., farmers who experienced loss.

What was stated previously can be confirmed in the last column of Table 3.3, which shows the percentage of survey respondents that received an indemnity payment in each decile. It can be seen there that deciles that experienced the highest losses were the ones which received indemnity payments with higher frequency. Consistent with this, percentages decrease when moving to the higher deciles.

Breaking down the analysis per year and per crop, we can observe differences in the stabilizing effect of gross incomes by the conventional contract in each case. Table 3.4 shows information for feed corn policies (El Empalme and Celica cantons) and Table 3.5 does it for rice policies (Daule canton).

As already mentioned, 2011 was a very adverse year for feed corn producers due to an acute drought and their limited access to irrigation, which explains that year's low incomes per harvest (only the 2 highest deciles have gross incomes larger than $1,000). In line with this situation, the percentage of QBE's indemnity payments is relatively high –especially in deciles 1 to 4-. As a result, income after considering indemnity payments minus premiums is better than the no-insurance case for all deciles, except for the tenth one. The last row of Table 3.4 shows three important points about year 2011. First, for the whole group of corn producers, no-insurance average income was only $687/ha, amount lower than the average production cost, which indicates the frequency and magnitude of loss among corn producers in 2011. Second, the fact that two thirds (65.6%) of corn producers received an indemnity payment in 2011 suggests that the insurance responded to the production crisis. Third, and in a related way, because of the insurance, gross income of the whole group of corn producers in 2011 increased approximately 10%, from $687/ha to $744/ha.

The situation for 2012 is the opposite to 2011 in terms of the insurance's capacity to improve or stabilize gross incomes of sample farmers. In that year, climate effects were not severe, thanks to which gross incomes larger than $1,000/ha are observed from the fifth decile on. Indemnity payments percentage is much lower than 2011's in almost all deciles and the average level of gross income for the whole group of corn producers was slightly lower with insurance ($1,267) than without insurance ($1,301). Again, this difference was to be expected in 2012 since that year was a lot better in terms of climate and then both frequency and magnitude of losses were smaller.

Table 3.4. Gross Income and Percentage of Indemnity Payments by Decile: Corn Farmers, 2011 and 2012

	2011			2012		
Decile	Gorss Income without insurance (US$/ha)	Gorss Income with QBE insurance (US$/ha)	% of policies that received indemnity payments	Gorss Income without insurance (US$/ha)	Gorss Income with QBE insurance (US$/ha)	% of policies that received indemnity payments
1	95	179	86.2%	380	376	39.3%
2	260	361	90.6%	700	674	33.3%
3	357	441	82.0%	880	881	50.0%
4	421	530	87.9%	997	975	40.4%
5	502	561	67.7%	1,121	1,065	16.3%
6	602	649	63.6%	1,277	1,230	21.6%
7	719	764	57.1%	1,439	1,400	24.6%
8	911	943	53.7%	1,635	1,596	29.8%
9	1,221	1,241	43.1%	2,049	2,000	24.0%
10	1,961	1,938	16.7%	2,662	2,604	16.7%
Total	***687***	***744***	***65.6%***	***1,301***	***1,267***	***29.6%***

Precisely due to their greater access to irrigation (more than 90% of rice producers in the sample have irrigation), Daule's rice producers did not suffered major losses in 2011, in spite of the drought. This can be seen in the gross incomes noticeably larger (higher than $1,000 from second decile on) for rice producers, compared to corn producers in 2011. However, better climate conditions in 2012 led to a better situation for rice farmers, compared to 2011, as it was the case with corn producers. This is reflected in the larger average gross income for the whole group of rice producers in 2012 ($1,882/ha) versus 2011 ($1,532). It is important to note that in both years, average gross income overtook substantially the average production cost, which revolves around $800 - $1,000/ha.

Consistent with the lower level of losses, in both years, the level of indemnity payments to the rice producers is quite low (even 0% in several deciles), even in the first decile, compared with the case of corn producers in 2012. This can be explained not only by the lower frequency of losses among rice producers, but also by the low level of loss claims from rice producers who indeed experienced losses in Daule (Table 3.6). This, in turn, would be explained by the lack of information or of understanding of the contract functioning, as was described in sub-section 3.2. As a result, insurance does not improve average gross income of famers in any of the deciles and in any of the two years.

Table 3.5. Gross Income and Percentage of Indemnity Payments by Decile: Rice Farmers, 2011 and 2012

	2011			2012		
Decile	Gorss Income without insurance (US$/ha)	Gorss Income with QBE insurance (US$/ha)	% of policies that received indemnity payments	Gorss Income without insurance (US$/ha)	Gorss Income with QBE insurance (US$/ha)	% of policies that received indemnity payments
1	652	613	5.0%	542	529	11.5%
2	1,005	969	7.5%	1,211	1,147	0.0%
3	1,196	1,150	2.5%	1,489	1,431	3.8%
4	1,312	1,259	0.0%	1,665	1,607	3.4%
5	1,459	1,417	5.0%	1,837	1,772	0.0%
6	1,574	1,521	0.0%	1,963	1,919	3.8%
7	1,708	1,667	5.1%	2,116	2,052	0.0%
8	1,830	1,781	2.5%	2,312	2,248	0.0%
9	2,081	2,036	2.4%	2,521	2,457	0.0%
10	2,548	2,494	0.0%	3,241	3,182	4.0%
Total	***1,532***	***1,486***	***3.0%***	***1,882***	***1,827***	***2.7%***

Table 3.6. Frequency of Claims among Farmers who Experienced Loss (cumulative years 2011 and 2012)

Canton	Farmers that experienced loss	% of farmers with a loss who filed a claim
Celica	429	83%
El Empalme	125	90%
Daule	98	19%
Total	***652***	***75%***

So far, we have explored the ability of the conventional insurance contract to improve or not improve gross farmer income, especially when yields are too low so that gross incomes are not enough to cover production costs. Now, we proceed to analyze how close the improved income (gross income with QBE insurance) is to the level famers would have expected due to the fact that they were insured. In order to accomplish this, we assume a measure of loss similar to the one introduced in sub-section 3.1, so as to define an expected indemnity payment. This is formalized in equation (4).

$$I^E = \begin{cases} 0.7p(D_{SC} - R) & si\ R < D_{SC} \\ 0 & si\ R \geq D_{SC} \end{cases} \quad (4)$$

Where, I^E is expected payment per hectare. Let us recall that D_{SC} is the "trigger" for the conventional insurance contract and that it indicates the level of yield that the farmer must obtain in order to cover production costs. The farmer suffers loss when his/her realized yields, *R*, are smaller than his/her individual trigger. In that case, the farmer expects to receive 70% of the value of the loss (due to the 30% deductible). In contrast, when realized yields are larger than the trigger, the farmer does not suffer loss and, therefore, expected indemnity is cero.

However, this level of expected indemnity payment should be taken with caution because it assumes that all are partial rather than total losses (that is, it assumes that all the resources were invested in the crop). Recall that, in the case of total loss, the insurance company only covers the amount invested in the crop until the time of the loss; this reduces the level of the trigger and hence the payment. Total losses were more common for corn in 2011 than for rice in that year or than for both crops in 2012.[13]

Having that warning in mind, we computed expected gross income for the farmer in the case of experiencing loss as follows:

$$Y_{SC}^E = pR + I^E - C \quad (5)$$

Where, Y_{SC}^E is expected gross income per hectare with conventional insurance ($/ha) and *C* is the value of the premium ($/ha). This expected income represents the closest that the farmer can get to recovering crop investment thanks to the insurance.

We observe for average rice and feed corn cases, the ability of the conventional contract of returning the policyholder a value that takes him/her to a gross income level that is as close as possible to the amount invested on the parcel. In order to define an average trigger, we use the average insured amounts per hectare and the average referential prices of the two years in each case (corn[14] and rice). For more information, Table 3.7 shows the average trigger for each canton in each year.

[13] According to QBE's data for the portion of our surveyed farmers who filed a damage claim, 60% of corn farmers had total loss in 2011 (loss of 85% or more of the crop), being the percentage only 8.6% in 2012. For rice farmers, the percentages are 11% that had total loss in 2011 and 22% in 2012. Nonetheless, it is worth noticing that the 60% of corn farmers with total loss according to QBE in 2011 is decomposed in 40% who reported to our survey having harvested up to 30 quintales per hectare and 20% who reported yields of more than 30 quintales. This could imply a continuation of investment in the parcel by farmers who had being declared as having total loss and who were advised by QBE not to continue investing in the crop.

[14] Once again, our calculations include both El Empalme and Celica.

Table 3.7. Triggers for the Conventional Contract

	2011 (QQ/HA)	2012 (QQ/HA)
Celica (Corn)	58	55
El Empalme (Corn)	49	52
Daule (Rice)	67	75

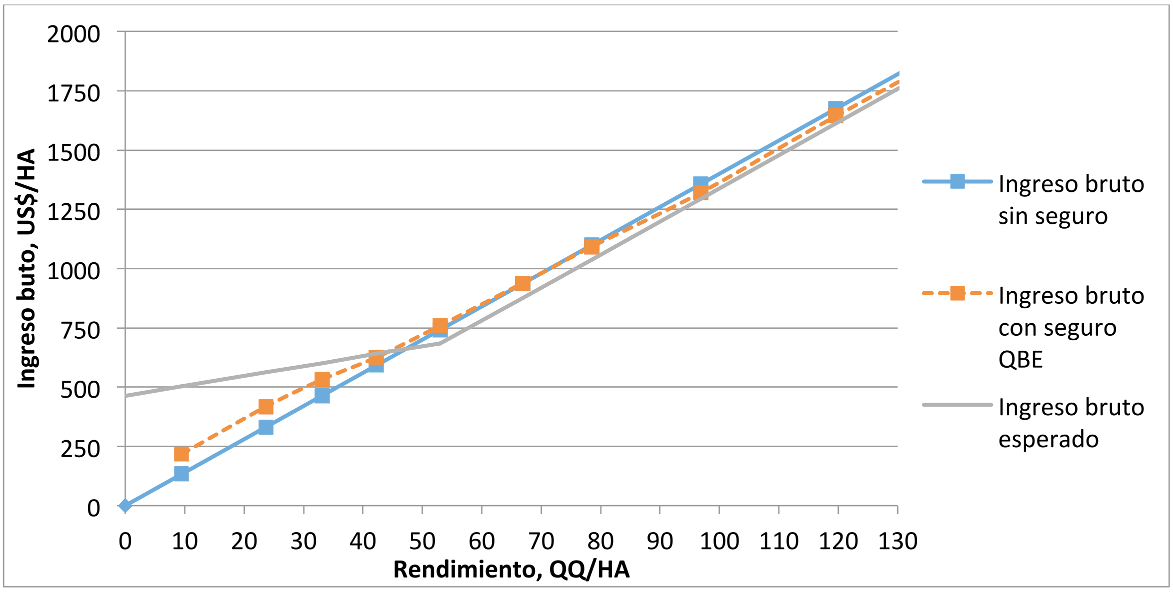
For the feed corn, the average trigger is 53.5 quintales per hectare, which implies a gross income of $749 per hectare when we apply the average referential price of $14 per quintal. Hence, farmers that obtained yields below this level, would have expected to receive an indemnity payment and hence to reach a gross income based on equation (5). Table 3.8 shows that farmers in the first four deciles experienced loss and therefore their expected income with QBE insurance is larger than the gross income without insurance. The contrary occurs for deciles 6 to 10. Given that no farmer in those deciles suffered loss, no one should receive a payment and, consequently, expected income with insurance for those deciles is approximately $62/ha less than the income without insurance. The difference corresponds to the premium. Finally, average yield of corn farmers in the fifth decile is half quintal less than the trigger, which implies that some farmers in that decile should not have received any payment while others should have received a small payment, lower than the premium, and hence expected gross income with insurance is also lower than gross income without insurance for that decile.

