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Research Paper no. 5/02

Consumption Hedging as a

Means of Uncertainty Management

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Research Papers from the Department of Social Sciences, Roskilde University, Denmark.

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Abstract

Based on fundamental uncertainty, this paper analyzes the conditions under which consumption hedging is viable. In the context of a debate on the desirability of fixed vs. flexible prices, an argument is made that if properly designed, an instrument for consumption hedging could make a significant contribution to the efficiency of uncertainty management. A preliminary technical definition of a consumption hedging instrument is provided.

Keywords: Uncertainty, consumption, price theory, financial innovation.

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TABLE OF CONTENTS

Introduction

Price stability is of strong interest in economics. In microeconomics the question is often whether economic activity benefits from sticky or flexible prices. The answer commonly given is that the allocation of scarce resources serves consumers and entrepreneurs best when prices are flexible. Although a flexible price constitutes uncertainty to buyers and sellers on a market as to the cost and revenue of consumption and production, respectively, research on the costs and benefits of flexible and fixed prices tends to assume away such uncertainty. Risk and uncertainty are taken to be interchangeable with one another: this either grants agents with perfect foresight – and so uncertainty is non-existent – or allows them to make quantifiable forecasts of prices.

While we in our daily economic activity are unquestionably short of perfect foresight, we are indeed able to foresee with fairly good, sometimes very good accuracy the prices of most goods and services we purchase on a regular basis. This gives us good reason to believe that the latter of the aforementioned fundamental assumptions – that of uncertainty and risk being interchangeable – is the most accurate one. As a consequence, we could accept that flexible prices are preferable to fixed prices, and that fixed prices are relevant only as a result of perfect foresight. However, this paper shows that there is a third viable alternative: by separating risk from uncertainty, allowing the latter to be defined in the Knight-Keynesian tradition. (Keynes 1937) we can conclude that fixed – or sticky – prices are preferable to flexible prices when the future is uncertain.

This paper takes as its starting point a debate on the benefits of flexible and sticky prices, respectively, that started with the definition of Waugh's theorem (Waugh 1944). This theorem says that under a given set of conditions the individual economic agent is better off under a regime of fixed prices rather than flexible prices:

> If a consumer has a given sum of money to spend for all goods and services, and if he can distribute this expenditure as he pleases among n equal periods of time, he will be better off if all prices vary than he would be if all prices were stabilized at their respective arithmetic means. (Waugh 1944, 608)

Waugh's original article drew a number of replies and rejoinders (Howell 1945; Lovasy 1945; Waugh 1945, 1966, 1972; Nelson 1961; Massell 1966; Samuelson 1972a, 1972b; see also Oi 1961, Tisdell 1961 and Newbery 1989). The debate which has shed light on the theorem from many angles, is interesting fort two reasons: it illustrates the theoretical foundation of the first two aforementioned conclusions on whether prices should be fixed or flexible; and it gives us a good starting point for showing how a distinction between uncertainty and risk can make a significant difference to our preferences for flexible and sticky prices. Like Samuelson (1972a), we will refute the theorem, but where Samuelson's refutation is founded on the employment of risk-uncertainty identity and perfect foresight, our refutation is built on a separation of risk from uncertainty. In this way we give the economic agent the longest possible distance between herself and perfect foresight.

The paper is organized as follows. First the debate on the Waugh theorem is reviewed, with emphasis on the development of the theorem during the course of the debate, concluding with Samuelson's refutation. Then, in section 2, we open for a distinction between risk and uncertainty by introducing asymmetric information. Section 3 outlines an alternative approach where risk and uncertainty are distinguished and the economic agent is assumed to have a normative preference for the reduction of uncertainty.

Waugh's theorem and price stabilization

As is stressed by Waugh, his theorem has important policy implications...

