Attitudes to Price Risk and Uncertainty: The Earnest Search for Identification and Policy Relevance

Marc F. Bellemare* Yu Na Lee†

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Abstract

After several decades of neglect, the food crises of 2007-2008 and 2010-2011 have brought food price volatility back on the policy agenda. The study of price volatility, however, is really the study of price risk and uncertainty as they relate to individuals, households, and firms. Because the study of behavior in the face of risk and uncertainty has mostly focused on behavior in the face of *income* risk and uncertainty, we first review the theoretical and empirical literatures on behavior in the face of price risk and uncertainty. Then, because policy recommendations are only as good as the empirical findings on which they are based, and because market-level phenomena such as price risk do not lend themselves well to randomization, we discuss the ways in which experimental economics can inform our understanding of price risk. Finally, because expected utility—the workhorse model used to study behavior in the face of risk and uncertainty—fails to account for a number of behaviors, we discuss how insights from behavioral economics could be incorporated into the study of price risk, with the ultimate goal of generating more policy-relevant findings.

*Associate Professor, Department of Applied Economics and Director, Center for International Food and Agricultural Policy, University of Minnesota, 1994 Buford Ave, Saint Paul, MN 55108, mbellema@umn.edu.

†Ph.D. Candidate, Department of Applied Economics, University of Minnesota, Saint Paul, MN, 55108, leex5244@umn.edu.

1 Introduction

The food crises of 2007-2008 and 2010-2011 were a one-two punch to the international food system. Between 2006 and 2008, the Food and Agriculture Organization (FAO) of the United Nations' food price index—a summary measure of the price of food worldwide—increased by 38 percent, and it increased by 27 percent between 2009 and 2011 (FAO, 2015).[1] Consequently, both food crises saw policy makers scramble to mitigate the effects of price spikes, and if the food crisis of 2007-2008 took the world by surprise, the food crisis of 2010-2011, which came after a rapid drop in food prices due to the Great Recession of 2008, was even more unexpected.

With the benefit of five years of hindsight, it is easy to minimize the effects of those two food crises, especially now that food prices almost back down to their 2006 level (FAO, 2015). The fact remains, however, that the food crises of 2007-2008 and 2010-2011 caused many in the media and among policy makers to characterize food crises as episodes of high food price volatility. Economists, however, knew that all that talk of food price volatility conflated the related concepts of rising food price levels (i.e., a significant increase in the mean of the food price distribution) and of actual food price volatility (i.e., a significant increase in the variance of the food price distribution). In other words, although it was immediately obvious that the food crises were associated with increases in the mean of the distribution of food prices, whether those food crises were associated with increases in the variance of the distribution of food prices remained an open question. Yet policy makers the world over pressed on with a host of measures aimed at stabilizing food prices—that is, by adopting policies whose ostensible goal was the elimination of fluctuations, both upward and downward, around the food price trend, such as buffer stocks, administrative pricing, variable tariffs, marketing boards, and so on (Bellemare, Barrett, and Just, 2013).

Though economists are well acquainted with the effects of rising food prices on net buyers of food and on net sellers of food (Deaton, 1989), the effects of food price volatility have received much less attention in the literature, which often more accurately refers to price volatility as price risk or price uncertainty.[2]

[1] All food price figures discussed in this section are the authors' own calculations using the FAO's real (i.e., deflated) food price index.

[2] For the remainder of this paper, we will use the expressions "price risk" and "price uncertainty" interchangeably to refer to the phenomenon often referred to as price volatility.

Our contribution in this paper is thus threefold. First, we provide a concise review of the literature on the attitudes of economic agents—i.e., consumers, producers, and agricultural households—to price risk, surveying a literature that began with Waugh (1944). Recall that the best measure of welfare available to economists is the indirect utility function $V(p, y)$, which is defined over a vector of prices p as well as income y. Traditionally, the study of attitudes to risk and uncertainty has focused on attitudes to *income* risk, i.e., on $-\frac{V_{yy}}{V_y}$. There is an entire vector of prices p, however, regarding whose risk and uncertainty economic agents have specific preferences, i.e., $-\frac{V_{pp}}{V_y}$.[3] Our review of the literature provides a unified treatment of the effects of price risk and uncertainty—a topic that has now preoccupied agricultural and applied economists for a few generations.