Table 3.8. Average Yield and Income by Decile: Corn Farmers (years 2011 and 2012)

Decile	Average yield (qq/ha)	Gross income without insurance (US$/ha)	Expected gross income with QBE insurance (US$/ha)	Actual gross income with QBE insurance (US$/ha)
1	9.5	133	502	216
2	23.7	332	562	418
3	33.1	464	602	532
4	42.3	592	640	626
5	53.0	741	685	759
6	66.9	937	875	939
7	78.5	1,099	1,037	1,093
8	96.9	1,356	1,294	1,320
9	119.6	1,675	1,613	1,643
10	170.9	2,392	2,330	2,343

Figure 3.1 presents the three types of gross income (three last columns of Table 3.8). The squared markers identify the different diceles. We can see there clearly how expected gross income (grey line) is greater than gross income without insurance (light blue line) for deciles one to four.

Figure 3.1: Gross Income by Decile. Feed Corn Case (average of years 2011 and 2012)*



*For better visualization, we show only until the ninth decile.

Now, if we observe realized gross income, represented by the orange line, which takes actual QBE's indemnity payments into consideration (see equation 3 above), we can appreciate that the insurance improved gross income for farmers who had loss; however, such gross income with insurance is significantly below the expected gross income with insurance. That situation could be the result of few farmers receiving payments in those deciles or of many farmers receiving just low payments. Table 3.9 shows that, for the feed corn case, the percentage of farmers that suffered loss and who received an indemnity payment is relatively high, especially in the first two deciles. In contrast, the average net indemnity (actual indemnity payment minus the premium) is much lower than the expected indemnity (expected indemnity payment minus the premium), with the exception of the fourth decile, and especially in the first two deciles.

Table 3.9. Actual versus Expected Indemnity for Corn Farmers: First Four Deciles

Decile	% of Insured farmers who received a payment	Average net indemnity payment (US$/ha)	Average expected net indemnity payment (US$/ha)
1	84%	99	369
2	82%	105	230
3	73%	93	138
4	57%	60	48

The differences between actual and expected indemnity payments could be because of the total loss cases mentioned previously, which were more frequent in the first two deciles,[15] but there are also

[15] Of the total corn farmers in the first two deciles (less than 24 quintales per hectarea), 68% were reported by QBE as having had total loss; that represents 92% of the farmers in those deciles that made a claim according to QBE.

implicit here cases of negatives to claims or of penalties to the insured amount due to late or incomplete filing of claims. In addition, there were cases of over-estimation of yields by the insurance company, which would have lead to indemnity payments lower than the expected amount.[16]

In the case of rice, the average trigger is 71 quintales (or $1,100). The only farmers that would have experienced loss are the ones in the first two deciles (Table 2.9); however, the low level of losses for the second decile implies an expected gross income lower than the gross income without insurance.

Tabla 3.10. Average Yield and Income by Decile: Rice Farmers (years 2011 and 2012)

Decile	Average yield (qq/ha)	Gross income without insurance (US$/ha)	Expected gross income with QBE insurance (US$/ha)	Actual gross income with QBE insurance (US$/ha)
1	38.6	598	891	576
2	69.1	1,070	1,033	1,019
3	81.1	1,257	1,199	1,206
4	92.4	1,431	1,373	1,385
5	101.8	1,578	1,519	1,520
6	110.5	1,713	1,654	1,667
7	120.0	1,859	1,801	1,811
8	132.5	2,053	1,995	2,000
9	147.1	2,281	2,222	2,221
10	186.2	2,886	2,827	2,827

Figure 3.2 shows how the expected gross income would have been greater than the gross income with no insurance for the first decile, but that the gross income with QBE insurance does not reach that level and is even a little lower than gross income without insurance. Contrary to the situation with corn farmers, in this case the difference is due to the little percentage of policies that received indemnity payments (only 9%). As a result, there is a big different between the net expected indemnity in the first decile ($293) and the actual net indemnity in that decile; the later one is actually negative, reflecting the low level of payments relative to the premiums received by the insurance company.

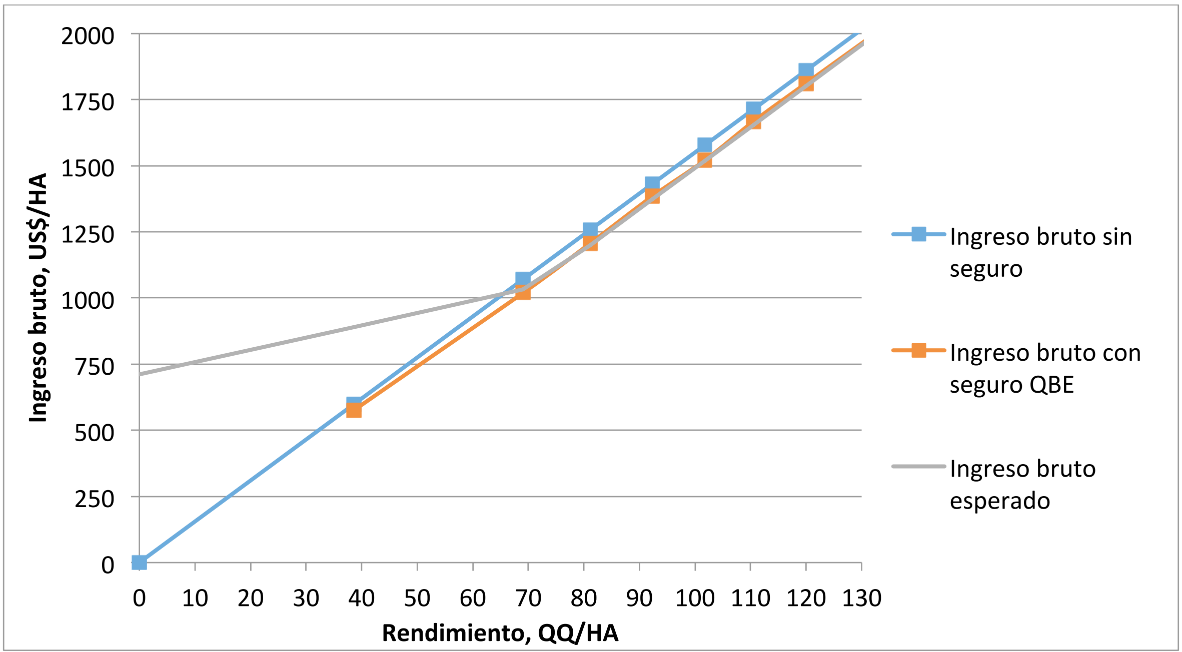
As it was previously stated, an important cause of this low capacity of the conventional insurance to return rice farmers a value that takes them closest to the amount invested in their crop, seem to have been due to the low percentage of claims by rice farmers in Daule (Table 3.7) as a result of disinformation or of high transaction costs. Nonetheless, here are also included cases of negatives to claims or of penalties to the insured amount due to late or incomplete claims, as well as cases of over-estimation of yields by the insurance company.[17]

[16] Of the corn farmers in the first four deciles who made a claim according to QBE's data, 22% had yields lower than the estimated yields during QBE's adjusting process.

[17] Of the rice farmers in the first decile who made claims according to QBE's data, 60% had yields lower than the estimated in the adjustment process. This percentage should, however, be taken with caution due to the low density of observations in this case (only 3 out of 5 policies).

The analysis in this section takes us then to understand the effect that limitations in effective coverage, due to the complexity of the conventional contract, can have on the actual gross income of insured farmers.

Figure 3.2: Gross Income by Decile. Rice Case (average of years 2011 and 2012)*



*For better visualization, we show only until the seventh decile.

4. THE ALTERNATIVE: A "SHADOW" AREA YIELD INSURANCE CONTRACT

As we saw in the previous section, the conventional contract offered by QBE requires one or two visits by the claims adjustor to every farm for which a farmer filed a claim. These visits, which are necessary to estimate the value of the loss and that the loss was caused by an insured risk, imply significant operating costs. These costs are likely to be especially large when the insured farmers are small-holders whose plots are typically located in relatively remote areas with poor infrastructure. These elevated costs raise the question of whether it is feasible to build an insurance market based on conventional crop insurance that is both economically sustainable and provides effective risk management to small-holders. In this section we argue that index insurance may provide an attractive alternative.

One of the main advantages of index insurance is the reduction in operating costs that results from not having to carry out on-site inspections on insured plots. In this section we briefly review the logic of index insurance. We identify alternative forms of index insurance and identify their advantages and disadvantages. We then describe the type of index insurance that we believe is most feasible in the case of Ecuador, area yield insurance, and we provide details about the construction and the characteristics of the "shadow" contracts that we design for rice and corn farmers in the three study regions.

4.1 Index insurance: A Brief review

In contrast to conventional, named peril insurance which pays an indemnity conditional on verification of a covered loss on the insured parcel, a payout is made in an index insurance contract if the value of an external index exceeds (or falls below) a contractually specified value known as the strikepoint. In order for an index to be viable, it must satisfy the following two characteristics:

- The index should be highly correlated with average yields of farmers in the contract area. This condition ensures that, on average, the insurance pays out when farmers are most in need. As we will discuss in more detail shortly, the lower is this correlation, the greater is the level of *basis risk*, or the risk that a farmer suffers a loss but does not receive a payout.
- The probability density function – i.e., the function that determines the probability that the insurance company must make an indemnity payment – must be exogenous, or independent, of the characteristics and the actions of the insured farmers. This condition greatly reduces the problems associated with moral hazard and asymmetric information that make the provision of conventional insurance so costly.

One of the factors that determine whether or not index insurance is appropriate is the nature of production risk that producers face. In general, we can decompose total risk into the following two types of risk:

- Covariate (common) Risk: is the variability in production due to factors – such as drought, widespread flooding and other climatic events – that adversely affect the production of the majority of farmers in the contract area. Covariate risk thus drives season-on-season variability in average yields.
- Idiosyncratic (individual) Risk: is the variability in production due to factors – such as non-epidemic health shocks, hail and other highly localized weather events – that affect only a small fraction of farmers in the contract area. Idiosyncratic shocks are independent of the variability in average yields in the contract area.

Since the index does not reflect the specific situation of each insured farm, but instead captures fluctuations in average yield in the contract area, a well designed index insurance contract should offer valuable protection against covariate risk. For this same reason, however, index insurance does not offer protection against idiosyncratic risk. This inability to protect against idiosyncratic risk, and the corresponding presence of basis risk, is one of the principal limitations of index insurance.

As mentioned above, basis risk is the risk that the farmer suffers a loss but does not receive an insurance payment because the index did not exceed the value of the trigger. Basis risk exists for two reasons. First, index insurance protects against covariate but not idiosyncratic risk. Therefore, the greater is the relative importance of idiosyncratic risk to the specific production context, the greater will be basis risk and lower will be the protection offered by index insurance. Second, the lower is the correlation between the index and average yields in the contract area, the greater will be basis risk.