> since it runs counter to the accepted doctrines upon which many national and international [price] programs are built. (Waugh 1944, 602)

Three propositions constitute the foundation of the theorem in its most general form:

1) Suppose two prices, $P_1 \neq P_2$, and their arithmetic mean, P_A; $P_2 - P_A = P_A - P_1$. Consumer surplus will now be larger than if for the same two periods $P_2 = P_A = P_1$.
2) It is held as a generalization that the gain in consumer surplus under price flexibility is approximately proportional to the square of the price variation.
3) With a given money income to spend, and given a specific set of preference functions, a consumer can always be better off under flexible prices than under fixed prices.

Critique was raised by Howell (1945) and Lovasy (1945). Howell points out that there is nothing in Waugh's argument for the theorem that shows why the pattern of distribution suggested by his theorem is the only or even the most feasible point to be chosen. On the one hand:

> If price stabilization operations were of necessity limited to stabilizing prices at or above the arithmetic mean, $P_0 = ½(P_1 + P_2)$, or if stabilizing prices at any other point would give essentially the same results, the theorem as stated would appear to give considerable support to [Waugh's] generalization. (Howell 1945, 289)

On the other hand, if stabilization operations established a price $P_i < P_0$, the case for Waugh's theorem would obviously be different. Also, if stabilization is not about the arithmetic average price, but the weighted average, the case for the theorem is weakened further:

> With a [given] demand schedule /.../ advances in P_1 and P_2 by amounts great enough for their weighted average to equal P_0, but without changing the spread between P_1 and P_2, would have about the same influence on the average consumer's surplus as that of stabilizing the price at the arithmetic mean. (Howell 1945, 290)

It is, in other words, possible to achieve the same results with a *weighted* average as with the *arithmetic* average. The theorem's uniqueness – and consequently its originality – is therefore questioned.

Pointing at a further problem, Lovasy stresses that Waugh's theorem needs all other prices to remain unchanged during the period when a product's price fluctuates. The reason is that consumers otherwise would be motivated to change their spending pattern to the disadvantage of the theorem:

> the consumer may either keep his total consumption stable by spending a larger proportion of his income in the period of high prices and a smaller one in the period of low prices, or he may increase consumption when prices are low, being "better off" in that period, and reduce consumption and be "worse off", when prices are high – he could not be better off in both periods. (Lovasy 1945, 297)

As a response to Howell and Lovasy, Waugh (1945) moderates his theorem a little bit:

> [Price] stabilization at, or above, the arithmetic mean of prices *harms* every consumer, and that stabilization at or below the weighted mean *benefits* every consumer. (Waugh 1945, 302-303)

Support for the implication of Waugh's theorem that flexible prices can be preferable to sticky prices comes from an unrelated article by Oi (1961). This contribution points at a positive relationship between a firm's profits and the flexibility of its product prices. A flexible product price benefits the firm more than a price fixed at the arithmetic mean. Oi's conclusion rests on two necessary conditions: that firms maximize short-run profits, and that profits increase monotonically with the product price. A third, though implicit, condition – shared with Waugh and stressed by Nelson (1961) in an unrelated study – is that a flexible price must move within a predictable frequency. We will return to this third condition in section 3 below.

Two characteristics of Oi's study makes it relevant. First, Oi explicitly assumes that uncertainty is stochastic price movements. While distinct from Waugh's risk-uncertainty assumption, it does not go as far as the Knight-Keynesian definition, but it nevertheless merits to be recognized. Secondly, Oi – unlike Waugh – concentrates exclusively on the producer's benefits from fluctuating prices. He does, as mentioned, assume that profits grow monotonically with prices. In a comment, Waugh (1966) stresses that there is a delicate balance between consumer and producer gains from price flexibility:

> I doubt if the welfare aspects of price stability can be analyzed, either from the consumer's standpoint or from the producer's standpoint without considering the level at which prices are stabilized. If they are stabilized at a very low level, the producer is harmed and the consumer benefits. If they are stabilized at a very high level, the producer benefits and the consumer is harmed. (Waugh 1966, 507)

This indicates that price stabilization cannot benefit both sides of the market as they do not have common interests in pricing at any other point than an optimal equilibrium. It will be argued in the next section that this is incorrect: if uncertainty is separated from risk, both sides of the market will have a mutual interest in reducing uncertainty that opens a wide range of alternative prices equally attractive to both sides of the market.

