CLIMATE POLICY INITIATIVE
NÚCLEO DE AVALIAÇÃO
DE POLÍTICAS CLIMÁTICAS
PUC-Rio

Improving Agricultural Productivity in Brazil: The Unmet Potential of Price Risk Policy

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January 2015

Technical Paper

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Abstract

Price volatility is a major source of risk in agriculture, since production decisions are usually made long before output is ready for sale. When capital markets are underdeveloped, financial tools to insure against price volatility are limited, and public policy may increase welfare by substituting for these tools. In Brazil, a major agricultural player in the world market, public policy focuses on guaranteeing a minimum price instead of decreasing volatility. We show that while farmers attribute a large value to price hedging, the current policy is able to achieve only a small small fraction of this value.

Keywords: agriculture, price volatility, insurance mechanisms JEL codes: D41, D42, D43, D86, I13

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January 29, 2015

1. Introduction

Production risks in agriculture are typically related to either adverse natural events, such as weather shocks and pests, or low output prices. The latter — henceforth referred to as price risk — is a major concern for both farmers and policymakers: Unmanaged risks can not only lead to low income for farmers, but also affect the agricultural banking sector, contributing to a rural poverty trap (for a more in-depth discussion on this, see International Bank for Reconstruction and Development [10] and Santos and Barrett [22]). In this work, we focus on price risk to quantify potential gains from providing insurance against price risk in Brazil, as well as estimate actual gains achieved by existing public policy.

This paper begins by looking at the institutional context for price risk insurance in Brazil. Capital markets serve as theoretically adequate tools for mitigating price risk. In principle, farmers may go to the private market to acquire sell options for output, or buy options for inputs, or even insure away any type of price risk using forward contracts. Yet, the role of agricultural public policy was historically very relevant in many countries, particularly at times when market mechanisms were underdeveloped. The type of policy used to support agriculture varies significantly across countries: it ranges from incentives to the use of market instruments (including publicly-provided versions of market tools) to guaranteed levels of income or simple government buyouts of farmers' output when prices fall below a given threshold.

The type of policy has also changed over time. The use of direct buyouts has decreased steadily since the 1980s in developed countries (namely, the United States and Europe), as has government financial support to guarantee minimum prices. In the US, the Farm Bill that was passed in 1985 cut public funds for output acquisition and stocking. A similar move started in Europe in 1993. Such policy changes responded to criticisms concerning high public expenditures, frequent overproduction, dumping in world markets and rotting stocks. Price mitigation today is mostly based on direct payments to farmers, thereby avoiding governmental distortion of market allocation.

In contrast, Brazilian capital markets are underdeveloped and financial tools to cope with price risk available in the country are usually limited due to low scale and informality. Price insurance in Brazil is essentially provided by the federal government through the annual Agricultural Plan (PAP). Resources for the 2012/2013 PAP totaled BRL 133.2 billion, BRL 5.4 billion of which were allocated to price risk management. However, a large share of resources for price risk mitigation is still used for government buyout policies, either through direct or indirect acquisitions; moreover, the PAP's focus is on minimum prices, not on price volatility itself.

After reviewing the institutional context for price risk insurance, the objective of this paper is two fold. First, we compute the value of insurance for farmers in Brazil – i.e., how much they benefit from moving from autarky (when they have to absorb all price fluctuations) to perfect insurance. Second, we ask how much of this value current policy

To address these questions, we use a simple variation of the recursive version of the neoclassical growth model (for details, see chapter 16 of [13]). A risk-averse decision maker (the farmer) chooses two inputs (land and labor) to produce a given quantity of output each period. He makes his production decisions before prices are known. The farmer then sells the output at given market prices, which follow an exogenous stochastic process, and decides how much to save and reinvest for the next period.

We model policies as follows. Under autarky, farmers face random prices. The only form of risk mitigation is capital accumulation, which acts as a form of self insurance when the agent's absolute risk aversion is decreasing in income. Under perfect insurance, farmers receive the expected price for each crop. The minimum price policy is simply a lower bound on the price farmers will receive given an exogenous price process. Under the current policy, the government buys all the output at the floor when prices fall below it.

We then consider price series for the four most important crops in Brazil according to production value: soybean, sugarcane, corn, and coffee. We have two sets of results. The first relates to the economic value of insurance: We ask how much farmers would be willing to pay to move from autarky (i.e., complete absence of risk mitigation) to full insurance. We interpret this as the potential market for price risk hedging.