Second, given the inherent difficulty that lies in accurately identifying price risk preferences with observational (i.e., survey) data, we discuss how experimental methods can be used in the lab and in the field to identify price risk preferences much more cleanly than the observational methods used so far. Indeed, the best available empirical evidence relies on (i) household survey data that are often measured with error as well as (ii) research designs that are less than ideal given their nonexperimental nature. To improve upon those methods, it is imperative for agricultural and applied economists who study price risk to start relying on experimental methods.

Third, given the important policy implication of the welfare impacts of price risk and uncertainty, we briefly discuss how the major insights of behavioral economics could be applied to the study of behavior in the face of price risk and uncertainty. Incorporating those insights into the study of price risk and uncertainty will enhance the realism of the theoretical models used to study price risk as well as the applicability of their empirical findings, and thus improve the policy relevance of this strand of research.

2 Price Risk and Uncertainty: A Review

In this section, we critically review the progress, both theoretical and empirical, made so far by economists studying price risk and uncertainty. We

When discussing Knightian uncertainty, i.e., uncertainty whose probability distribution is unknown, we will use the expression "price ambiguity."

[3]See Bellemare, Barrett, and Just (2013) for a derivation, and for why the denominator is V_y instead of V_p.

review what theoretical predictions have been made regarding the welfare effects of price risk for consumers, producers, and agricultural households. Throughout this discussion, we pay particular attention to how key underlying assumptions have evolved.

2.1 Consumers

Waugh (1944) was first to examine the welfare impacts of price volatility. Based on a geometric presentation of consumer surplus, he argued that consumers are better off under price variability than under a price stabilized at its mean. Waugh, however, relied mostly upon a graphical analysis of Marshallian consumer surplus, thereby ignoring the concept of risk aversion. Stiglitz (1969) was first to connect the theory of consumer demand with that of risk preferences by showing that risk neutrality at all incomes and price ratios is associated with linear income-consumption curves, and by showing that if all income-consumption curves are linear, there exists a cardinal utility representation that is linear in income.

Indirect Utility Function Approach. A key issue in investigating the relationship between risk aversion and a demand function is that risk aversion is a property defined over a cardinal utility function, whereas a demand function is defined from an ordinal utility function. Consider a consumer whose utility function $U(x_1, ..., x_n)$ is defined over n commodities. An indirect utility function $V(y, p_1, ...p_n)$ (where y is income and p_i is the price of the ith commodity) is obtained from maximizing the utility function subject to the budget constraint $\sum_{i=1}^{n} p_i x_i = y$. Not only does the indirect utility function allow measuring welfare without having to rely upon a graphical concept of consumer surplus, it also allows connecting risk aversion with the demand function.[4] In addition, the indirect utility function is homogeneous of degree zero in y and p, which allows for an analysis that is unit-free. Using these properties of the indirect utility function, Deschamps (1973) analyzed the connection between risk aversion and the demand function, showing which utility functions satisfy the properties that (i) absolute risk aversion be a function of income but not prices; and (ii) absolute risk aversion

[4] Absolute and relative risk aversion are defined as $-\frac{V_{yy}}{V_y}$ and $-y\frac{V_{yy}}{V_y}$, respectively. V_y and V_{yy} respectively indicate the first and the second derivatives of the indirect utility function with respect to income. The demand function x_i can also be derived from the indirect utility function via Roy's identity, i.e., $x_i = -\frac{V_{p_i}}{V_y}$.

be independent of compensated price variation (i.e., independent on each indifference curve).