Emphasizing the uniqueness of an optimal solution, Samuelson (1972a) refutes Waugh's theorem. Sticking rigidly to Waugh's original premises, he demonstrates that stable prices *are* preferable to flexible prices because of the properties of an optimal distributive solution: if a change from quantity to another is possible, the reason for a transition from the first equilibrium to the second is that the original equilibrium was sub-optimal – optimum is optimum, plain and simple. As a further critique, Samuelson points out an error in Waugh's use of consumer surplus in his argument for this theorem:

> Arguing [Waugh's] way is tantamount to thinking that, whenever we raise the price of wheat (by making it scarce), we thereby raise in equivalent proportion the *utility* of the background good(s) on which the money spent on wheat could otherwise be spent. This is money illusion with a vengeance (illusion be it noted on part of the economist observer and not on part of the consumer)! (Samuelson 1972a, p. 482)

Waugh's theorem is thus refuted within the boundaries of its own axiomatic structure, including the identity of risk and uncertainty. But Samuelson only shows that when the conditions for optimum are fulfilled, administered price stability is harmful. Given that the conditions under which such equality can be accomplished are unrealistic – e.g., the condition of time symmetry – we proceed to separate them from one another. We begin with introducing asymmetric information.

Price stabilization and asymmetric information

Newbery & Stiglitz (1981) make a case against administrative price stabilization based on uneven distribution of information. Their major result is that price stabilization is beneficial neither to consumers nor to producers (Newbery & Stiglitz 1981, 23). They are also critical of the methods for evaluating price stabilization schemes in earlier studies, and conclude, as a case, that on the world food market the result of price stabilization regimes can actually be increased international inequality:

> Indeed, there seems a serious possibility that at least some of the [less developed countries] will actually be worse off as a result of price stabilization and that the major beneficiaries of such programmes might be the developed countries. (Newbery & Stiglitz 1981, 23)

There are two approaches to price stabilization: one that uses income stabilization (demand-oriented stabilization) and one that stabilizes quantity (supply-oriented stabilization). A major reason why they are both problematic is the distinction between risk and uncertainty that Newbery & Stiglitz maintain. While risk is quantifiable and therefore can be hedged against by standard means, uncertainty is a situation where "there is no consensus about the relevant probability distribution" 1981, 48). Therefore, it is practically not possible to determine the allocation of resources to stabilization programs.

Probability consensus is an institutional phenomenon and cannot be built unless relevant institutions are in place.[1] Every market for future contracts is an institution geared to establish probability consensus. Section 3 suggests the establishment of such a consensus-building institution in the consumer market for gasoline, an invention that would, it is argued, solve the problems with price stabilization addressed by Newbery & Stiglitz. To get there, however, we need to follow Newbery & Stiglitz as they discuss the role of risk markets when agents are risk averse and risk is separated from uncertainty. The question is, therefore, how risk markets can add to efficiency on commodity markets under a regime of risk aversion. Newbery & Stiglitz suggest a multi-price model where producers form expectations on the probability of a product price over a series of future market periods. Demand depends on the product price in each period of time and there is no storage. Knowing this, producers form expectations about a probability distribution of production volumes that corresponds to the distribution of prices.

If producers have limited price-setting power due to competition, the premise of rationality in expectations is a guarantee that producers' price expectations will be self-fulfilling:

(1) $$F^*(p) = F^e(p) = F(p)$$

With prices thus stabilized around a mean price, it appears as though the Newbery-Stiglitz model shares its fundamental lay-out as well as its implications with the Waugh theorem. This is not the case, however. In addition to their explicit separation of risk and uncertainty, Newbery & Stiglitz express detailed critique (p. 122) against on the Marshallian concept of consumer surplus which, in turn, is employed by Waugh. Two points of critique are: its dependence on zero income elasticity and the awkward consequence of a withdrawal of demand for product A in favor of product B, namely that consumer surplus – and therefore consumer welfare – will fall. More importantly to our current discussion, the Marshallian surplus concept is liable to be criticized because it cannot unify arithmetic average stabilization of a product's price with quantity unless the demand schedule is linear. However, the question is whether the Newbery-Stiglitz model is capable of generating a conclusion that, in principle, is similar to that of the Waugh theorem, namely that at least one side of the market will suffer from price stabilization as compared to controlled price flexibility.