In general, we can classify indices into two classes: *indirect and direct*. Indirect índices are used to provide indirect estimates of average yields in the contract area. Examples of indirect índices include various functions of weather phenomena including rainfall and temperature as well as indices, such as the Normalized Difference Vegetative Index, that are based on satellite imagery. An important challenge of indirect indices is understanding the relationship between the weather event (or satellite imagery) that generates the data (i.e., millimeters of rainfall) and average yield and then to design the index to best capture this relationship. In many cases, this requires a good agronomic model of crop growth for the specific insured crops. The potentially large advantage of these indirect índices is that relatively low cost of index measurement which, in many cases, simply requires taking measurements from weather stations or downloading publically available satellite data from the internet.[18] Although indirect índices, generally, imply relativley low operation costs, they also have several disadvantages. Most importantly, if the index only captures one of the multiple sources of covariate risk, then basis risk may be significant. For example, coffee production is adversely affected by excess rainfall in the flowering period as well as by a deficit of solar radiation during the period of fruit growth. If the index is based solely on rainfall, for example, the contract will likely suffer from significant basis risk.

Direct indices, in contrast, directly estimate average yield in the contract area, typically by through a production survey or plant cuttings of randomly selected plots. *Area yield* is the main direct index.[19] Precisely because they directly measure average yields, direct indices take into account all of the potential sources of covariate risk that affect average production levels and, as a result, will be characterized by lower levels of basis risk than indirect, weather-based indices. A second advantage of direct indices is that they are typically more intuitive, transparent and easy to understand for farmers relative to indirect indices.

The main disadvantage of direct indices is the greater cost associated with directly measuring average yields through farmer surveys or crop cuttings. This cost will depend on various factors, including the sample size needed to achieve a specified level of statistical precision of the average yield estimate as well as the spatial dispersion of and ease of access to the sampled plots. Another important factor affecting the cost of direct índices is the existence (or not) of a national agricultural production survey. As we will see shortly, Ecuador carries out a national production survey that, with some modifications, could serve as the basis for the measurement of area yields for an index insurance contract. The existence of this national survey represents a particularly important cost savings and, additional coordination with the National Statistics Bureau (the state entity that implements the survey), could make an area yield insurance contract feasible in the case of Ecuador.

In summary, there exists a tradeoff when we choose between conventional versus index insurance. From the point of the insurance provider, the premium must cover, in expected value terms, the cost of offering the insurance. These costs have two main components – the expected value of the indemnity payments made to farmers and operating costs. Given that index insurance implies lower operating costs, for a given level of premium index insurance can offer larger indemnity payments tan conventional insurance. In the absence of basis risk, index insurance would thus provide greater protection to the farmer for the same Price. The presence of basis risk, however, reduces and may negate this advantage. The empirical exercise we carry out in the rest of this paper evaluates this tradeoff.

4.2 The shadow area yield contract in Ecuador

According to the discussion above, the appropriate type of index insurance will depend greatly on context, including the types of crops grown and, especially important, the availability of information. In the specific case of Ecuador, we have chosen to evaluate the viability of an area yield index

[18] In practice, acquiring and assembling data underlying indirect indices may imply some costs. First, there may exist fixed costs to design the index (including research to identify the strongest relationship between the available weather or satellite data and yields). Second, the information may not be freely available. Although it is typically the public sector that collects and manages weather data, the institutions that manage the data may charge for their access. In the case of satellite data, experts often need to be hired to convert the raw data into data that is usable for the purpose of an index. Finally, installing and maintaining weather stations implies a non-negligible cost.

[19] In the case of cattle, livestock mortality measured via survey is an example of a direct index.

insurance contract. This decisión was based on three factors. First, as we mentioned above, area yield based index insurance offers the greatest potential for protection because it has the lowest incidence of basis risk (among potential indices). Second, Ecuador enjoys a privileged situation with respect to data availability. Specifically, since 2000 the government of Ecuador has administered the Continuous Area and Agricultural Production Survey, known by its Spanish acronym ESPAC. The ESPAC is a national survey that collects data on area planted and yields and thus can potentially serve as the basis for an area yield index. Finally, while a relatively high quantity and quality of yield data exist, the opposite occurs with weather data in Ecuador. There are relatively few meteorological stations, including only two automated stations, and the data that do exist are simply insufficient to design index-based contracts.

We describe the construction of the shadow area yield contract in the following steps. First, we describe the historical yield data which are the primary input for estimating the probability distribution function for the index. Second, we describe the construction of contract areas, which are the areas for which we propose to measure area yield for the execution of the contract. Finally, once the contract areas are defined, each one of which will have its own shadow contract, we describe the estimation of the probability distribution function and the ensuing calculation of the premium for the contract in each contract area..

The Historical Data: The ESPAC yield survey

The construction of an area yield index insurance policy requires the existence of historical yield data in order to estimate the probability distribution function of the index. This function determines the probability that the average yield in the contract area falls below the strikepoint and thus is crucial for determining the level of the premium.

The historical data that we use come from the ESPAC, a survey administered annually by Ecuador's National Census and Statistics Bureau (INEC), with the primary objective of generating province-level estimates of production and yields for the country's most important crops. The ESPAC uses the 2000 agricultural census as its sample frame. The census divided the country's cultivable land into Primary Sampling Units (UPM), which are contiguous areas of approximately 10 square kilometers that are homogeneous in terms of agro-ecological conditions. Each UPM , in turn, was sub-divided into smaller sampling units called Sample Segments (SM). Each SM has an approximate area of two square kilometers. In 2002, from a total of 69,272 SM throughout the country, INEC randomly selected 2,000 for inclusion in the ESPAC sample. Within the SM that were selected for the ESPAC simple, INEC applies the annual ESPAC survey which collects information on land use, area planted and production in the entire area within each SM.

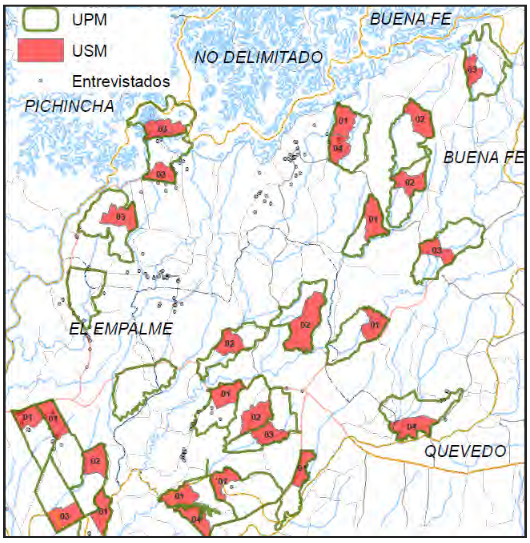
Beginning in 2002, INEC carried has carried out the ESPAC in the same 2,000 SM each year.[20] If we include the data collected from these same SM's in the 2000 census, there exists a 12 year panel data base of these 2,000 SM (2000, 2002 – 2012). This is the data base that we use to construct the indices.[21]

Figure 4.1 shows the sampling units for the canton of El Empalme. The green lines are the borders of the UPM. The smaller red areas are the Sampling Segments (SM's) that were selected for the

[20]2006 was the only exception. In that year, due to a one-time budget expansión, the ESPAC was carried out in 3,610.
[21]Note that while the land that is included in the ESPAC survey each year does not change, the individuals that cultivate and thus who are surveyed may change..

ESPAC and for which we have historic data on production and yields. The grey dots represent the plots of the insured farmers from our study sample.

Figure 4.1 Sampling Units of the National ESPAC Survey



Given that our objective is to construct a shadow index contract for corn and rice, we restrict attention to those SM that have sufficient planted area in these crops between 2000 – 2011. Specifically, we only included in our analysis those SM's in which at least one plot was planted in the relevant crop (rice in Daule and corn in El Empalme and Loja) in at least 10 of the 11 years. Table 4.1 summarizes the density of historical data from the ESPAC that we use to construct the indices.

Table 4.1. Summary of Historical Data from the ESPAC used in our Analysis

	Celica (Corn)	El Empalme (Corn)	Daule (Rice)
# of Sample Segments (SM)	12	36	28
Average # of plots per SM	23	17	55
Average area planted per SM (ha)	87	53	171

According to Table 4.1, there were 12, 36, and 28 Sample Segments that met our criterion in Celica, El Empalme y Daule respectively. Of the three cantons, Daule has the greatest density of data (on average 55 plots per SM). This is a result of the relatively high level of mono-cropping of rice in Daule, which implies that in segments that have rice production, a relatively high percentage of the area is dedicated to rice. In contrast, in the SM included in Celica and El Empalme, corn is less dominant of a crop.

Definition of Contract Areas: Clusters of Sample Segments

Above we described the spatial structure of the ESPAC data. For our shadow index contract we propose to use these ESPAC data not just to design the contract but also to execute the contract moving forward. As a result, the next step is to define contract areas. By contract area, we mean the area in which average yields will be measured using the ESPAC data in order to execute the index contract. Each contract area has its own probability distribution function and, as a result, also will have its own contract terms. Once the contract areas are defined, we then turn to a rule for assigning each plot to its contract area.

There are several options for defining the contract areas. At one extreme, we could define the entire canton as a single contract area. Under this option, we would combine the data from all of the ESPAC SM's within the canton in order to estimate the average yield in the canton. This option would be attractive if canton was characterized by a high degree of homogeneity in terms of agro-climatic conditions. Unfortunately, the cantons in our study (and in general in Ecuador) are characterized by a high degree internal heterogeneity and, as a result, this option would result in a high degree of basis risk.

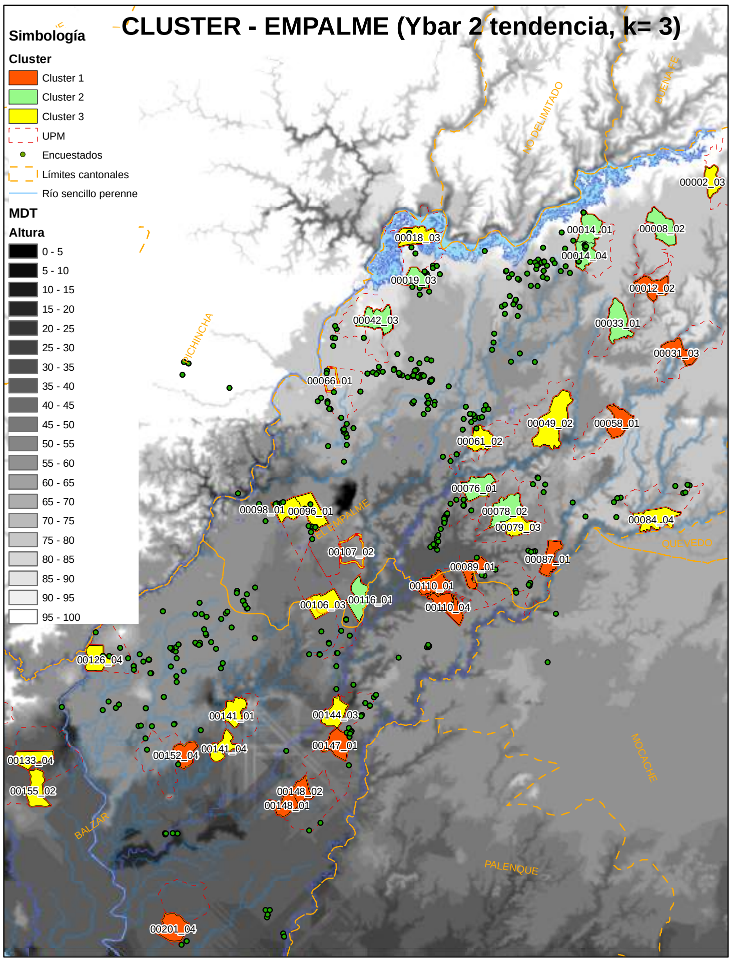
At the other extreme, we could define one contract area for each SM. While this option would reduce the level of basis risk, it suffers from two potentially serious problems. First, since there are relatively few (between 10 – 50) plots in each SM, this option would generate an estimate of average yield that may have relatively low statistical precision (i.e., relatively large confidence interval around the estimate). The second concern is more operational. This option would imply defining and executing a different contract for each SM and, as a consequence, would increase the operating costs of the insurance policy. In the case of El Empalme, for example, this option would imply defining 36 separate contracts.