Price Risk Preferences. The welfare effects of price volatility (alternatively, the benefits of price stabilization) are more directly assessed by consumer risk preferences towards prices. An important contribution by Hanoch (1977) was the analysis of the relationship between income risk preference and price risk preference. He showed that (i) a necessary condition for a consumer to be price risk-loving is that relative risk aversion over income be less than 2; and that (ii) a consumer can never be price risk-averse with respect to *all* commodities. Turnovsky et al. (1980) evaluated the benefits from price stabilization in terms of the convexity and concavity of indirect utility function with respect to prices. In the case where the price of a single commodity is stabilized, just as $V_{yy} < (>)\, 0$ indicates that the consumer loses (gains) from income volatility, $V_{pp} < (>)\, 0$ indicates that the consumer loses (gains) from volatility in price of the commodity. With this as a starting point, Turnovsky et al. showed that a consumer's preference for price stabilization is a function of (i) the income elasticity of demand for the commodity; (ii) the price elasticity of demand for the commodity; (iii) the budget share allocated for consumption of the commodity; and (iv) the coefficient of relative risk aversion. Based on this framework, they show that the desirability of price stability is positively associated with higher income risk aversion, but that it is negatively associated with higher price and income elasticities. Moreover, they show that for plausible values of the parameters (i)-(iv), it is theoretically possible for a consumer to be price risk-loving over the price of a commodity. This is especially so when the budget share of that commodity is small and income risk aversion is low. Thus, preference for commodity price volatility can vary considerably across economic environments.[5]

2.2 Producers

Various researchers have developed the theory of competitive firm behavior under price uncertainty. Oi (1961) challenged the intuition that price instability is undesirable for firms, and showed that "price instability is a virtue rather than a vice," given that price instability results in greater total profits for firms in a perfectly competitive market. The major shortcoming of

[5] On this Barrett (1996, p. 202) writes that "price risk aversion might exist among poor agrarian populations even though it is generally thought unlikely in wealthier, industrial countries."

Oi's analysis, however, was the implicit assumption that firms can perfectly predict future prices, and that they can adjust their output instantaneously.

Impact of Profit Risk Aversion. Oi (1961) assumed that firms maximize expected profits, thereby assuming that firms are (profit) risk-neutral. In later studies, researchers adopted the expected utility approach in which firms (or firm managers) maximize a von Neumann-Morgenstern utility function, and took into account potentially nonlinear utility functions. McCall (1967) compared profit risk-loving, risk-neutral, and risk-averse firms, and showed that under price uncertainty, the optimal output for the risk-averse firm is no larger than the optimal output for the risk-neutral firm, which is itself no larger than the optimal output for the risk-loving firm. Baron (1970) generalized McCall's result and showed that when price is a random variable, optimal output is non-decreasing in the degree of Arrow-Pratt risk aversion. Baron also showed that, under price uncertainty, a risk-averse firm produces at a level below the long-term equilibrium at which marginal cost equals average total cost. Baron thus argued that a risk-averse firm's output will be less than the Pareto-optimal output level, whereas a risk-neutral firm will produce at the Pareto-optimal level.

Impact of Output Price Uncertainty. Baron considered price uncertainty as given and focused on the effect of profit risk aversion on firm output. Sandmo (1971), for his part, considered profit risk-aversion as given and focused instead on the impact of price uncertainty on output. In his seminal article, Sandmo proved that a risk-averse firm's optimal output under price uncertainty is below optimal output under price certainty. In other words, price uncertainty, which is the result of a failure of the futures and options market, can be the cause of inefficiency.

Impact of Marginal Increases in Price Uncertainty. Sandmo also studied the effect of mean-preserving spreads (which he called "stretches"), but he was unable to determine the direction of the impact of a mean-preserving spread of the output price distribution on the firm's production decision. Batra and Ullah (1974) proved that the firm's optimal output is decreasing in marginal increases in price uncertainty under the additional assumption of decreasing absolute risk aversion (DARA). Epstein (1978) then showed that it is possible to yield a result contradictory to Batra and Ullah's even under DARA in cases where coefficient of relative risk aversion exceeds unity.