A key premise behind the conclusion by Newbery & Stiglitz that price stabilization is harmful (pp. 26-27) is the concern that producers have with stabilization of income (and therefore of consumption) instead of the product price per se. So long as agents are not risk neutral and do not have perfect foresight, a stabilization of the price may squeeze all variability that is caused by uncertainty into quantity fluctuations, which can cause income to vary more violently than when prices are not stabilized. This effect is made possible if we keep product demand from being even partly determined by changes in price stability, whether in terms of elasticity or sum.

[1] Every market for future contracts is an institution geared to establish probability consensus. Section 3 suggests the establishment of such a consensus-building institution in consumer-oriented commodity markets to solve the problems with price stabilization addressed by Newbery & Stiglitz.

It makes sense to extend a separation of uncertainty and risk, along the lines of Newbery & Stiglitz, into a model where demand does depend on changes in price stability: to the consumer uncertainty takes shape in predictability of money prices. Since prices are set by producers, this extension establishes a ground for common interest of consumers and producers that, in turn, opens for price stability to be beneficial as compared to flexible prices.

A model for consumption hedging - groundwork

When uncertainty is distinguished from risk, the individual economic agent – whether a consumer or a producer – a model must take into account two specific constraints on that are imposed by such uncertainty. First, because of the nature of uncertainty any planning of economic activity is impossible *until a predictable environment for that activity has been created*. The creation of that environment, in turn, is an act the sole purpose of which is to transform a state of uncertainty into a state of risk. As a consequence, economic agents must be assumed to respond positively to stability in their economic environment: building and preserving uncertainty-curbing institutions make economic agents better off than abstinence from doing so. Hence, the following model ascribes a positive utility experience to activities that create and maintain uncertainty-reducing institutions.

Secondly, as we distinctly split uncertainty from risk we also say that the economic system cannot have any mechanical ability to revert to equilibrium after a shock. Even the concept of equilibrium must be restated: in a situation of genuine uncertainty there is no state of resource allocation that can be unquestionably preferred to any other by both sellers and buyers. As Newbery & Stiglitz point out (ref.), there is no consensus on what prices and quantities best promote return on economic activities. Uncertainty is by definition an intertemporal phenomenon, and therefore any state of economic activity through which uncertainty is handled to the benefit of both producers and consumers is by necessity an intertemporal state. “Equilibrium” is not obviously an atemporal concept, but the way it is commonly used in economic literature its meaning is independent of the course of time (ref). To specifically address intertemporal phenomena we need to add that concept to “equilibrium”.

Even then, however, “equilibrium” does not work purposefully in a theoretical context with Knight-Keynesian uncertainty. A state of equilibrium is selected through a trial-and-error process guided by an auctioneer or market maker where prices and quantities are adjusted prior to trade or in an equilibrium-converging course of trade. Common to both these alternatives is the premise that convergence to equilibrium consists of price and quantity adjustments where both consumers and producers benefit from a high degree of flexibility in prices and quantities. But the problem is that in a state of Knight-Keynesian uncertainty a high degree of flexibility is a manifestation precisely of that uncertainty, whereas a narrow bracket of prices and quantities to move within is a benefactor to both sides of the market. By *creating* a price that will remain unchanged over a series of market periods, producers and consumers do exactly the opposite than is implied by the equilibrium process to reduce uncertainty about the future return on economic activities. As a fundamental premise we hold that the longer a price stays unchanged, the more purposeful it is to both producers and consumers.