We find that corn farmers would pay 15.3% of total production value, which amounts to BRL 5.7 billion in 2013. This figure reaches 25.8% for soybean (BRL 23.5 billion), 37.6% for sugacane (BRL 18.5 billion) and 14.4% for coffee (BRL 2.0 billion). Altogether, the value placed by farmers of these crops in price risk mitigation is BRL 49.6 billion, or 25.9% of total production value for the four most important crops in Brazil, suggesting a large potential market. Lastly, we find that insurance gains are more relevant for small farmers, which are more exposed to risk as their output is closer to the minimum consumption need.

The second set of results measures how much of this potential gain may be delivered by current policy in Brazil. We find that the value of the current policy was BRL 163 million for corn, BRL 1.3 billion for soybean, BRL 2.3 billion for sugarcane, and BRL 203 million for coffee. The total value farmers of these four crops place in the current policy was BRL 3.98 billion — only 8.0% of the potential market. These results suggest that the current policy is not cost-effective, since more than BRL 2 billion were reserved for government acquisitions and storage in the 2012/2013 PAP.

One possible explanation for the current policy's inefficiency is that it was designed within a very different context than that for which it is used today. It was developed in the 1960s to prevent small-scale farmers from extreme poverty when agricultural prices were low. Yet, the need for risk mitigation changes in the process of economic development. Minimum price guarantees typically offer protection against drastic circumstances that might affect farmers' subsistence. However, with the development of other sectors, capital expenditures in agriculture are only feasible with a favorable combination of risk and return. Minimum price guarantees are not of much help in this scenario. When prices are above minimum thresholds, the return of agricultural investments are still exposed to price risks. Moreover, there are tools to deal with catastrophic risk — the US, for example, has been switching to crop insurance since the 1980s, as described in [9]. One of the first full-fledged evaluations of price support in agriculture may be found in [12].

This paper contributes to the literature on agricultural risk and its impact on welfare and farm decisions. [17] is an early and comprehensive text on price risk, price stabilisation schemes, and their impact on risk-taking behavior in settings without perfect insurance markets. It highlights the role of systematic risk, as opposed to the typical non-systematic shocks related to weather and pests. A recent and substantial body of research has developed on the impact of insurance, both formal and informal, in farming activities. [11] studies the channels through which kinship-based arrangements affect financial decisions. [20] evaluate the impact of improved forecasting of rainfall (which amounts to an exogenous reduction in risk) on profits and investment decision; in a companion paper ([21]), they establish its impact on wages. [16] further investigates this point: they use a large-scale randomized experiment to test a series of general equilibrium labor market effects. As for the determinants of the usage of insurance tools, [6] describe barriers that prevent the large-scale adoption of risk-mitigating tools (i.e., insurance products)[1]. Lastly, and closer to the present paper, [15] study the demand for formal insurance by farmers who rely only on informal arrangements.

Our work also relates to a large body of literature that uses calibration methods to evaluate financial decisions in agriculture. [3] develops a model to study how financial frictions affect productivity; it may be interpreted as the underpinning of the production values we take from the data in the current exercise. Other applications include the impact of price risk on the inverse farm size - productivity relationship, as in [1], and transition dynamics from an agricultural economy to a more developed one, as in [4] (for other examples, see [19]). The current paper adds to this literature by offering a measurement of potential market size and of the value created by the minimum price policy.

The paper proceeds as follows. Section 2 describes the institutional background in Brazil, Europe, and the United States, focusing on recent changes in price risk mitigation policies. Section 3 lays out the model and presents the results. Section 4 concludes. Technical points are left to the appendix.

2. Institutional Context

Agricultural producers' demand for protection against price risk is typically met by: (i) the government, through targeted public policy; (ii) capital markets, most notably via future and option contracts; and/or (iii) private agents of agribusiness, such as agricultural trading companies, dealing directly with producers. The actions of the first two can be tracked, to a lesser or greater extent, through data and legislation, whereas transactions involving the third are essentially invisible in publicly available data. This section provides a brief overview of the first two components in this market.

[1] It is worth mentioning that [5] fail to reject the assumption of complete insurance markets in Thai villages: given heterogeneous levels of risk aversion, the average household would benefit from decreased risk, but those with low risk aversion would be worse off.

2.1. Public Policy

Over the past decades, the United States and Europe have moved away from market-distorting policy interventions for protecting agricultural producers from output price risk. While Brazil has made some progress in the same direction, it still reserves a substantial amount of public resources — over USD 1 billion in 2013 — for use in arguably inefficient agricultural support programs.[2]

In the context of agricultural price risk management, an efficient public policy should hedge producers against reductions in output price without interfering in the allocation of agricultural production — products should reach the same consumers as in the absence of the price shock. Direct government acquisitions associated with price floors are the typical example of an inefficient policy for protecting against price risk: when market prices fall below a pre-determined minimum price, the government purchases agricultural output from producers for either redistribution or storage. Although such minimum price guarantees do, in fact, protect producers from price volatility, they also introduce significant market inefficiencies. First, because the product no longer reaches the same final consumer as in the scenario without government intervention. Second, and perhaps more importantly, because the product might be used for purposes whose value is lower than those of its original market-based allocation. In this sense, the distortion in product allocation can essentially destroy value in the economy.