The option we chose for this exercise represents a middle ground in terms of spatial aggregation. Specifically, in each canton, we use the statistical technique of cluster analysis to group together similar SM's into a small number (two in Celica and three in Daule and El Empalme) of contract areas. While this definition of contract areas based on "clusters" offers greater operational simplicity as it reduces the number of contracts, it implies a statistical tradeoff that may affect the quality of the insurance. On one hand, the grouping of multiple SM's implies the use of a larger number plots (from the ESPAC survey) and a larger planted area in the calculation of the average yield of the contract area. If the yields of all of the plots within the clustered contract area follow the same (or similar) probability process, then this increase in the sample size would increase the precision of the average yield estimate. On the other hand, if the clustering process combines parcels from relatively heterogeneous SM's, we would run the risk of increasing basis risk because the average yield of the clustered contract areas would be less correlated with the yield individual insured plots.

In order to minimize this tradeoff, we used the cluster analysis to define clusters that maximize the co-movement between average yields across SM's over the historical period for which we have data from the ESPAC survey: 2000 – 2012. As a result of this statistical procedure, we define three contract areas in the cantons of El Empalme and Daule and two contract areas in Celica. While in some cases the clustered contract areas include SM's that are quite spatially concentrated, in other cases the contract areas include SM's that are more distant from each other but that share certain characteristics (for example altitude or bordering a river) that imply a high degree of co-movement in average yields.

Figure 4.2 depicts the outcome of this clustering process for the canton of El Empalme. The 36 SM's of this canton were grouped into three distinct clusters, each representing a separate contract area. In the Figure, these three contract areas are represented by different colors (red, light green and yellow). The dark green points represent the location of the plots of the farmers in our survey. In order to evaluate the performance of the shadow index insurance contract, we need to assign each parcel to a contract area. The rule we followed was to identify the SM closest to each plot and then assign the plot (the points in dark green) to the contract area that includes that SM.

Figure 4.2 Contract Areas in canton El Empalme as defined by cluster analysis



Calculation of the Index Insurance Premium

We conclude this section with a general discussion of the calculation of the area yield index insurance premium. We apply this methodology to the specific contracts for each crop and contract area in the next section.

The Premium of any insurance policy, in general terms, consists of two components: the *pure (actuarially fair) risk premium* and the *loading factor*. The pure risk premium is the premium that the insurance provider would have to charge so that, on average (i.e., in expected value terms) the indemnity payouts just equal the value of premiums received. The loading factor is the percentage of the pure risk premium that the insurance provider charges in order to cover operating costs and profits.

The pure risk premium depends on three factors. First, it depends upon the value of the strikepoint. En the case of an area yield index, the higher is the strikepoint, the greater is the probability that the insurance provider makes an indemnity payment and, as a result, the greater will be the pure risk premium. Second, the pure risk premium depends on the indemnity schedule, which specifies the values of the indemnity payments for each level of average yield below the strikepoint. Again, the larger is the value of the indemnity payments, the greater will be the pure risk premium.

Finally, the pure risk premium depends on the probability distribution function of the index itself, which in our case is the average yield of the contract area. Using the 12 years of historical data from the ESPAC survey, we estimate these probability distribution functions using parametric regression methods. Specifically, we assume that the probability distribution function takes the form of a Gamma distribution, which has two parameters: one describing the "location" and the other describing the "shape" of the distribution.[22] The result of the regression procedure is a probability distribution function for each of the 8 contract areas: three in El Empalme, three in Daule and two in Celica.

5. EVALUATION AND COMPARISON OF INDIVIDUAL INSURANCE AND INDEX INSURANCE

The third section of this report used information at the crop level from the years 2011 and 2012 to characterize the effectiveness of Ecuador's current conventional agricultural insurance program, which was designed as a mechanism to protect the livelihoods of small farmers exposed to negative shocks from the weather and other insurable risks. The fourth section used annual yields from the ESPAC survey to construct a shadow index insurance contract designed to cover the risks faced by the farmers surveyed in 2011 and 2012. Using the analytical tools developed in the previous sections, this section looks to compare both insurance scenarios, asking the question: Which type of agricultural insurance is better for small farmers and, at the same time, which is a better use of public resources: the conventional insurance or the index insurance?

5.1 Ways to compare the individual insurance and the index insurance

There are various strategies to compare the conventional contract with the index contract:

(i) An index contract could be designed to offer the same level of protection against risk as the existing conventional contract, at which point the question can be posed: Which of the two contracts offers the given level of protection at the lower cost? Or,

(ii) A shadow index contract can be designed to have the same cost as the conventional contract, at which point the question can be posed: Which of the two cost equivalent contracts offers the better protection against risk?

Either of these two strategies offers us a balanced evaluation, in some sense comparing 'apples to apples'. In this section's analysis, we will use the second approach. In other words, we are going to compare the quality of protection offered when the same amount of money is spent on the conventional insurances versus the index insurance. The results of this evaluation should be of interest for both the public sector (which subsidizes the cost of the insurance for the farmer) and for the farmers themselves, who also pay an important part of the cost of the insurance. Finally, the results should also be of interest for the financial institutions that offer credit to the agricultural sector because their default rates and level of profitability depend on farmer earnings.

Although this comparison of apples to apples allows us to compare some critical aspects of the two types of contracts, there are other aspects of relative performance that are outside the reach of this analysis. In particular, we do not have the necessary information to directly evaluate the financial sustainability of the insurance system in the long run. We do however know that, historically,

[22] An alternative to parametric estimation is to use the historical data to simply calculate the empirically observed probabilities of each value of average yield. However, since we have only 11 years of historical data, we prefer to use the parameteric method described in the text .

conventional insurance schemes for small farmers have failed, either because the premium was insufficient to cover the operating costs, or because the limited ability to effectively monitor the behavior of the famers lead to excessive loss claims (moral hazard), which raised loss rates to unsustainable levels and inflated operating costs for the insurers.[23] Nevertheless, we do not have any evidence that the current system of conventional insurance in Ecuador is unsustainable, and we are going to assume for the analysis we develop that it can continue to operate under the current conditions. There are, however, other elements can also threaten the financial sustainability of an index insurance, which will be duly analyzed later in this section. Nonetheless, for the majority of this document we will assume that the "shadow" contract of the index insurance is also financially sustainable.

Finally, it would be desirable to evaluate the impact of an insurance contract through a wider spectrum of results than simply the quality of protection. In particular, insurance for small farmers is especially relevant as economic policy given that it permits famers to invest more in their farms and thus increase their average earnings and, consequently, their quality of life. In other parts of the world, there is some evidence- though still limited- that insurance can fulfill this role.[24] In the case of Eduador, we have not had the opportunity to evaluate these impacts in the long run. A greater understanding of these impacts could contribute to making better-informed decisions about the desirability of investing limited public resources in an insurance system versus alternative interventions such as improving rural infrastructure or extending and deepening information technology, among others.

Unfortunately, this comparison is not possible given that the index contract still lives in the shadows. In the meantime, we will assume in this analysis that the true impacts of an insurance product are based only on its quality, measured by the level of income protection and the price of the insurance, and that, for a given level of quality and price, the type of insurance (conventional or index) does not influence the impacts. This assumption would not be valid, for example, if it were the case that farmers had more (or less) confidence in the index insurance than in the conventional insurance.

In summary, we are going to undertake a comparison based on two measures of the quality of protection offered by the conventional insurance and the index insurance when these two types of contract are offered at the same price.[25] Both measures, which we have already seen in the initial analysis of the performance of the conventional insurance in Section 3, evaluate the way in which the insurance affects the distribution of earnings with emphasis on the ability of the insurance to maintain a minimum level of earning for those farmers who suffered the greatest losses, which is to say those who are in the lower deciles of the yield distribution. The two measures are:

- The average net payment of the insurance and the total revenue received by the farmers (gross revenue plus net payment) in the different deciles of the average yield distribution,

[23] J. Skees et. al. (2006) reports that individual insurance schemes in the 80s in Brazil, Costa Rica, Mexico and the Philippeans had costs (indemnity plus operating costs) that were three to five times greater than the value of the premiums charged.
[24] For example, the work of Karlan et. al. (awaiting publication), Elabed et al. (2014) y Janzen y Carter (2013) demonstrate that the behavior of farmers changes significantly with insurance.
[25] Although both measures focus on the performance of the insurance from the perspective of the farmer, they are of equal interest to agricultural lenders because farmer incomes determine their ability to cancel loans. Effectively, insurance contracts generally pay indemnity directly to lenders in order to cover farmer debts.

- The fraction of farmers in each decile of the yield distribution who receive an indemnity payment.

5.2 How can contracts that are cost equivalent offer different protection?

It is important to consider two factors that determine the quality of coverage provided by an insurance product. The first is the fraction of the premium that is set aside to cover operating costs. For a given price, a contract with lower operating costs will be able to assign a greater percentage of the premiums charged to paying farmers, and offer a more generous indemnity structure.

The second factor is the failure of the contract itself. As was previously discussed, a contract failure occurs when a farmer incurs a loss but the contract fails to pay out. The contract failures under an index insurance scheme occur when the index is not perfectly correlated with farmer losses. This is the problem called "basis risk" which was introduced in the previous section. Under a conventional insurance scheme, the contract failures occur when the farmer suffers a loss that is the result of a cause not insured (a risk not included in the contract).[26] It is important to mention, however, that contract failures are not necessarily a sign of bad implementation of the insurance.

A contract with lower operating costs and a lower incidence of contract failure could then better protect the insured than another contract offered at the same price.

5.3 Apples to apples: Defining index insurance contracts with costs equivalent to the existing conventional insurance

In order to pursue a fair comparison of the quality of the conventional insurance and the index insurance, it is important to ensure that both contracts have the same price. This strategy allows us to evaluate which contract offers better protection to the farmer at a single level of expenditure on premiums (regardless of how much of the premium is paid by the government through subsidies and how much is paid by the farmer himself).