Addressing Preferences. Schmitz et al. (1981) revisited Oi (1961), who had claimed that price instability was desirable for producers by considering risk aversion and expected utility. Schmitz et al. (1981) use the indirect utility function $V(\cdot)$ in their analysis of producers, just as Turnovsky et al. (1980) did for their analysis of consumers. By doing so, Schmitz et al. (1981) assess the benefit of price stabilization to producers by directly addressing the impact of price stabilization in relation to preferences, rather than just analyzing its impact on the level of output. According to Schmitz et al.'s analysis, whether a producer prefers price stability depends on the convexity or concavity of $V(\cdot)$ with respect to output price. Based on this framework, they showed that for a single-product firm, Oi's result holds if the firm is profit risk-loving whereas if the firm is risk-averse, it may prefer price stability.

2.3 Agricultural Households

The theoretical approaches discussed so far have analyzed consumers and producers separately. Agricultural households, however, often consume some of their own outputs. This is especially so for agricultural households in developing countries, which are especially likely to face price uncertainty given the absence of futures and options markets in almost all developing countries. Given the dual consumer-cum-producer nature of agricultural households, economists have combined consumer and producer approaches to price risk and have thus studied the consequences of price risk for agricultural households.

Finkelshtain and Chalfant (1991) noted that agricultural households face multivariate risk, because both the prices of the commodities those households consume and their income are random. This is unlike the case of the firm analyzed by Sandmo (1971), in which price volatility is only realized in the form of profit volatility. Finkelshtain and Chalfant thus incorporated the concept of marketed surplus (i.e., a household's production minus its consumption, or its net supply) into Sandmo's model to analyze the behavior of agricultural households. A key assumption here is that the decision-making process involves two-periods: In the first period, *ex ante* of the realization of uncertain prices, the household makes its leisure and output decisions; in the second period, *ex post* of the realization of price uncertainty, it makes its consumption decision.

Based on their framework, Finkelshtain and Chalfant showed that production under price uncertainty can be greater, equal to, or smaller than the certainty output, thereby showing that Sandmo's (1971) result is a special case in which the wealth effect of price volatility dominates the consumption effect.

2.4 Empirical Evidence on Price Risk and Uncertainty

Though there is an important theoretical literature on the welfare effects of price risk and uncertainty, there are only a handful of empirical studies on the topic. Barrett (1996) investigated the role of price risk as an explanation for the inverse farm size-productivity relationship often observed in developing countries. Adapting the derivations in Finkelshtain and Chalfant (1991), he modified Turnovsky et al.'s (1980) theoretical model of pure consumers to account for the agricultural household context and derived the coefficient of price risk aversion of a household producing and consuming single staple commodity. Barrett showed that the estimated coefficient is larger for the smallest (i.e., more likely to be net buyer) farms, which is a sufficient condition for the overemployment of labor on smaller farms relative to large farms, which leads to the existence of an inverse farm size–productivity relationship.

Bellemare, Barrett, and Just (2013) extend the theoretical framework of Barrett (1996) to the case where agricultural households produce and consume several commodities in order to investigate the welfare effects of price stabilization in rural Ethiopia. They develop an estimable matrix of price risk aversion for agricultural households and derive a measure of willingness to pay (WTP) for price stabilization. Based on this framework, they show that the average household in their Ethiopian data is price risk-averse and willing to give up about 18 percent of its income to stabilize the commodity prices. Moreover, they show that WTP for price stabilization is increasing in household income, but this finding has been shown by McBride (2015) to be sensitive to how one deals with missing observations. Similarly, Mason and Myers (2013) derive the welfare implications of price stabilization by looking at the effects of the Zambian Food Reserve Agency on maize markets, finding that relatively wealthier farmers are the ones who benefit from more stable maize prices.