Despite being inefficient, direct government acquisitions associated with minimum price guarantees played an important role in providing protection against price risk in the past. They were the main mechanism for supporting rural producers in the United States from the 1930s through the 1970s, and lasted even longer in the European Union, where minimum price guarantees stood as the basis of agricultural policy through the early 1990s (see last subsection of the Institutional Background for a policy overview for the United States and Europe). As policy developed, however, both the United States and the European Union moved away from minimum price guarantees via direct government acquisitions, gradually adopting more market-oriented instruments to support agricultural producers. In particular, direct payments were introduced as substitutes for government acquisitions. Thus, instead of purchasing output, governments transferred resources to producers as a means of compensating low market prices. Deficiency payments, in which the government covers the difference between market prices and price floors, are an important form of direct payment — producers are protected against price volatility, but the market-based allocation of agricultural output is not changed.

More recently, agricultural policy in the United States has incorporated revenue insurance. When supply of output is high, prices are typically low — instead of tying policy intervention to price floors via minimum price guarantees, the government can use public resources to ensure minimum revenue, thereby accounting for both

[2]For a more thorough history of the American system of price support see of Agriculture [18] and Dimitri et al. [8]. For the European context, see Delayen [7].

increased production and decreased price effects. Revenue insurance thus reduces market distortions to the extent that it takes market effects into consideration.

The following overview of Brazilian policy for dealing with agricultural output price risk shows that, although Brazil appears to be moving in the same direction as the United States and Europe, there is still much room for improvement.

Brazil

Since its creation in 1966, the federal government's Minimum Price Guarantee Policy (PGPM) has served as the cornerstone of Brazil's policy efforts for protecting agricultural producers against price volatility.[3] Although the essence of the PGPM has remained largely unchanged, new policy instruments have been added over time.[4] Through the mid-1990s, the PGPM offered price support via government purchases and financing for storage. When market prices fell below PGPM price floors, agricultural producers could either sell their output to the federal government, who was obligated to purchase it, or obtain a loan from the federal government to cover storage expenses, so as to sell output during off seasons (when market prices would supposedly have risen above price floors). Financing could be obtained with the option to sell output to the federal government at the established minimum price when the loan contract expired, or without the sell option, in which case producers would either have to sell output at prevailing market prices or extend storage using their own resources.

Although direct government purchases and financing for storage were offered at low costs to producers, they resulted in substantial expenses for the government, particularly due to the high cost of storage. This contributed to the adoption in the second half of 1990s of new PGPM instruments that were more market-oriented. Starting in 1997, the federal government subsidized the reallocation of agricultural production from areas of excess supply to those of excess demand. Auctions were held such that producers still received PGPM price floors (or, in a later development of this PGPM instrument, some other pre-determined reference price), but buyers effectively paid a lower price for output — the government covered the difference.

Government option contracts were also introduced in 1997. If market prices fell below PGPM price floors, agricultural producers could exercise their options, forcing the federal government to buy their output.[5] The move towards market-oriented PGPM instruments was further strengthened in the mid-2000s, when the federal government introduced a subsidy to suppliers of private agricultural option contracts. Although this represented an important step towards the private market for agricultural risk

[3]Since 1991, the Brazilian Supply Company (Conab) executes the PGPM under the coordination of the Ministry of Agriculture (MAPA).

[4]For a summary of PGPM instruments introduced over time, see Ministério da Agricultura, Pecuária e Abastecimento [14]. The Ministry of Agriculture's annual Agricultural Plans, which determine the guidelines for agricultural policy, also contain brief descriptions of policy instruments available to support agriculture.

[5]There is no secondary market for government option contracts. The government can only revert its position in option contracts through a repurchase auction or a transfer auction. In both cases, the government pays the new contract holders a subsidy to cover the difference between exercise and market prices.

management, it still depended on government decisions regarding product selection, price, quality, quantity, and destination.[6]

The incorporation of new instruments into the PGPM over the past two decades aimed at alleviating the policy's burden on public expenditure while not compromising protection to the producer, as well as modernizing Brazilian agricultural policy. Yet, total resources allocated to price support are still sizable — in 2013, the federal PGPM budget totaled approximately USD 2.4 billion, with over two fifths of it being destined for direct government acquisitions and storage expenses. As previously argued, this type of price support introduces market inefficiencies and are best avoided. The reallocation of output, even if less costly to public coffers than direct acquisitions, still imply market distortions to the extent that the government — not the market — ultimately determines the allocation of production.