The index contract that we will compare to the conventional contract is the average yield contract based on ESPAC and described in the previous section. Additionally, we will use the standard methodology, also described in the previous section, to determine the parameters of the index insurance (trigger and indemnity level) which imply that the index insurance has the same price as the current conventional contract. The key assumption in these calculations is that the premium of the index insurance includes a "loading" factor of 30%, which implies that the final premium is 130% of the value of the pure risk premium. This additional 30% is a little higher than the "loading" factor used by the United States Department of Agriculture (20%) to determine the premium for insurance contracts indexed by average yield in the USA. A "loading" factor above 30% would result in an average yield contract that is less efficient than the one we are reporting in this document

[26] A contract failure could also result from a lack of understanding about the rules of the contract or about the responsibilities of the farmer in the execution of the contract. It could also result from a failure in the execution of the contract by the insurer. This problem can affect both types of contract, though the first should be less of a worry for index contracts due to the fact that they do not require any action, such as sending a loss notice, by the farmer.

As we mentioned previously, one of the attractive features of the index insurance – indexed by average yield or another index – is the reduction in operating costs. Although we do not know the percentage of the conventional insurance premiums that correspond to operating costs for the Ecuadoran case, we can determine what types of index insurance contracts can be offered at the same price as the conventional insurance.

We are going to analyze two alternative index contracts; both of which have the same premium value and utilize average yield as their index, but are differentiated by their payment structures (strike point and indemnity values). The first contract is a fixed income (*piso fijo*) index contract. The basic idea of this contract is to maintain a constant income level for the farmer independent of the size of the loss. Formally, the indemnity paid by the fixed income index contract, I_{PF}, is defined by the following equation:

$$I_{PF} = \begin{cases} p(D_{PF} - \overline{R}) & si\ \overline{R} < D_{PF} \\ 0 & si\ \overline{R} \geq D_{PF} \end{cases} \tag{6}$$

where p is the reference price of the crop, D_{PF} is the trigger (in qq/ha), and $\overline{R}$ is the average yield for the contract area.

The second type of index contract that we analyze is a variable income (*piso inclinado*) contract. Like the conventional insurance, this contract includes a 30% deductible, which implies that the contract only covers 70% of losses below the strike point and, as such, does not attempt to maintain a fixed income level but rather income levels that gradually decline with the magnitude of the loss. Nonetheless, due to the deductible and in order to maintain the same price as the fixed income contract, the strike point of the variable income contract is higher than the strike point of the fixed income contract; which implies that it offers protection over a greater range of the index. The indemnity of the variable income contract, I_{PI}, is defined by the following equation:

$$I_{PI} = \begin{cases} 0.7p(D_{PI} - \overline{R}) & si\ \overline{R} < D_{PI} \\ 0 & si\ \overline{R} \geq D_{PI} \end{cases} \tag{7}$$

where D_{PI} is the strike point of the variable income contract.

To calculate the value of the strike points for the two types of index contract which imply that the "shadow" contracts have a premium value equal to the conventional contract, we find the values of D_{PF} and D_{PI} that satisfy the following equations:

$$C^{SC} = 1.3 \int_{\overline{R}}^{D_{PF}} p\left(D_{PF} - \overline{R}\right) dG\left(\overline{R}\right) \tag{8}$$

$$C^{SC} = 1.3 \int_{\overline{R}}^{D_{PI}} 0.7p\left(D_{PI} - \overline{R}\right) dG\left(\overline{R}\right) \tag{9}$$

where C^{SC} is the value of the premium of the conventional contract and $G\left(\overline{R}\right)$ is the cumulative density function for the average yield of the crop in the contract area.

As we describe in Section 4, we assume that the function $G\left(\overline{R}\right)$ takes the form of Gamma distribution, whose two parameters are estimated using historical data from the ESPAC survey. The integral on the right had side of both equations represents the pure risk premium for both types of index contracts. We multiply the pure premium by 1.3 to incorporate the 30% *loading* factor. These two equations implicitly define the value of the two strike points, D_{PF} and D_{PI}, which result in index contracts with the same cost as the conventional insurance. Finally note that we apply these two equations for each crop/contract area; of which there are eight in our case (3 rice areas in Daule, 3 maize areas in El Empalme, and 2 maize areas in Celica).

Table 5.1 presents the strike points that result from these calculations for the three maize contract areas in El Empalme and the three rice areas in Daule. Comparing these strike points with the strike points implicit to the conventional contract in Table 3.7 above, we can see that both index insurance contracts have higher strike points, which implies (without taking into account basis risk) a greater level of protection for the farmer.

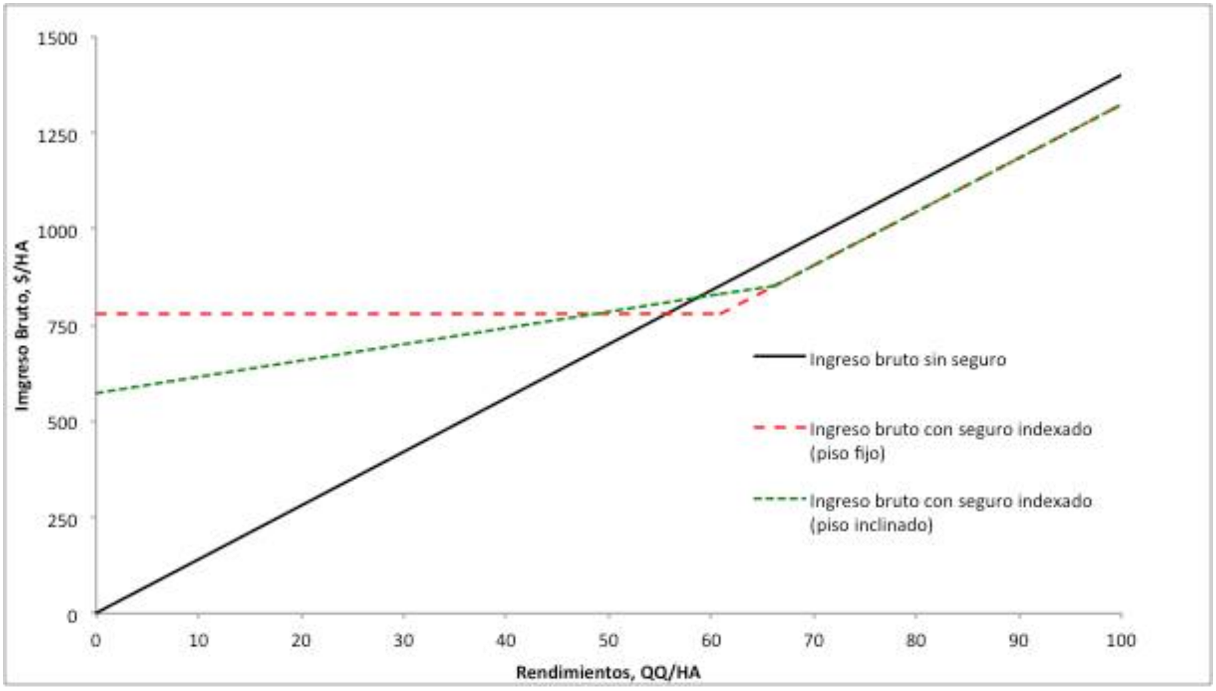
Table 5.1 Strike points for Index Insurance

	Fixed Income (D_{PF}) (QQ/HA)	Variable Income: (D_{PI}) (QQ/HA)
El Empalme (Maíz)		
Contract area 1	59	63
Contract area 2	66	71
Contract area 3	61	66
Daule (Arroz)		
Contract area 1	95	96
Contract area 2	103	105
Contract area 3	93	95

Figure 5.1 visually presents the impact of the two types of index insurance on the gross revenue of the farmer for the specific case of maize in El Empalme's contract area 3.[27] The red dashed-line corresponds to the first contract, which we are calling "fixed income" because it allows the famer to maintain fixed gross revenue independent of the magnitude of the loss (corresponding to the average yield minus the strike point). This fixed income contract has a strike point of 61 quintales per hectare, which represents 90% of the average historical yield, and the indemnity that is paid when the average yield falls below this level permits the farmer to maintain revenues of approximately &779/ha. As can be seen with reference to Table 3.7, this strike point is substantially higher than the strike point of the conventional insurance contract for El Empalme which was 49 and 52 quintales per hectare in 2011 and 2012 respectively. This increase in protection partially reflects the lower operating costs of the index insurance, which permits the assignment of a greater percentage of each dollar charged to farmer indemnity rather than to the operating costs of loss adjustments.

[27] To simplify the exposition, we assume in Figure 5.1 that the average yield of the farmer is the same as the average yield in the insured area and that there is no basis risk – that is to say, the farmer's yield co-moves perfectly with the average yield in the insured area.

Figure 5.1. Alternative index insurance contracts for Maize in El Empalme with costs equivalent to the conventional insurance



In Figure 5.1, the green dashed-line shows the gross revenue corresponding to the variable income index contract. In the specific case represented in this Figure, the strike point of the contract is 66 qq/ha, which represents 97% of the average historical yield. As mentioned above, the fact that the variable income contract has a marginal deductible of 30% implies that it pays less to the farmer than the fixed income contract when the average yield is lower than the strike point. However, this deductible permits the variable income contract to offer a higher strike point and, thus, pay indemnity to farmers over a range of average yields (from 61 to 66 qq/ha) where the fixed income contract does not offer any indemnity

Figure 5.1 then shows us two alternative insurance contracts indexed by average yield based on the yields collected by the ESPAC that can offer the same price as the existing conventional insurance (we have designed equivalent contracts for rice producers, which we will analyze below). Although, on one side, the index contracts have more generous strike points than the conventional contract, this generosity does not necessarily imply that the index insurance offers better protection. As previously mentioned, the presence of basis risk can seriously reduce the quality of index contracts as mechanisms to protect farmer incomes. To better understand which contract offers better protection, we should analyze both contracts in greater detail in terms of their ability to stabilize income.

5.4 Comparing the quality of contracts for feed corn: The index insurance versus the conventional insurance

Ideally, we would like to have multiple years of data over which to compare the performance of both types of contract; however, we only have information on two years. Fortunately, these two years were very different in agricultural terms, which has given us a useful window through which to evaluate the quality of the contracts. Although it is possible to simulate the performance of conventional and index contracts in the long run, we concentrate only on what we can learn from the two years on which we have data (2011 and 2012).

For the analysis, we focus on the fixed income index contract. The results for the variable income index contract are similar; the only difference is that with the variable income contract, the percentage of farmers who receive payments is a bit higher, but the value of those payments is a bit lower.

Beginning with maize, Figure 5.2 presents the aggregated data from 2011 and 2012 using the graphical structure introduced previously. The horizontal axis represents the maize yield obtained by the farmers in the survey for the given years. Like we did in Section 3, we have divided the observations from the two years into ten groups based on their yields, and we show the mean value for each group. The first decile (made up of the 10% of observations with the lowest yields) had an average yield of 9.5 quintales per hectare. In continuation, we present three pieces of information for this group (and for the other nine deciles):

- The mean gross income per hectare if they had not had insurance;
- The gross income per hectare adjusted by the payment offered by the actual conventional insurance scheme (gross income minus premium payment, paid either by the government or the farmer, plus the indemnity payment).
- The gross income per hectare adjusted by the payment that would have been received under the "fixed income index contract" scheme (gross income minus premium payment, plus the indemnity payment that would have been received based on the average yield measured with the ESPAC data, for the contract area to which each farmer was assigned).