3 The Role of Experimental Designs

The most general measure of price risk aversion for a single commodity is the estimable coefficient of price risk aversion A derived by Barrett (1996) which is such that for, any economic agent (i.e., consumer, producer, or household),

$$A = -\frac{M}{p}[\beta(\eta - R) + \epsilon], \tag{1}$$

where M denotes the agent's marketable surplus of the commodity (which can be positive, zero, or negative depending on whether the agent is a net seller of the commodity, autarkic with respect to it, or a net buyer of the commodity), $p > 0$ denotes the price of the commodity, $\beta = \frac{pM}{y}$ denotes the commodity's share of the agent's budget (wherein y denotes income, and wherein β can also be positive, zero, or negative), η denotes the income-elasticity of the agent's marketable surplus of the commodity, ϵ denotes the price elasticity of the agent's marketable surplus of the commodity, and R denotes the agent's coefficient of relative (income) risk aversion.[6] When combined with the variance of the price of the commodity under study, the coefficient A can be used to derive a measure of willingness to pay for price stabilization WTP, which is such that (Bellemare, Barrett, and Just 2013)

$$WTP = -\frac{1}{2}\sigma\frac{M}{p}[\beta(\eta - R) + \epsilon], \tag{2}$$

where σ is the volatility of price p.

As noted in Bellemare, Barrett, and Just (2015), the major difficulty so far in estimating coefficients of price risk aversion has been that extant studies have had to rely on observational data in order to obtain an estimate $\widehat{A}$ of A. Given the nonexperimental nature of survey data, it is difficult to make the case that the estimates of β, η, R, and ϵ that go into making $\widehat{A}$ are unbiased, and so the estimation of A often requires making a number of ad hoc assumptions.[7]

[6] This framework has been extended to the case where agents consume or produce several commodities by Bellemare, Barrett, and Just (2013), but we focus on the single-commodity case for simplicity in this paper.

[7] As alluded to above, see McBride's (2015) comment on Bellemare, Barrett, and Just (2013) and the reply by Bellemare, Barrett, and Just (2015) for how changing only one of those ad hoc assumptions can change qualitative results.

Generally speaking, the goal of any empirical research agenda on price risk should be to look at two related questions. Given that equation 2 involves variables which vary at the market level (i.e, p and σ) and other variables which vary at the individual agent level (i.e., M, β, η, R, and ϵ),

1. Do increases in the amount of price risk σ consumers, producers, and households face have consequences on consumption, production, or both as well as on the welfare of the economic agents involved? Are those consequences in line with the predictions of the theoretical literature? This presents researchers with a set of reduced-form questions which are most promising when it comes to studying the effects of food price volatility on welfare.

2. Do agents with different preferences A for price risk behave differently? Because this requires estimating price risk preferences before studying the consequences of those preferences on behavior, this presents researchers with a set of questions that require the use of "deep" structural parameters which can contribute to our understanding of human behavior.

Faced with the task studying price risk preferences, one might be tempted to reach for the gold standard of randomized controlled trials (Duflo, Glennerster, and Kremer, 2007). The problem with that approach, however, is that it would be practically impossible to randomly assign a marketable surplus, price, or income to the different agents involved so as to cleanly identify A. Moreover, randomizing market-level variables such as price or price volatility is difficult, if not impossible.

Given that prices and price volatility are market-level phenomena, we see a few potentially fruitful avenues for research on price risk involving RCTs. The first would involve randomly treating households with discount vouchers for a staple crop that they can redeem at local stores but for which the exact value of the discount is uncertain and varies between treatment households until the household commits to purchasing from the store. This would introduce some exogenous uncertainty in the price of the staple, which could then be exploited to study how some outcome of interest (e.g., the consumption of the commodity whose price is uncertain, the consumption of other commodities, and so on) varies in response to changes in price uncertainty.

Another option for RCTs, which a reviewer suggested, would be to randomize the type of contract offered to a grower in the context of a contract farming agreement. Indeed, it is not uncommon for such contracts to completely insure growers (i.e., the agents) against price risk by having the processor (i.e., the principal) pay a fixed, pre-determined price. It might be possible to randomize growers into various contracts which vary in how much they insure growers against price risk. Given that growers offered different kinds of contracts could form risk-pooling coalitions that would defeat the goal of this kind of study, it is likely that such an RCT would require randomization at the village level.