Moreover, the PGPM might well be carrying an anachronistic legacy. The policy was introduced before the 1973 creation of the Brazilian Company for Agricultural Research (Embrapa), which was instrumental in developing and implementing key technological advances in Brazilian agriculture, as well as before the large-scale occupation of the Cerrado biome, which is now central to Brazilian agribusiness, started in the 1970s.[7] Brazil's agricultural structure when the PGPM was created in the 1960s was vastly different from today's predominance of large-scale commercial agribusiness. At the time, the majority of the country's rural producers were smaller-scale farmers who were relatively poorer and more vulnerable than they are today. The PGPM policy was created as much to relieve rural poverty as it was to encourage agricultural growth and protect producers from price shocks. Today, the nature of demand for hedging against agricultural output price risk has changed considerably in Brazil.

Anecdotal evidence suggests that producers of Brazil's leading export commodities operate on such a large scale that using the PGPM becomes unfeasible and/or have access to international private markets for risk management instruments that provide better insurance against price shocks. Producers who have no such access — namely, those who operate at smaller scales or produce for domestic consumption only — are restricted to whatever instruments are offered in Brazil. In light of the current scenario of limited private instruments for agricultural risk management available in the country, which we describe in the following section, these producers will typically turn to the PGPM.

A brief policy overview for the United States and the European Union

American agricultural policy is determined by Farm Bills issued every five to seven years. The first bill, dating back to 1933, adopted minimum price policies for select crops as a means of decreasing farm poverty. Such price support policies were the main mechanism for increasing and stabilizing agricultural income until the 1980s. Direct payments for income support, which were first introduced in the mid-1960s, gained

[6]Revenue insurance is a novel element in Brazil. The first of its type was offered by a private entity in the country in 2011, but only at an experimental level for a limited number of crops and producers.

[7]Bragrança [2] provides a background to the incorporation of the Cerrado intro Brazilian agriculture and discusses the role played by Empraba in the agricultural development of Central Brazil.

further strength in the 1981 Farm Bill, in part due to high expenditures caused by the misalignment between international prices and American price floors.

In the second half of the 1980s, agricultural policy in the United States started shifting more strongly towards market-oriented practices — incentives were provided for the marketing of commodities, and the 1996 Farm Bill ended governmental supply controls and adopted the large-scale use of decoupled payments to support rural income.[8] More recently, the 2007 Farm Bill launched a revenue insurance program such that agricultural producers were hedged against drops in revenue.

A similar trend away from price support was observed in Europe. Since the early 1960s, the European Union has had a Common Agricultural Policy (CAP) towards food security and agriculture. The CAP determined minimum price guarantees, which aimed to raise agricultural producers' incomes to match those in other sectors of the economy (while not making them so high as to compromise food security).[9] By the 1980s, overproduction and increasing costs of storage contributed to the dumping of European agricultural output in world markets. With international prices typically below minimum prices in Europe, this practice implied an European subsidy for agricultural exports.

CAP reforms began in 1984, but minimum price guarantees remained unaffected through the early 1990s, when direct payments to support farmers' incomes were introduced as substitutes for price guarantees. The scope of price support policies decreased significantly to help boost competition in both European and international markets. In the late 1990s and early 2000s, policy reform further developed direct payments and introduced a series of productivity and competitiveness-enhancing measures to reduce the need for price guarantees.

Finally, the incorporation of ten new countries into the European Union in the early 2000s rendered union-wide minimum price guarantees too expensive to be sustained. Direct payments were decoupled starting in 2003, giving European agricultural producers greater freedom to respond to market demands and conditions, including oscillating output prices.

2.2. Private Capital Markets

Brazilian capital markets for hedging against agricultural output price risk are at an early stage of development. For example, the Chicago Mercantile Exchange Group (CME Group), which is considered the world's leading marketplace for agricultural commodities, saw over 1 million contracts negotiated each trading day in 2013. In contrast, during this same time, the Brazilian stock market (BM&FBovespa) saw an average daily volume of less than 9 thousand contracts.[10] Moreover, at the time of

[8]Decoupling meant that direct payments were no longer associated with current production, but rather with historical production records. This was done to avoid influencing production decisions and thereby introducing market distortions due to policy.

[9]CAP price support expenses — as all CAP expenses — were financed by a common European fund.