To capture this property of a state of “equilibrium” we reduce complexity of the following analysis if we speak of *stability* instead of equilibrium. We will refer to stability as a state of economic activity where the product money price remains unchanged over at least three consecutive periods of economic activity.[2]

On the individual market buyers and sellers will respond to Knight-Keynesian uncertainty by building an institutional framework that, in turn, motivates them

[2] The choice of three periods is discussed in Larson (2002, section 2.1).

to engage in economic activity over time. Every price contract is in itself a stabilizing feature of the market's institutional framework. But in a world of Knight-Keynesian uncertainty it is not possible for any individual agent to have any detailed knowledge – or, for that matter, *any* knowledge – of all prices on the market. Therefore, trade takes place at very different prices until the erected institutions have enabled establishment of successful prices and successful relations between buyers and sellers; the result is the emergence of a stable price structure.

This stabilizing process can, as we will see, be brought about by the introduction of a consumption hedge instrument, or C-Hedge as we will call it. Technically, this instrument brings to consumer markets what has long been a distinct feature of equity markets, namely an attached risk market. Being a derivative instrument, the C-Hedge is introduced to help consumers hedge their future spending in a fashion similar to that of traders on established equity markets. The next section introduces the instrument; then we put the C-Hedge to work on a market.

The hedge instrument

We will use the gasoline market as an example of how the introduction of the C-Hedge would make a difference. This market exhibits a relatively high degree of price flexibility, and oil products prior to gasoline in the production chain are or can be traded on futures market, but consumer-oriented gasoline itself is only sold spot. Prices are announced at outlets (gasoline stations) as take-or-leave offers to consumers, though being at the same time liable to change at very short notice.

It is important, before we proceed, to recognize three distinct characters of the gasoline market each of which constitutes an obstacle to the development of a gasoline consumption hedge instrument:

- Each individual purchase involves a relatively small amount of money.
- Purchases are relatively frequent – an average American driver stops for gasoline fill-up 40-50 times per year.
- There is a relatively significant degree of market heterogeneity, despite the homogenous product. The reason is the geographical dimension of the market, where the physical location of one or a small number of gasoline stations can form a regional or local non-competitive market.

These characteristics condition the design of the C-Hedge in the following way:

- The first two characteristics say that individual occasions of trade must be pooled in order to make hedging profitable to either side of the market. This pooling must combine the need for predictability with the need of the market to stay liquid.
- The third characteristic tells us that the C-Hedge must be physically portable.

The pooling requirement can be met if we can pool together a consumer's purchases for a number of future periods under one hedge contract. E.g., I can hedge all my gasoline purchases for the next six months by buying one single, six-month contract that gives me the right to buy gasoline at $1.10 per gallon. To avoid making the C-Hedge holder a middle-man who can profit unrestrictedly on price differences, and to prevent price discrimination, we must make the C-Hedge tradable on a continuously accessible market. Such a market is necessary to make the contract interesting both to consumers and to producers. Another necessary condition of the C-Hedge's configuration is that carrying it must be of maximum convenience to consumers as they move from gas station to gas station. To assure insignificant carrying costs the contract is best given a form that fits an already existing means of payment, such as a credit card. In order to make a C-Hedge "visible" to each gasoline station I decide to shop at, the C-Hedge is carried by the credit card and the price enclosed in the contract is made visible to the gasoline pump as the card is swiped to open the pump for filling.

Pooling of several future purchases must come with an obligation to spend. The seller of gasoline demands revenue certainty of as high a degree as possible, and will only supply futures contracts, not options. Thus, the purchase of a C-Hedge must involve a deposit requirement: if a regular fill-up costs $25, and the consumer decides to hedge purchases for the next six months (amounting to, say, 25 purchases), she will have to deposit $625 in exchange for a locked per gallon price within the aforementioned institutional structure. For every purchase of gasoline $25 (for simplicity) is deducted from her deposit. The holder of a C-Hedge can then, at any time, put her contract up for sale on the market, at a price that will be formally defined below, but which is determined by the remaining deposit, the difference between the hedged price and the current spot price of gasoline, and an uncertainty factor.

The model's basic characteristics

Let us now proceed to outline the basic characteristics of the C-Hedge market. To begin with we outline the structure of the model, with recognition of the aforementioned properties of the C-Hedge.