Table 5.2 also presents this same information. As can be seen, for the 10% of maize farmers with the lowest yields in the 2011 and 2012 periods, the gross income per hectare would have only been $133 if they had not had insurance; it was $217 under the existing conventional insurance scheme; and it would have been $329 under the index contract. To make these differences more visible, Figure 5.3 presents the information for the first three yield deciles.

Figure 5.2. Income with and without Insurance: 2011 and 2012

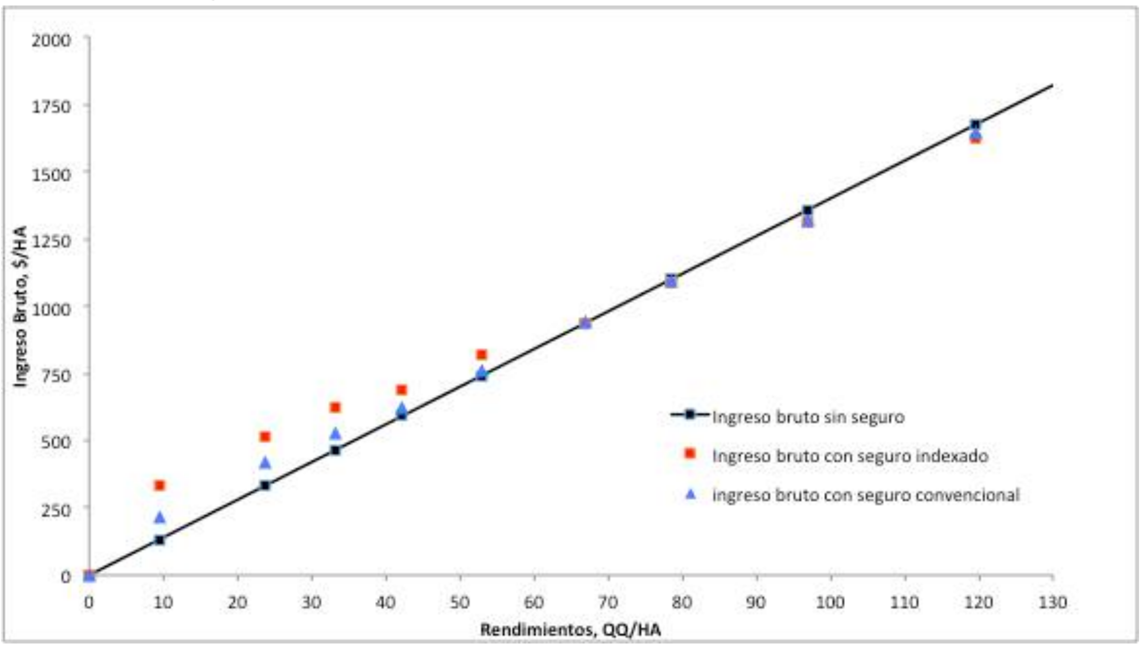


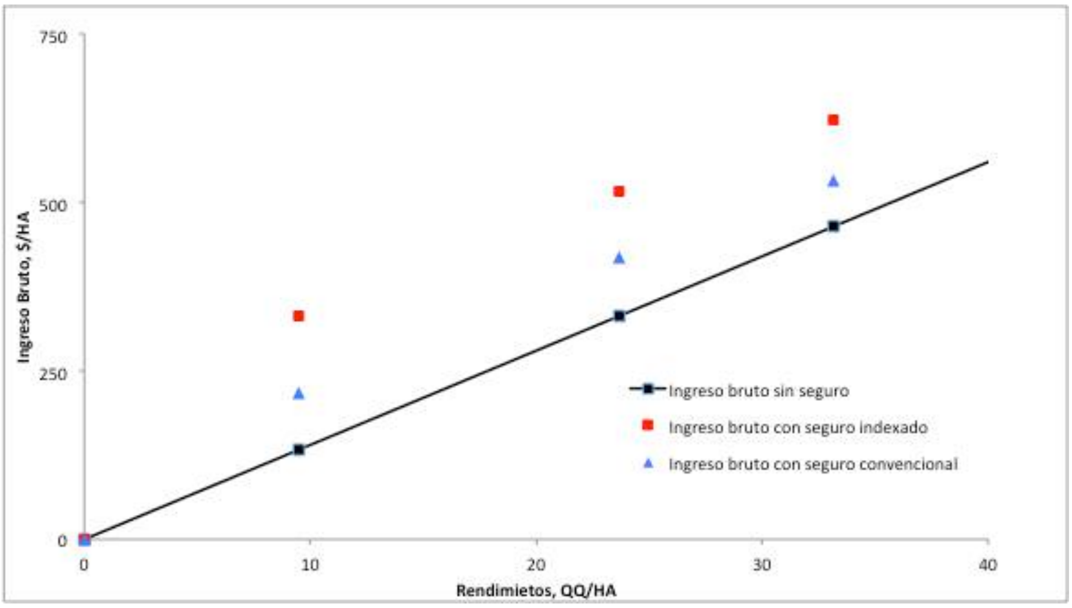
Table 5.2. **Mean Yield and Income by Decile with Index Insurance: Aggregated Corn Farmers in 2011 and 2012**

Decile	Mean Yield (qq/ha)	Gross Income without Insurance (US$/ha)	Gross Income with Conventional Insurance (US$/ha)	Gross Income with Index Insurance (US$/ha)
1	9.5	133	217	332
2	23.7	332	418	517
3	33.1	464	532	621
4	42.3	592	626	690
5	53.0	741	759	819
6	66.9	937	939	937
7	78.5	1,100	1,093	1,090
8	96.9	1,356	1,320	1,311
9	119.6	1,675	1,643	1,627
10	170.9	2,392	2,343	2,349

The figures also show the same information for other deciles. The third decile, for example, is made up of those farmers who had a yield greater than the lowest 20% of farmers, but less than the highest 70% of farmers. For this group we observe that:

- The gross income per hectare would have been only $464 without any type of insurance;
- The gross adjusted income was $532 with the conventional insurance currently offered;
- The gross adjusted income under the "fixed income index contract" would have been $621.

Figure 5.3. Income with and without Insurance for Maize Farmers: First three deciles (average of 2011 and 2012)



If we go to the eighth decile (those farmers with a mean yield greater than 70% of the others), we observe that:

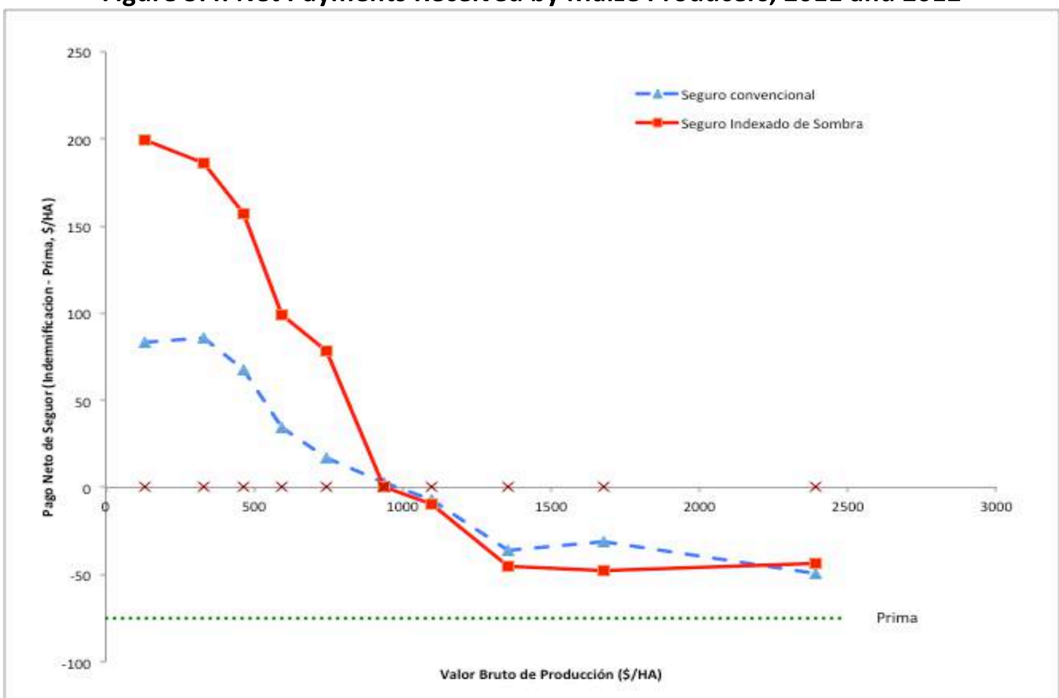
- The gross income per hectare would have only been $1,356 without any type of insurance;
- The gross adjusted income per hectare was $1,320 with the conventional insurance;
- The gross adjusted income per hectare under the “fixed income index contract” would have been $1,311.

That is to say, the maize farmers in the eighth decile had relatively good yields. As such, it is to be expected that few of them would have received an indemnity payment under any insurance scheme. It is not a surprise then that these farmers would have been slightly better off without insurance than with either of the two insurance types (because they had paid premiums or the premiums had been paid by others on their behalf). This is how an insurance is supposed to operate: the premiums are paid with the objective of receiving an indemnity payment in bad years, but not in normal or good years.

Figure 5.4 presents the same information in a form that may be a bit more transparent. The horizontal axis represents the value of production for the various deciles in dollars per hectare. The ‘x’ on this axis show the position of the various deciles. The solid red line shows the difference between the gross income with the index insurance and the value of production. In other words, the red line shows the value of the indemnity minus the cost of the premium for the insurance. Without any indemnity payment, the line would be at the level of -$75 per hectare (the value of the premium).

As can be seen, for the first decile (with a value of production of only $133 per hectare) the shadow index insurance would have offered a net payment of some $200 per hectare, raising the income of the farmers by 150%. For the second decile, the payment would have been a bit less than $200 per hectare. After the fifth decile, the net increase is negative, indicating that the indemnity payments were, or would have been, less than the premium for those with higher yields.