[10]Figures include both crop and livestock contracts. On average, about half of the contracts negotiated in the BM&FBovespa in 2013 referred to crop products.

writing, while the CME Group offered more than 100 different types of crop contracts, the BM&FBovespa only offered 10. It is worth noting that CME Group transactions cover products from all over the world, including Brazil. Thus, despite the relatively low volume and variety of agricultural commodity contracts in the BM&FBovespa, some Brazilian producers likely go to exchanges abroad to find financial products to hedge against price risk.

The extent to which capital market transactions insure producers against price risk depends on the type of contracts being negotiated. Although future contracts offer some protection against price volatility, in the sense that they reduce uncertainty, they are not necessarily an efficient form of insurance against output price risk. Future contracts bind producers to delivery of output at contracted prices, regardless of market prices at the time of delivery. They therefore limit producers' gains when market prices are above contracted prices. Option contracts, on the other hand, effectively insure producers against price risk. Producers pay a premium to acquire the option, but they can choose whether to exercise the option (when market prices are relatively low) or not (when market prices are relatively high).[11] Yet, in 2013, option contracts accounted for only 7% of the total volume and less than 2% of the total value of crop contracts negotiated in the BM&FBovespa. These figures suggest that the efficiency of protection against output price risk obtained via capital markets in Brazil could be improved.

Anecdotal evidence indicates that the Brazilian stock exchange is seldom reached directly by agricultural producers, with cooperatives, traders, and even the government often serving as intermediaries. Relatively high costs of operating in the BM&FBovespa, alongside a limited understanding of how to do so among most rural producers, likely contribute to this scenario.

Interestingly, producers commonly use credit instruments — not insurance — to provide some degree of protection against agricultural output price volatility in Brazil. The Rural Product Certificate (CPR), a forward contract that allows producers to raise funds for production via the early commercialization of output, is a typical example. CPRs ensure a producer will sell output at a pre-determined price, but, unlike insurance, they also serve as a source of financing, since the contracted price is paid in advance to the producer. The previous discussion regarding the use of forward contracts as protection against price risk also applies to CPRs — even if they do allow producers to hedge against price volatility, CPRs are likely not the most efficient means of doing so.

Bearing in mind this institutional overview, two main questions arise. First, what is the value of price hedging for Brazilian farmers? Second, how much of this value is current policy able to achieve? We address each of these questions in turn in our empirical exercise.

[11]This transaction is equivalent to purchasing insurance — buyers pay a premium to transfer risk onto the seller and only receive insurance payment in the case of an adverse event.

3. Results

Model

We evaluate quantitatively the insurance gains for Brazilian farmers. For a full description of the model we apply in this analysis, we refer the reader to the appendix of this paper.

We measure the gains for the four largest crops in Brazil in terms of production value: soybean, sugarcane, corn, and coffee. Soybean is by far the largest crop in Brazil, having reached BRL 91.0 billion in 2013. It is mostly a well-organized business, with a relatively uniform productivity across the country, and farmers have access to price hedging in international capital markets.

Sugarcane, the second largest crop, achieved BRL 49.1 billion in 2013. It is an input both in the food market (sugar) and in the energy market (ethanol). While it faces several international trade restrictions, it is still a highly productive business in different regions of the country.

Corn is the third largest crop, with BRL 37.0 billion in 2013. Brazilian corn farming displays significant variation throughout the country in terms of farm size and productivity. It is frequently produced on smaller farms with limited access to organized markets to insure risk away, as opposed to soybean. Farmers have a very high exposure to price risk, and we use corn as the leading case to present the results.

Coffee is the fourth largest crop, with BRL 14.3 billion in 2013. It is historically a very important crop in Brazil: it was by far the most important export product in the country in first half of the twentieth century, and has been subject to price insurance policies for more than a century now. Moreover, it is a long-term crop, which subjects farmers to additional risk: a low price in a given year affects current crops and may signal a long period of low prices.

Results

In markets where full insurance is available, farmers only save the necessary resources for future production. In contrast, in markets with uninsured risk, farmers keep an excessive amount of resources for normal production reasons. While this allows farmers to build a buffer against low profits when prices are low, it limits both consumption and reinvestment into improved production. In other words, greater risk diversification frees up resources for other uses; insuring farmers against low output prices effectively decreases the exposure of farmers to volatility, which is particularly relevant for poor farmers - who are at risk of reaching extremely low values of output if prices go down.