A second-best approach involves the use of lab or lab-in-the-field experiments, an area in which there has been no work besides recent work by Lee, Bellemare, and Just (2015). In such experiments, subjects can be cast in the role of consumers, producers, or agricultural households who respectively have to make utility maximization decisions, profit maximization decisions, or both in the face of uncertain commodity prices.

In Lee, Bellemare, and Just (2015), the experimental design exactly mimics the theoretical model in Sandmo (1971). Experimental subjects play the role of firm managers who have to maximize profit in the face of output price risk. In each round, experimental subjects are asked to make a production decision *ex ante* of the realization of price uncertainty. In Lee, Bellemare, and Just's experiment, subjects get to see the distribution of prices they face in each round, and that distribution is randomly selected from among five, which all vary in how risky they are, ranging from no risk at all (i.e., a certain price) to very risky, with intermediate degrees of price riskiness in between those extremes. For each price level, experimental subjects know exactly how much profit they will make at each output level if that price level is the one that is drawn after they have taken their production decision. Contrary to Sandmo's theoretical prediction, according to which a move from a certain price to an uncertain price whose mean is equal to the certain price causes producers to hedge against price risk by producing less than they would in the certainty case, Lee, Bellemare, and Just find that the presence of price uncertainty—the move from a certain to an uncertain price—causes experimental subjects to produce *more* at the margin, but that subsequent increases in uncertainty (i.e., mean-preserving spreads) cause them to decrease how much they choose to produce.

The experimental methods used by Lee, Bellemare, and Just (2015) can and should be extended in several ways. First and foremost, they should be applied to the study of choice in the face of price risk by consumers and agricultural households. This could be done by having experimental subjects play the role of consumers who have to allocate their income to the consumption of various commodities whose prices vary in how uncertain they are, or to have them play the role of agricultural households who have to make their production decisions *ex ante* and their consumption decisions *ex post* of the realization of price uncertainty. In the latter case, it would be useful to randomly assign a specific market position (i.e., net buyer, autarkic, or net seller) to experimental subjects so as to study the likely asymmetric effects of price risk on behavior for agents with heterogeneous market positions.

Second, Bellemare, Barrett, and Just (2013) having shown that the households in their data generally not only care about the variance of each price, but also about the covariance between any two prices in their data, experimental methods should be applied to the study of price risk over more than one commodity. This could be done by having experimental subjects play the role of producers, consumers, or agricultural households involved in the production or consumption of two commodities whose prices co-vary. This would allow characterizing what happens in cases where the two commodities are substitutes or complements.

Third, researchers should pay particular attention to the potentially differential effects of price risk (i.e., an uncertain price whose distribution is known) and price ambiguity (i.e., an uncertain price whose distribution is unknown), as Lee, Bellemare, and Just (2015) have found that the two can have very different effects on experimental subjects placed in the role of producers.

Fourth, researchers should study the demand for insurance against price risk in the lab by developing experimental games wherein subjects face uncertain gambles over the prices they face, but also have the possibility of buying price risk insurance. In the case of Lee, Bellemare, and Just (2015), for example, this would require allowing experimental subjects to buy an insurance product in the lab which insures them against catastrophic losses due to price risk. One advantage of this approach would be to allow randomly varying the various parameters of the insurance (e.g., its price, the threshold at which it starts paying, etc.)

Lastly, the obvious shortcoming of such experimental studies is that they lack external validity. That is, their findings generally only apply to the specific pool of subjects who have taken part in an experiment, who are often undergraduate students. As such, researchers should strive to replicate their own experiments in as many different contexts as possible in the context of a single research project. Whether this means running the same experiment with college students and business executives, with college students and smallholder farmers in a developing country, with undergraduate and graduate students, etc. obviously depends on the application, but for the study of price risk preferences, which matter most in agricultural settings in developing countries, where insurance markets are highly fragmented or altogether absent, involving smallholder farmers from developing countries seems ideal.