<u>Interdependent supply and demand.</u> In order to acknowledge the mutual interest of producers and consumers in bringing uncertainty down to manageable properties, supply and demand are dependent upon one another (unlike standard perceptions of the operation of markets, where demand and supply sides of the market are independent of one another). Any activity on one side of the market which changes the preferences for or abilities to participate (as consumer or producer) will in turn change the perception of uncertainty on the other side of that same market, thus altering its preferences or abilities to participate (as producer or consumer).

Technically, the interdependence is manifested as a distribution of responsibility for uncertainty management between producers and consumers. At the beginning of a market, in absence of historic regularities, both price and the quantity to be traded are uncertain. Both variables have to be determined, which means that sellers and buyers have to go through a very costly process of trial and error in order to stabilize the conditions of trade. With a simple distribution of labor between buyers and sellers, this information problem can be solved at less a cost than otherwise, such that one side of the market is responsible for determining the price and the other for determining the quantity. It is assumed – as an empirical generalization – that the common distribution of labor to make uncertainty manageable is one where sellers set product prices and buyers respond by determining the volume demanded. Sellers make prices suggestions, each of which is accompanied by a *carte blanche* in terms of production volume; the volume is then decided by buyers based on the prices offered by sellers.

On the related risk market, the producer of the underlying commodity plays a more active role, having the authority to decide the volume of the market. Consumers who are interested in hedging based on their risk aversion absorb contracts in proportion to their product demand, and since an increase in access to hedge contracts is an improvement in the consumer's ability to hedge, the response to increased supply of C-Hedge contracts will be a proportional growth in demand for gasoline. In other words: supply and demand are interdependent.

Lack of inherent stability. Since stability must be created by producers and consumers in interaction, the model we are using is not inherently stable. There are no mechanisms in the model that bring price and quantity on the product market in stability at any point of time, under any circumstances, unless stability is actively sought by producers and consumers. If fear of future losses from taking positions – whether spot or forward – surface today and motivates consumers and producers to refrain from consumption and production, then activity on the market may plunge uncontrollably. The market can only keep away from such extreme a scenario if its agents actively want and strive for that stability. But it will also be shown that instability – in the other end of the spectrum – can result from extreme use of hedge contracts.

The market

We begin with defining the market and the properties of the C-Hedge contracts. To start with properties, there are two of these behind consumer demand for hedge contracts that influence their design. First, occasions of demand for gasoline must be bundled together to make hedging attractive. These occasions occur continuously, and as a result consumers are motivated to have price *stability* as the overall interest behind their demand for gasoline price hedging. We have to take this property of demand into account as we design a function for its representation.

Secondly, hedging means protecting future consumption and production against unpredictable price swings. The expectations of such price swings exercises a decisive influence over the demand for hedge contracts. Together with the first property, the influence of expectations form the following C-Hedge demand:

(2) $$q_H = z^y\left({}_X\widetilde{P}\right)$$

${}_X\widetilde{P}$ is the expected price variability in the periods for which price hedging is considered. z^y is the risk aversion preference of consumers. Supply of hedge contracts partly depends on the same properties: it has to be pooled over time to make contracting attractive, and with pooling goes a demand for price stability over the pooling horizon. However, given that their overall objective is profit maximization their concern with price stabilization is only instrumental. Instead, the producer's choice to hedge supply ultimately depends on her profit expectations. When profit is expected to rise the motivation to secure a steady revenue stream by means of hedging is weaker; when profit expectations are pessimistic the motive for hedging is stronger. Therefore:

(3) $$q_H = \hat{q}_H - æ\left({}_X\Pi\right)$$

$\hat{q}_H$ is the highest volume that producers are willing to hedge. $æ$ is a risk aversion preference of firms, and contrasts to the risk aversion preference of consumers: while consumers prefer to hedge as a precaution against risk, firms prefer to relax hedging to be free to adjust prices in response to contingencies.

Demand for and supply of gasoline under hedge contracts can be brought into agreement on what volume to hedge if and only if there is consistency in expectations between supply and demand. Consistency in turn depends on two conditions: that the slopes of the functions are stable and that the maximum hedge volume, $\hat{q}_H$, stays unchanged. A sufficient condition for pushing the market out of stability is that one of these conditions is not fulfilled.