We quantify the welfare gains from improved insurance: We evaluate how farmers' decisions respond to changes in price risk. Tables 1 and 2 present the main results,

Table 1
Value of Insurance and Gains from the Current Policy

	Value of Insurance			Gains from Current Policy	
	Share of Production Value	BRL billion	Consumption Gain	Share of Value of Insurance	BRL billion
Soybean	25.8%	23.5	35.0%	5.4%	1.273
Sugarcane	37.6%	18.4	41.4%	12.7%	2.343
Corn	15.3%	5.7	28.4%	2.9%	0.163
Coffee	14.4%	2.0	21.9%	10.0%	0.203
Total	25.9%	49.6	36.7%	8.0%	3.982

Table 2
Value of Insurance and Gains from Current Policy by Farm-Size Group

	Value of Insurance (Share of Production Value)			Gains from Current Policy (Share of Value of Insurance)		
	Small Farms	Average Farms	Large Farms	Small Farms	Average Farms	Large Farms
Soybean	29.3%	26.4%	20.6%	7.3%	6.2%	4.5%
Sugarcane	41.1%	37.1%	31.0%	13.5%	13.0%	8.9%
Corn	19.6%	12.3%	8.2%	3.8%	3.1%	1.2%
Coffee	17.2%	14.4%	5.3%	13.2%	10.5%	8.8%

discussed in the next two subsections. We aim at answering the following questions. First, what is the value of price insurance for Brazilian farmers? Second, how much gain does the current policy actually achieve?

The Value of Insurance

The first exercise measures the economic gain of risk diversification. Thus, we may evaluate the potential size of the insurance market and establish a threshold to compare this to the outcome of the current policy. We use two criteria, described below, to make this measurement: willingness to pay and consumption gains.

The first measure relates to how much farmers would be willing to pay to avoid price volatility. This is a market-based measure of the value created by improved insurance: it is the total amount farmers would pay to insurance price risk away. We interpret it as the economic value of insurance as it captures all the potential gain from avoiding risk.

The second measure relates to direct gains to farmers: if the freed-up resources were entirely redirected to farmers' private consumption, how much would it increase? This is a direct measure of economic benefit, since improved agricultural production should eventually turn into higher consumption. We highlight that it is immaterial whether consumption actually pertains to farmers, or if it goes to some other segment of society; in other words, we do not measure the distributional impact of improved insurance.

We use these two criteria to measure the economic gain from diversification as follows. We compare two scenarios: autarky (in which farmers cannot diversify risk at all) and a hypothetical setup with perfect insurance (in which farmers know exactly the price they will receive, which is the average of observed prices).

We find that the value of insurance for corn farmers is 15.3% of total production value, or BRL 5.7 billion in 2013. Average consumption by corn farmers increases by

28.4% with respect to the autarky scenario, in which the average is taken with respect to all levels of land holdings for Brazilian farmers and considers the median prices.

Moreover, this gain is higher for farmers with low levels of land and capital – i.e., small and poor farmers gain more through price risk insurance. To illustrate this point, we consider three levels of land holdings: low, medium, and high. These groups are divided so that each includes one third of Brazilian municipalities. The gains (in terms of insurance value) for small corn farmers is 19.6%, while for large ones this value reaches only 8.2%.

The gains to small farmers partly relate to the need to avoid extremely low levels of consumption; when prices go down, part of this group falls below the poverty line, since poor farmers are by definition closer to the poverty line. A given fall in prices and profits which is irrelevant for large farmers may be enough to drive them into a range of insufficient consumption. Hence they save proportionally more than large farmers as a response to a given level of price volatility.

An examination of coffee farming yields similar figures to that of corn: the value of insurance is 14.4%, or BRL 2.0 in 2013. Gains for soybean farmers are even higher: the value of insurance is 25.8% of total production value, or BRL 23.5 billion in 2013. Again, these figures are higher for small farmers. A high value of insurance, associated with the fact that soybean is the largest crop in Brazil, offers a partial explanation as for why soybean farming activity reached a level of organization to reach international capital markets: the gain from insuring risk away is large enough to cover coordination costs. The largest gains are found for sugarcane: 37.6%, or BRL 18.5 billion in 2013. This relates to the series of sugarcane prices we analyze: prices displayed a relevant probability of becoming very low in the period 2009-2014. Overall, the value of insurance for the four crops we consider is BRL 49.6, or 25.9% of total production value.

The Current Policy in Brazil

The current policy is Brazil has two main features. First, it protects farmers against price risk by guaranteeing a minimum price; hence it provides insurance against low prices, but does not affect volatility above this threshold: the minimum-price policy only offers partial insurance against price risk. Second, it destroys value by distorting the market allocation: the government diverts the product from the buyer who values it the most and chooses a different destinatary (either the government buys the output directly, or it simply matches a producer with a consumer out of the regular market — the latter implementation saves on operational costs, but the government still chooses who will receive it). Destruction of value may be complete if no alternative use is found in time and stocks rot. It should be noted that the government cannot simply sell in the same market as it would depress prices. As a sidenote, one should note that there is a large political uncertainty in the minimum price policy: government intervention is frequently unanticipated as it may take place even if the annual Farm Bill does not establish a minimum price for a given crop.