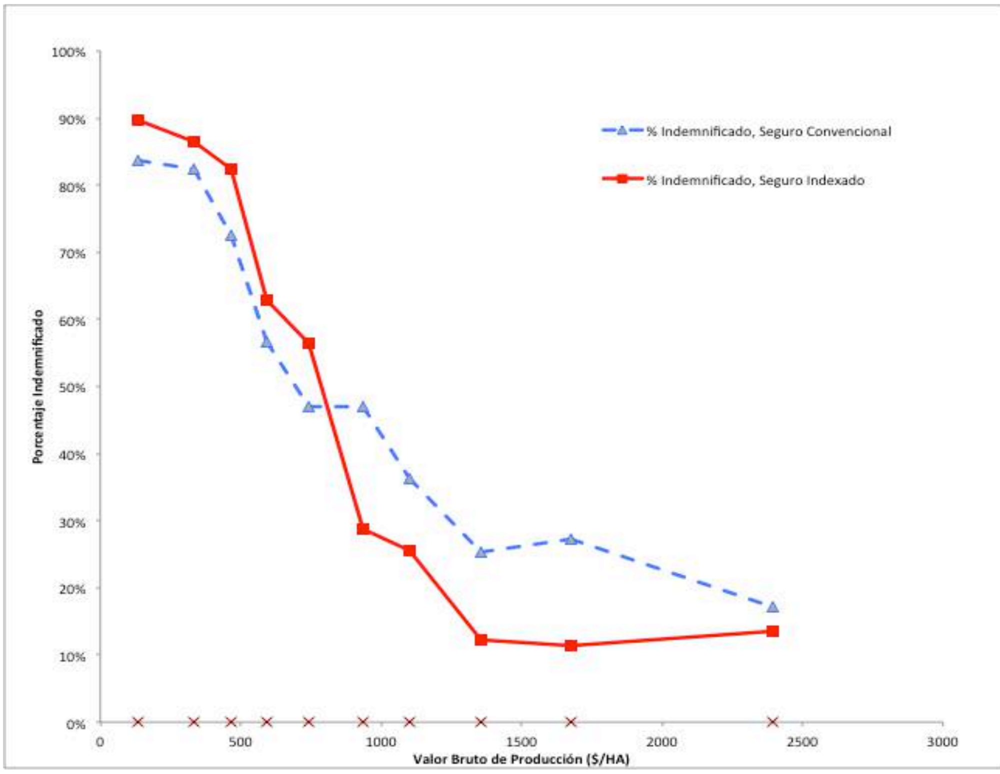
Figure 5.4. Net Payments Received by Maize Producers, 2011 and 2012



In the same Figure 5.4, the blue dashed-line shows the same net impact on income for farmers in the various deciles for the conventional insurance. As can be seen clearly, for farmers in the first five deciles – who suffered the greatest losses and needed the largest indemnity payments – the net payment of the index insurance would have been about two times as high as the payment from the conventional insurance. This difference does not necessarily indicate a failure of the conventional insurance, rather it reflects the higher operating costs and the less generous level of coverage. The index insurance is positioned to cover income losses given that it ensures an average yield, while the conventional insurance only covers lost expenditures (it ensures a level of investment on the plot). What is interesting is that for the same cost, an index insurance can be purchased which is more complete.

Figure 5.5 shows the other dimension of quality, the fraction of farmers who receive indemnity payments for each yield decile. According to this metric, the performance of the two contracts is similar. For the first decile (the lowest yields), a bit more than 90% of farmers would have received a payment by the index insurance, while slightly below 90% received a payment from the existing conventional insurance. According to this measure of quality, the index insurance dominates the conventional insurance in the first five deciles. In the highest deciles, the realized losses are surely more idiosyncratic and do not reflect events, such as drought, that result in massive losses. In these deciles, we can see the existence of basis risk with the index insurance, although it is clear from Figure 5.4 that the payments by the conventional insurance are small on average.

Figure 5.5. Percentage of Corn Farmers receiving Indemnity Payments: 2011 and 2012



Returning to figures 5.2 and 5.4, in global terms we see that, for the first five deciles the average income of farmers is higher under any insurance scheme than in the case with no insurance. Nonetheless, we observe that the fixed income index insurance contract offers greater protection than the conventional insurance for this group, given that the net payments are largest for the lowest deciles (for the first decile, the index insurance would have increased income by $200 per hectare, while the difference is only $100 for the fourth decile). On the other hand, we observe that the conventional insurance is slightly better than the index insurance for the highest deciles (at the most it offers $10 per hectare on average).

These finding for maize are important given that they are a strong indicator that the lower operating costs associated with the index insurance allow a greater percentage of each dollar of premium charged to be used to pay farmers rather than to cover the operating costs necessary to carry out field inspections and loss adjustments.

Although these results show clear advantages for the insurance indexed by average yield based on the ESPAC data, we need to be cautious given that these results have been built on only two years of information, one of which was characterized by a catastrophic drought for maize producers. As was mentioned previously, the protection offered by the index insurance is much greater against this type of adverse covariate shock (common to the majority of individuals in the contract area) compared to adverse idiosyncratic shocks, or more routine shocks, which tend to affect few people.

To have a more complete appreciation of this point, Figure 5.6 recreates Figure 5.4, but only using data from the more normal year, 2012, in which there was no drought.[28] First, note that the average yield (or the value of production per hectare) for the first decile in 2012 was four times higher than the average yield obtained by the first decile in 2011, the year of the drought. This implies that the farmers of the first decile in 2012 were in a significantly less precarious economic situation than the same decile in 2011. For example, the average yield of the first decile in 2012 was approximately equal to the average yield of the sixth decile in 2011. In other words, the farmers with the worst yields in 2012 obtained better results than 60% of all farmers in 2011.

In a given year, without the presence of a common adverse shock, we anticipate that the conventional will be better than the index insurance. In 2012, no maize producer would have received payment under the shadow index contract. As such, the impact of the index insurance in this normal year would have been a reduction in income equal to the value of the premium. In contrast, about 25% of farmers received payments under the conventional insurance in 2012 (Figure 5.7). As can also be seen in Figure 5.6, these payments were small on average and did not reach the level of the premium in any decile. For both contracts, this is what would be expected in a year without large losses.

[28] If we only use data from 2011, the index insurance performs much better than both the individual insurance and the alternative situation without insurance, even significantly more-so than what is shown in Figure 5.4.

Figure 5.6. Net Payments Received by Corn Farmers in 2012 ("normal" year)

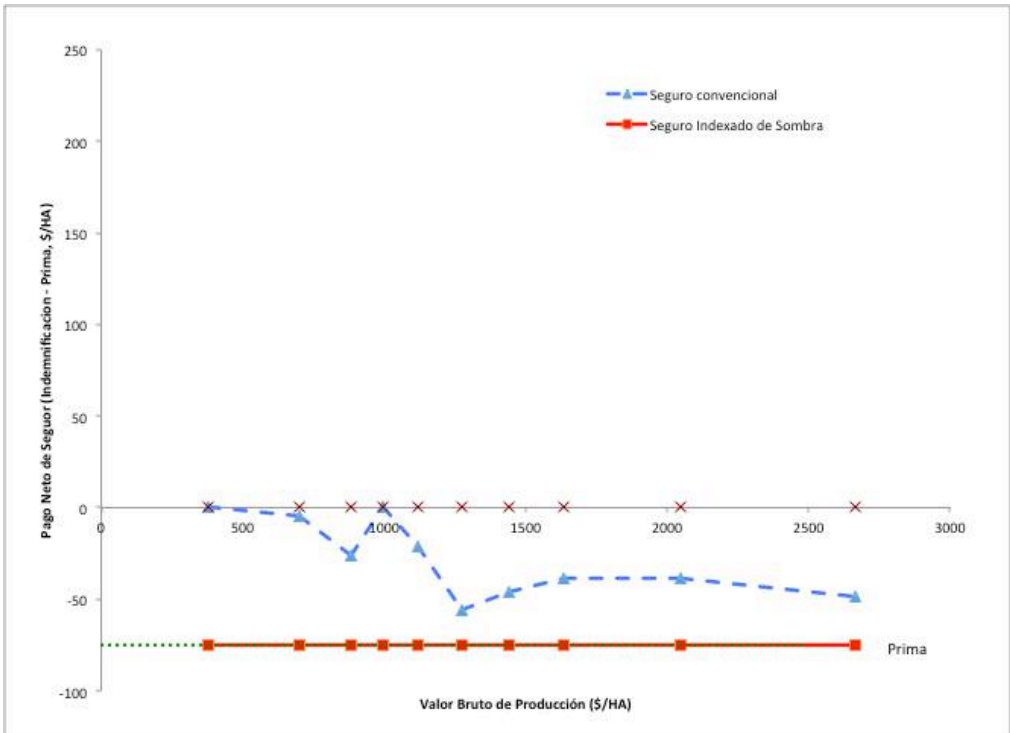
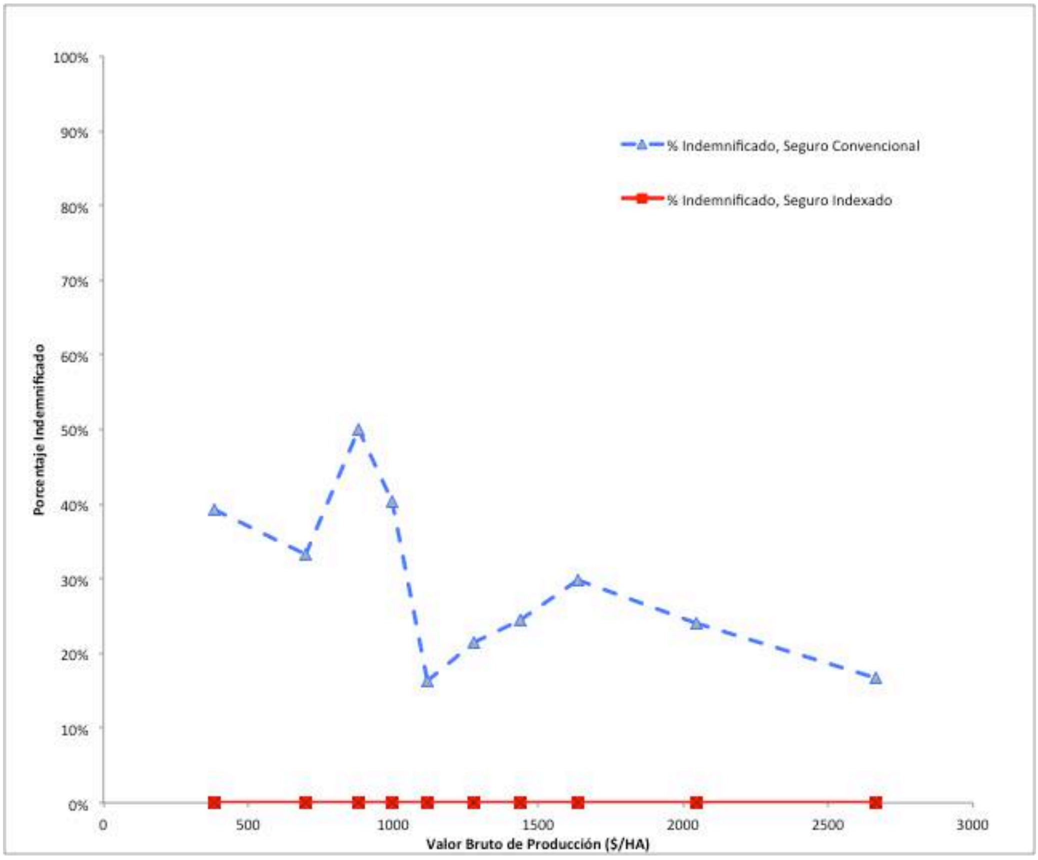