Holding the slopes of the functions constant for simplicity, we will use a fall in $\hat{q}_H$ as a cause to illustrate how the market for C-Hedge contracts is thrown into instability, and how this in turn has repercussions on the market for gasoline.

The C-Hedge market's functions have different slopes and intuitively we would assume that the hedge volume is determined where the two functions intersect one another. This is, however, not the case: it is the product of pure coincidence if the intersection determines the traded volume. Instead, a hedge volume is normally agreed on when the values of the expected variables diverge: when price volatility is expected to be high and profits expected to be low, or vice versa. Demand for hedged gasoline increases with expected increases in price volatility, whereas supply of hedged gasoline increases with expected *drops* in profits. The mechanism that warrants correlation between ${}_X\widetilde{P}$ and ${}_X\Pi$ works as follows:

1. a rise in price volatility weakens consumer confidence and therefore consumer spending;
2. corporate profits fall as a direct result of reduced spending and as a result of rising consumer price volatility;
3. given that all other variables are constant, and given rationality in expectations subject to the stipulated uncertainty, firms will adjust their expectations in accordance with expectations on price volatility.

So long as this mechanism is allowed to function, q_H is determined by coinciding interests of buyers and sellers. So long as ${}_X\widetilde{P}$ and ${}_X\Pi$ correlate, an entire bracket of possible ratios of consumption hedging is open. The hedge ratio will be determined over time by the interaction between, on the one hand, expectations of price volatility and profits, and on the other hand the actual development of these variables. Expectations are, we say, rational, but this does not have to mean anything more than that economic agents do not make systematic mistakes. In addition to that, their content – the nominal development of a variable as expected by, e.g., consumers – is adaptively determined: recent history of price volatility exercises a significant influence over expectations.

Therefore, as economic agents respond to historic trends they enter into contracts or otherwise plan their economic activities, and every step they take will make it more likely that they will actually accomplish the goals they have set for themselves. As the institutional structure becomes established, it becomes easier to estimate quantitatively the probable outcomes of production and consumption. Uncertainty is transformed into risk through collective institutionalization of expectations collectively. These expectations-carrying institutions form a framework within which individual consumers and producers can go about their economic activities on a regular basis. So long as the framework of contracts and conventions prevails as a predictable framework for daily economic activity, consumers and producers will extrapolate history into the future with the highest level of confidence. But if the institutions fail to deliver the predictable economic environment, individual agents will fail to predict the future with expected accuracy. The failure is an injection of uncertainty that will motivate more pessimism – a pessimism that in turn will appear as a shortening of planning horizons. Consumer behavior is affects demand for gasoline in the following way.

The preference that consumers have against flexible prices makes it impractical to employ a traditional demand function where price and quantity are determined simultaneously. What matters is instead the stability of the product money price over time: the more stable the price is, the less uncertain consumers are; the less uncertainty among consumers, the higher is demand. Price flexibility is now a relevant argument in the demand function, and therefore our demand function looks as follows:

(4) $$Q = Q^{*} - z^{\mu}\widetilde{P}$$

Q^{*} is the quantity demanded when consumers harbor the strongest possible confidence in the future. z is a risk aversion preference: when consumers are risk averse, $z > 0$. μ is the degree of hedging on the market, determined as $\mu = \frac{m_S}{m_H}$, or the ratio of gasoline purchased spot relative the ratio of gasoline purchased under hedge contract obligations.

$\widetilde{P}$ is the volatility of a money price over time and a key argument in the demand function. It is determined in the following way:

(5) $$\widetilde{P} = P_H + \Phi\left(\frac{g}{\mu}\right)^{-\tau}\cos\left(\frac{\mu}{f}\right)\pi\tau$$

P_H is the price established by hedge contracts with the life of τ periods of time. Φ is the variability at the period when contracts are issued. Together with the ratio $\left(\frac{g}{\mu}\right)$ it gives us the decrease in amplitude of the price. The next ratio, $\left(\frac{\mu}{f}\right)$, determines the intensity of price swings. g and f are constants, the size of which express the relative importance ascribed by consumers to a reduction in amplitude and frequency, respectively, as a means to reduce uncertainty.