We focus on the first issue: incomplete insurance. In other words, we quantify the benefit of the current policy when compared to the autarky benchmark. The analysis is based on average willingness to pay (interpreted as value of insurance); results are similar for consumption gains.

We find the value of the insurance offered by the current policy to corn farmers is only 2.9% of the potential gain, or BRL 163 million. These gains are slightly higher for smaller farmers, for the same reasons discussed in the previous subsection.

It should be noted that the rationale behind the gains to larger farmers is not related to avoiding the poverty line. These are competitive producers who derive little benefit from the current system, which aims at insuring very small farmers from calamitous risk — i.e., risk of being unable to afford food and basic services when output prices are too low. Large farmers aim at insuring their profit margins against price volatility — a risk that is essentially unattended by the minimum price policy, since volatility is unchanged for all prices except the lowest ones.

These figures indicate that the impact of price risk affects farmers mostly through high volatility (which affect both small and large farmers), and not through the risk of extreme poverty. This relates to the fact that the current policy dates from the 1960s, when a significant share of Brazilian farmers were small, while contemporary agriculture usually operates at a scale as high as to rend the risk of poverty less relevant.

We find that soybean and coffee derive a higher benefit from the current policy, although it is still low in overall terms. The current policy reaches 5.4% of the potential gain, or BRL 1.3 billion in 2013. This figure reaches 10.0% for coffee growers, or BRL 203 million. The highest gain from the current policy goes to sugarcane farmers: 12.7%, or BRL 2.3 billion in 2013. Overall, the gains from the current policy for the four crops is BRL 3.982, or 8.0% of the total value of insurance for these crops (BRL 49.6).

We conclude that the current policy seems unable to affect risk exposure significantly in the sense that the value it creates for farmers is small compared to potential gains from insurance. Moreover, it is an expensive policy: the resources reserved for price support (including but not limited to government acquisitions) ranged from BRL 2.0 billion to BRL 5.4 billion in 2012/2013.

4. Final Remarks

This paper studies the current policy for agricultural price support in Brazil. The current policy is still mostly based on direct government intervention: when prices fall below a threshold, the government either buys the output directly, or matches the producer to some out-of-the market consumer who values it less than the market itself.

We find that this policy offers very limited insurance to farmers, who are still exposed to volatility above the threshold. We suggest policy should move in the same direction as the United States and the European Union moved in the past decades. First, government should not buy out farmers' output, or decide its destination; the market allocation should be preserved so as to avoid inefficiencies. As a corollary, the government should not pay for the whole output, which imposes a huge burden on public expenditures; instead, it should pay only the necessary amount to avoid poverty or excessive volatility. Such policies are particularly relevant in Brazil as capital markets, which offer the natural tools for price hedging, are less developed in Brazil than in developed countries.

5. Appendix: Model

We use a version of the neoclassical growth model in which prices are modelled as an exogenous stochastic process. Decisions are made before uncertainty is realized and future utility is discounted at a rate β.

We consider a Cobb-Douglas production function with two inputs: land and labor. One may write:

$$y = Ak^{\alpha}l^{\gamma} \tag{1}$$

where k stands for land and l means labor. Capital may accumulate and is used as the endogenous state variable of the recursive formulation; it depreciates at an exogenous rate $\delta = 0.1$. Labor is hired in every period in a competitive market. Price is an exogenous state variable: it is assumed to follow a Markov process with a given transition matrix, described below.

In each period, the agent decides a quantity c, while k' is saved for the next period and may be used to acquire land. The agent's utility function is concave and displays decreasing absolute risk aversion, with a subsistence consumption level equal to BRL 3,285 (roughly, one dollar a day):

$$u(c) = (c - 3285)^{1-\rho}/(1-\rho) \tag{2}$$

We set $\rho = 0.4$ and notice that with this funcional form, savings act as a substitute for self-insurance: farmers are less hurt by price volatility when they have high levels of capital (and hence high expected profit). The agent's value function V depends on the state variables k and p:

$$v(k,p) = max_{k'}u(pAk^{\alpha} * l^{\gamma} + (1-\delta) * k - k') + \beta * E[v(k',p)] \tag{3}$$

in which primes denote next-period variables. As a matter of notation, we assume that next-period variables already account for depreciation. Notice that labor and consumption may be rewritten as funcions of the state variable. Using information from the Brazilian Agricultural Census of 2006 (the last edition), we match the competitive wage that determines optimal labor hirings to the average wage, in annual terms, of a crop farm establishment with no less than 10 hectares pays to a worker (see tables 812 and 833 of the Agricultural Census).