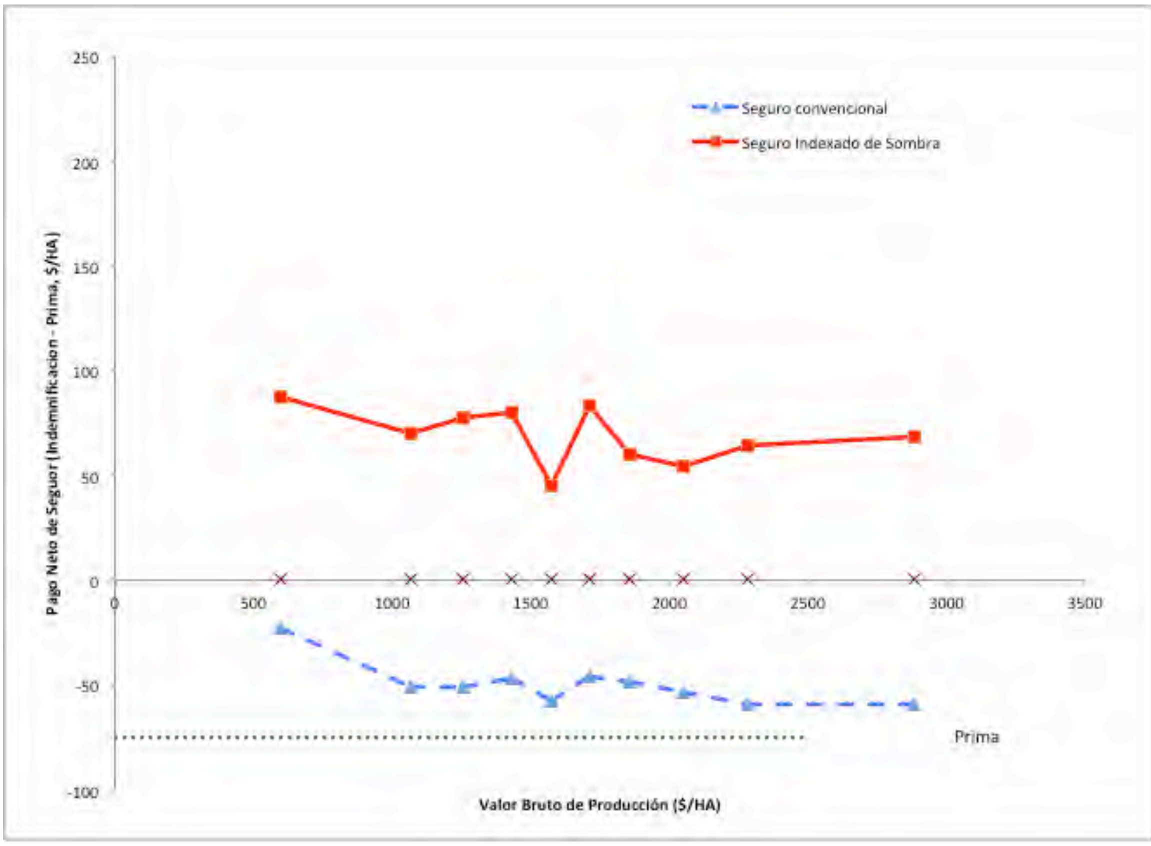
Figure 5.7. Percentage of Corn Farmers Receiving Indemnity Payments in 2012 ("normal" year)



5.5 Comparing the quality of contracts for rice

The rice in the area of our study is a low risk crop, and as such is subject to different types of risk than maize. Despite these differences, the comparison of the conventional insurance and the index insurance is similar. Figure 5.8 shows the results. If we combine the information from the two years (2011 and 2012), we observe that the shadow index contract offers better protection than the conventional insurance contract and the no insurance case. The relative advantage of the index contract is, however, less than in the maize case. The fact that the index insurance performs better in maize than in rice is understandable given that irrigation gives rice farmers a measure of protection against common adverse shocks such as drought. Even under these circumstances, however, the average yield index insurance contract based on ESPAC offers better protection per dollar of premium than the conventional insurance when we consider both years, 2011 and 2012. As seen in the earlier analysis, there was a widespread failure to report losses to the conventional insurance in the Daule area, which could explain a good part of the inferior performance of the conventional insurance when compared to the index insurance.

Figure 5.8. Net Payments Received by Rice Farmers: (Average of 2011 and 2012)



6. SUMMARY AND RECOMMENDATIONS

Ecuador, like several other countries in the Andean region, recently implemented a policy initiative to strengthen crop insurance markets for small and medium farmers. To meet this objective, since 2010, the Ecuadorean government adopted a strategy to expand the existing conventional, named-peril contract, which was (and continues to be) the only crop insurance policy in existence. The primary means of supporting this market expansión have been the provision of a 60% premium subsidy for policies purchased by small and médium farmers, the creation of a specialized unit (AgroSeguro) within the Ministry of Agriculture to administer the subsidy, and, more recently, the requirement that any loan received from the formal banking sector must be accompanied by the subsidized crop insurance.

This strategy of relying on conventional crop insurance to massively expand the insurance market to small-holders is unique in the región and, from both an economic theory standpoint as well as troubling experiences with conventional insurance in other countries, raises a series of doubts and concerns about the likely effectiveness and sustainability of this public policy strategy. The primary concern is the high operating costs associated with offering conventional crop insurance to small-holders. These costs are the result of the difficulty in overcoming information problems inherent in conventional insurance contracts and are reflected in the high costs associated with the claims adjustment process which requires multiple visits to the insured plots to verify losses and estimate the value of production to determine the size of the indemnity payment.

In addition, the need to verify the existence of damages and determine that the damages were due to insured events (as opposed to farmer negligence) implies a series of responsibilities that must be carried out by the farmer. These responsibilities include: filing a claim within the contractually specified time window, coordinating the visit with the claims adjustor, filing the harvest notification (*aviso de cosecha*) and coordinating the second visit with the claims adjustor to estimate the value of the harvest. Our research project has identified a series of problems and challenges that impede farmers' understanding of and ability to meet these responsibilities as well as other operational challenges that reduce the real value of protection provided to farmers by the conventional insurance contract.

It is important to point out that, at the beginning of a large-scale and complicated policy initiative such as insurance expansion, a certain level of operational problems, including farmer misunderstanding, is to be expected. Nonetheless, the continued high level of misunderstanding that is reflected in the large gap between expected versus actually received income (and insurance payouts) that we found is particularly worrisome and, we suggest, reflects the large and real challenges confronting the offering of conventional insurance to small-holders on a large-scale basis.

Acknowledging the problems associated with high operating costs and lack of understanding by farmers is an important step in deciding how to structure the next phase of the expansion of the conventional crop insurance market. In Ecuador, this next phase has already begun. In 2013, the conventional insurance product was linked to the "Seed Plan" (*Plan Semilla*), a government program offering credit to purchase a package of subsidized inputs to small-holders. The farmers who participate in the program are required to purchase crop insurance. This strategy for expanding the conventional insurance market raises two important concerns. First, the Seed Plan program will require a rapid, large-scale expansion of conventional insurance supply. As a result of this program, the number of insured farmers nearly tripled from approximately 11,000 in 2013 to just over 30,000 in 2014. This expansion will require a significant increase in the administrative and claims adjustment capacity of the insurance provider. If this large-scale institutional and human capital investment does not occur, the obligatory expansion of insurance will likely exacerbate instead of alleviate the problems described above associated with offering and executing the conventional insurance. Second, if the Seed Plan is not accompanied by a strong insurance literacy campaign, the obligatory nature of the insurance will likely perpetuate and exacerbate the problems associated with lack of understanding by farmers. Under an obligatory scheme, the farmer does not make their own decision about purchasing the insurance and, as a result, has less incentive to take the time and effort to understand the full costs and benefits as well as the "fine print" of the insurance.

Given these challenges associated with conventional insurance, it is worth considering the possibility of complementing or, from a public policy perspective, substituting support from the conventional insurance towards index insurance. Thanks to the investment that the Ecuadorean state has already made in systematic and high quality production and yield data in the form of the ESPAC survey, Ecuador is in a privileged position with respect to the possibility of developing an index insurance market based on area yield.

Our analysis, based on primary data collected from 1,000 insured corn and rice farmers in 2011 and 2012, shows that the ESPAC survey can indeed serve as the basis for the development of an area yield index insurance policy that, dollar for dollar, offers better protection for small and medium farmers compared to the existing conventional insurance policy. This conclusion does not imply that index insurance can provide better protection for all farmers in every year. For example, in years in which there are no large covariate shocks and in which the losses that do exist are the result of idiosyncratic factors, it is likely that conventional insurance offers better protection. In contrast, in years characterized by severe or catastrophic climate events, in which farm losses tend to be massive and widespread (eg., 2011 in corn-producing regions in Ecuador), index insurance offers significantly better protection than the conventional insurance product. As a result, the area yield index insurance contract we propose here offers the potential for better protection not just to individual farmers, but also to protect the portfolios of financial institutions with agricultural loan portfolios and, potentially, to local governments in regions with high dependence on agriculture against climate-related disasters.

There is no magic underlying this advantage of index insurance. Instead, it is the result of significantly lower operating costs which permit a larger percentage of each dollar of premium to go towards indemnity payments to farmers instead of paying for more claims adjustors and on-farm inspections. Although we acknowledge that index insurance suffers from basis risk, the lower operating costs should permit the definition of sufficiently high strikepoints so that farmers are well-protected against catastrophic loss.

In spite of these clear advantages, we acknowledge several important limitations of our study. First, we have limited our analysis to two crops: rice and feed corn. We have not analyzed other crops, such as potato, that are produced in regions with greater spatial variation in agro-ecological and climatic conditions. In these contexts, index insurance likely will suffer from greater basis risk and its performance would be relatively poorer than in the coastal and inter-andean valley regions of this study. It is likely that an effective insurance strategy in these more challenging areas will require a mixed strategy that incorporates ideas and mechanisms from both conventional and index insurance. For example, in order to improve the risk management capacity of small-holder coffee growers, the Colombian government is considering the possibility of offering a weather-based index insurance contract that, due to the high micro-variability in climate in the highland coffee regions, would be complemented by the measurement of area yields.

The second limitation has to do with the availability of timing of the availability of data from the ESPAC survey. Our evaluation of the shadow index contract did not require having these data immediately after harvest in order to determine whether a payout is made. The real-world implementation of the index insurance contract, will indeed require that these data are made available in a timely fashion. This would require an important, and increased, degree of collaboration and coordination between the national statistics bureau which administers the survey (INEC) and the insurance system. It would also likely require some modifications to the current methodology of collection and processing of the ESPAC data. Ecuador finds itself in an ideal moment to implement this coordination. INEC is currently in the process of updating and expanding the

ESPAC survey and, in the near future, will include a larger number of both Sampling Segments (SM's) and parcel. This expansion should allow an improved index product with lower basis risk.

In summary, the existence and planned expansion of the ESPAC survey provides a unique opportunity to develop a high quality area yield index insurance market. As such, we make the following recommendations to the Ecuadorean government:

1. Support a pilot offering of index insurance and initiate a process of coordination between AgroSeguro and INEC;
2. Carry out the ESPAC survey at the appropriate moment (immediately after the primary harvest season) for the insured crop in this pilot program;
3. Provide AgroSeguro with the ESPAC data rapidly (and before the public release of the data) so that Agroseguro can estimate area yields in each contract area in order to execute insurance payouts (if they are warranted) in a timely fashion.

In conclusion, the government of Ecuador has taken important steps forward to support the creation and expansion of a crop insurance market for small-holders. This emphasis on insurance markets is crucial since enhancing small-holders' risk management capacity can reduce poverty and increase investment, growth and income in the agricultural sector.

This research project has shown that, in order for this initiative to be successful in the long term, the government should consider complementing or substituting the existing conventional insurance with index insurance. Resource, both from the government's and farmers' pockets, can be better used under an index insurance scheme due to the higher dollar-for-dollar protection offered compared to conventional insurance in years of severe climate shocks.

Although there remain challenges to overcome in moving index insurance from the "shadows" to the light of day, the high potential gains we have documented justify movign towards a pilot project as soon as possible.

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