4 Insights from Behavioral Economics

The foregoing laid out a research agenda to cleanly identify price risk preferences and behavior in the face of price risk and uncertainty according to the neoclassical paradigm. Researchers in psychology, economics, and related fields, however, have identified some systematic departures from the predictions of the neoclassical model in the 1970s and 1980s, they have developed alternatives to neoclassical model in the 1990s and 2000s, and they have begun empirically testing the predictions of those new theoretical models around the mid-2000s, three waves of research which have added up to form the field of behavioral economics.[8]

Because the empirical study of behavior in the face of price uncertainty has been rather limited, it is perhaps no surprise that the issue has been ignored by behavioral economists. Yet there are many areas where behavior in the face of price uncertainty and behavioral economics could intersect. In the spirit of Timmer (2012), who looked at how behavioral economics can inform our understanding of food security, this section explores what a behavioral research agenda on behavior in the face of price risk might look like.

Reference-Dependent Utility and Loss Aversion. Kahneman and Tversky's (1979) article on prospect theory, which is now the stuff of core courses in most graduate programs in agricultural and applied economics, identified several departures from standard models. Among those are the fact that reference points appear to matter (i.e., utility is reference-dependent), and that a monetary loss appears to translate into a greater welfare loss than an equivalent monetary gain translates into a welfare gain (i.e., people are loss-averse). Moreover, Kahneman and Tversky (1979) found that people

[8] See Rabin (1998) and Camerer and Loewenstein (2004) for reviews on the first two waves of research, and DellaVigna (2009) for a review of the third wave of research.

seem to behave as if risk-loving over losses, and they behave as if risk-averse over gains. These phenomena deserve to be investigated in the area of price risk. Lee, Bellemare, and Just (2015) find some evidence that people make bolder choices (i.e., they expose themselves to more price risk by producing more) when they experience a loss in the previous round, and they make more conservative choices (i.e., they expose themselves to less price risk by producing less) when they experience a gain in the previous round.

Though this is far from a clean test of prospect theory in the context of price risk, it suggests that prospect theory might also have something to say about price risk, and the phenomenon deserves systematic investigation. One way to test for the loss aversion might be to present experimental subjects with randomly assigned asymmetries (i.e., left- and right-skewness) in the price distributions they face, which would exogenously vary the likelihood of experiencing a gain or a loss relative to a symmetric distribution, which places equal amounts of probability density in either of the tails. Similarly, one way to test for reference-dependent utility might be to vary how much each experimental subject expects to take home by participating in an experiment, though it is not clear that subjects incorporate their expectation of experimental gains into their reference point, or whether it is a departure from their reference point.

Judgment under Uncertainty. One of the most fruitful areas of research in behavioral economics has doubtless been the search for better explanations for behavior than the workhorse expected utility model of neoclassical economics. Those better explanations are rooted in the fact that, here too, people make systematic mistakes and make decisions based on heuristics, all of which adds up to behavior that often resembles little (or not at all) the predictions of expected utility theory. People do not always know the probability distributions behind the uncertainty they face—that is, choices are made in the face of ambiguity rather than risk—and even when they know those probability distributions, they sometimes have a hard time processing that information, making inferences based on what has been referred to as the Law of Small Numbers (Rabin, 2002) or seeking confirmatory evidence for what they already believe in (Rabin and Schrag, 1999). In Lee, Bellemare, and Just (2015), for example, subjects fail to behave according to expected utility theory when they face price risk, and they appear to respond sharply to price ambiguity by making inferences based on very few realizations of the price distribution.

Here, there are as many possibilities for experimental designs aimed at testing alternatives from expected utility theory as there exist such alternatives theories. In this area of research, the challenge will lie in developing experimental protocols that nest two or more theories to account for judgment under uncertainty, which would allow researchers to run a horserace between competing theories. For example, it might be possible to design an experimental protocol that allows convincingly testing whether expected utility theory or prospect theory best explains behavior. See Liu (2013) for an example of how this has been done in the field.