We set $\alpha = 0.5$ and choose A and γ for each crop so as to match $l = 1.80$, the average number of workers in farms with at least ten hectares; and the steady state level of capital to the median level observed in the Agricultural Census of 2006, which informs that the average value of capital and land holdings is BRL 42,643 and BRL 33,792, respectively. Capital varies from BRL 134 to nearly BRL 4 million, while land holdings go from 11.49

to nearly 14 million (see table 831 of the Census). The results reported in the paper use only land holdings.

Under autarky, the decision maker faces current prices in every period; there is no risk sharing. However, some forms of self-insurance are possible. As discussed above, decision makers are less sensitive to risk when capital levels are high. Under perfect insurance, farmers receive the expected value of prices in each period. Under the current policy, the minimum price is such that the lowest three market prices in the support is avoided. This is precise for corn, and is an approximation that slightly overestimates the gain from ghe current policy for coffee. This exercise overestimates the gain for soybean, since the lowest market price was always above the minimum price set by the government in the period under study. Lastly, we input the same threshold for sugarcane even in the absence of declared minimum prices. Table 4 reports yearly average prices for the period we consider.

Table 3
Price Supports

Product	Reference Unit*	Minimum**	Maximum**
corn	60kg	9.35	20.86
soybean	60kg	20.21	47.69
coffee	1kg green coffee	1.86	4.92
sugarcane	1kg	0.21	0.39

*Units for average monthly prices received by farmer
** Prices deflated to January 2004 BRL

Transition matrices for agricultural commodity prices were built from monthly nominal price series for corn, soybean, coffee, and sugarcane. Data for the first three products were obtained from the Paraná state Secretariat of Agriculture and Supply (SEAB-PR) and captured average prices received by producers. These series covered the January 2004 through December 2013 period and were deflated to January 2004 Brazilian reais (BRL). Data for sugarcane prices were obtained from the São Paulo state Council of Sugarcane, Sugar and Alcohol Producers (CONSECANA-SP) and also captured average prices received by producers. This series covered the April 2009 through March 2014 period and was deflated to January 2014 Brazilian reais.

Table 4
Average Yearly Minimum Prices

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
corn	13.04	12.73	12.94	12.45	11.68	12.41	13.13	12.77	12.04	11.47
soybean	13.16	12.47	12.07	10.61	11.27	16.83	17.63	16.54	16.02	15.06
coffee	-	144.75	140.18	134.68	159.43	190.96	190.77	178.96	169.73	177.99
sugarcarne	-	-	-	-	-	-	-	-	-	-

Notes: minimum prices for each product are averaged across months and states. Prices are deflated to 2004 BRL.

Based on each product's deflated price range within the whole period covered, we used product-specific price deciles to determine category thresholds such that, for each product, we had ten different price categories. Table 3 shows minimum and maximum prices for each of the four products. We then associated observed prices with one of these ten categories and calculated a 10x10 transition matrix for prices, where the entry occupying position *ij* indicates the probably that, having observed category *i* prices in any given month, one would observe category *j* prices the following month. The transition matrices for all four products exhibited a similar and intuitive pattern, with a concentration of positive probabilities along the main diagonal and higher probabilities near the extremes, indicating that both very high and very low prices tend to persist.

We report in the main text the results for $\rho = 0.4$. Table 5 reproduces the same exercise for higher levels of risk aversion; $\rho = 1$ corresponds to the logarithmic utility. The value of insurance increases in the level of risk aversion; hence one may consider the results reported in the main text as the lower bound for this value, computed for a conservative degree of aversion. Lastly, it is possible to check that whatever the value of insurance, the amount captured by the current policy is roughly unchanged.

Table 5
Robustness

		Value of Insurance		Gains from Current Policy	
Parameter of Risk Aversion		Share of Production Value (%)	BRL billion	Share of Potential Gain (%)	BRL billion
0.6	Soybean	0.3118	28.3698	0.0562	1.5944
	Sugarcane	0.4032	19.8084	0.1301	2.5771
	Corn	0.2014	7.4585	0.027	0.2014
	Coffee	0.1896	2.7038	0.095	0.2569
0.8	Soybean	0.3648	33.1921	0.0571	1.8953
	Sugarcane	0.4754	23.3555	0.1312	3.0642
	Corn	0.2605	9.6471	0.029	0.2798
	Coffee	0.2371	3.3812	0.1011	0.3418
1	Soybean	0.418	38.0326	0.0601	2.2858
	Sugarcane	0.502	24.6623	0.1315	3.2431
	Corn	0.3181	11.7802	0.0301	0.3546
	Coffee	0.2849	4.0628	0.1056	0.4290

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