Intertemporal Choice. In order to hedge against or speculate over price risk and uncertainty, consumers, producers, and agricultural households will often store some commodities, and several theoretical models explore the causes and consequences of storage (see Wright and Williams, 1984 and 2005). Yet behavioral economists have identified a number of departures from the neoclassical model of intertemporal choice. Chief among those is the existence of present-biased preferences (O'Donoghue and Rabin, 1999) and related self-control issues. Intuitively, individuals tend to have a sharp preference for the present which, in the absence of commitment devices, leads them to adopt sub-optimal behavior when the future arrives. For example, an individual whose preferences are present-biased—in other words, a individual with self-control issues—might overconsume today some of the food she has stored for the lean season, which leads to issues of food insecurity when the lean season finally arrives (Laibson, 1998; Harris and Laibson, 2001).

One way to explore the behavioral dimensions of intertemporal choice would be conduct a lab-in-the-field experiment aimed at eliciting respondents' hyperbolic discounting parameters (the β and δ of O'Donoghue and Rabin, 1999; see Olea and Strzalecki, 2014 on how to elicit those parameters) and then use those parameters in order to explain some economic behavior related to food storage. Alternatively, it would be possible to run an RCT in which respondents are treated at random by being given a small silo in which they can store food for longer periods of time, or to elicit respondent willingness to pay for such a storage technology.

Fairness and Social Preferences. Finally, it turns out that, in contrast to what the neoclassical model typically assumes, people care about fairness and are averse to inequity (Yaari and Bar-Hillel, 1984; Charness and Rabin, 2002). Though this aspect of behavioral economics might seem a priori of less relevance to the study of attitudes to price volatility, the fact that different economic agents (i.e., individuals, households, and firms) have different net positions (i.e., net buyer, autarkic, net seller) vis-à-vis the market for those commodities whose prices fluctuate may cause some agents to bear the consequences of price volatility while others reap benefits from it, i.e., the former are hedgers, while the latter are speculators. Bearing in mind that very distinction, many in the media and among policy makers were quick to blame speculators for the food crises of 2007-2008 and 2010-2011, and historically, speculators have often had a bad reputation of holding to certain assets purely to profit from market fluctuations. As such, an investigation of the political economy of food crises which takes into account the impacts of food price volatility on heterogeneous households and firms, the response of governments, and the importance of social preferences might help guide policy makers when the next food crisis hits.[9]

5 Summary and Concluding Remarks

In this article, we have reviewed the economic literature on behavior in the face of price risk and uncertainty and, on that basis, we have laid out the foundations of a future research agenda on price risk and uncertainty which relies on experimental methods and incorporates the insights of behavioral economics.

As with many other market-level economic phenomena, the tools of randomization are of limited usefulness when it comes to studying price risk and uncertainty. In order for empirical findings to be policy relevant, the inferences derived therefrom need to be credible and based on the clean (i.e., causal) identification of empirical relationships. Though quasi-experimental methods—that is, methods relying on natural experiments or plausibly exogenous instrumental variables—hold some promise on that front, we believe that experimental methods are best-suited to cleanly identify consumer, producer, and household preferences and behavior in the face of price risk and uncertainty, though we certainly recognize that those methods can be limited in their external validity.

Likewise, incorporating insights from behavioral economics can also enhance the policy relevance of research findings from the study of behavior in the face of price risk and uncertainty. Though expected utility theory has been the workhorse model in economics when it comes to studying risk and

[9] That said, Bellemare (2015) finds that, for the period 1990-2011, it was rising food prices that caused food riots, and that increases in food price volatility were not systematically associated with social unrest.

uncertainty, behavioral economists have identified systematic departures in behavior relative to what expected utility predicts. Between the internal consistency provided by expected utility theory and the greater realism afforded by behavioral economics, policy relevance most likely is predicated on the latter.

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