The ratio of spot price trade vs. hedged price trade enters the volatility equation as determining argument of the amplitude decrease as well as the frequency (or intensity). A higher degree of hedging – which appears as a rise in m_H and a fall in m_S – brings μ to fall; with all other variables unchanged this speeds up amplitude reduction and slows down intensity. Uncertainty is reduced by both moves, which from a theoretical standpoint makes it indifferent which of the two constants g and f is the largest.[3]

Equation (4) provides us with an explanation of how a product market moves towards and stays in stability. It also explains how the same market can be thrown out of stability. There are two possibilities for the latter, both of which originate in changes in the hedging ratio – a ratio that in itself is a source of stability since changes in the numerator and the denominator are directly linked to one another.

The first case is one where $(\mu \to \infty) \Rightarrow \left(\left[\frac{g}{\mu} \right] \to 0; \left[\frac{\mu}{f} \right] \to \infty \right)$. Hedging is now infinitesimally small which leaves the entire market to spot pricing. In the second case, the reverse course of development, $(\mu \to 0) \Rightarrow \left(\left[\frac{g}{\mu} \right] \to \infty; \left[\frac{\mu}{f} \right] \to 0 \right)$, takes place.

Both cases of instability emerge because price and profit expectations of buyers and sellers on the C-Hedge market no longer pull the hedged volume in the same direction. To start with the first case, q_H and therefore m_H fall to become infinitesimally small. The effect is a pull-out of the C-Hedge market by either demand or supply, or by both; the cause is a discrepancy between expectations of, respectively, price volatility and profits. Consistency in expectations means, as we said above, that sellers and buyers of C-Hedge contracts can agree on what volume of trade in the underlying product be hedged. Discrepancy in expectations means that no such agreement can be reached.

Suppose that on market day one the volume $q_{H(1)}$ is hedged. For obvious reasons, $\hat{q}_H > q_{H(1)}$, and there is symmetry in information used by consumers and producers to establish their expectations on, respectively, future price volatility and future profits. So long as the information used stays symmetrical, consistency and stability on the C-Hedge market will prevail. But when an asymmetry in information emerges, there will no longer be consistency, but instead discrepancy, between consumers' expectations of price volatility and producers' profit expectations.

Suppose that consumers turn more pessimistic about price volatility in the near future. This will motivate them to demand a larger volume of gasoline under hedge contracts. But suppose that at the same time gasoline companies have information that motivates them to alter their preferences for participating in the market. They expect falling profits, which normally would mean that they were willing to increase q_H, but in this case we assume that they read the information they have at hand as being unusually pessimistic. The degree of

[3] Empirically, on the other hand, it makes a significant difference. If consumers prefer a rapid reduction in amplitude, they will prefer to hedge large volumes over relatively short periods of time; if reduced intensity is preferred, longer contracts are more desirable. The design of C-Hedge contacts depends, in the last resort, on the preference of consumers in this respect.

pessimism motivates them to re-think their participation on the market in question: they may redesign their pattern of outlets (gasoline stations), their mixture of products, production facility structure and other long-term factors. Such restructuring means gasoline suppliers need to reduce their commitments on the market, and so they cut $\hat{q}_H$. This shifts supply of C-Hedges down, and the market is rationed from the supply side. A turn to the negative of profit expectations can be strong enough to cause $\hat{q}_H$ to fall towards zero, and because of the supply rationing this will eventually eliminate gasoline hedging.

Consumers are now forced to buy all their gasoline spot, which according to equation four makes expectations of higher price volatility come true. As a result demand for gasoline will shrink radically in line with equation three. It is important to notice, however, that the quantitative values cannot be adequately depicted by our model: as designed, the model describes well how stability on the gasoline market is preserved by hedging, and how stability can be brought to an end. But states of instability cannot be modeled in the traditional sense: when an economic process is unstable, it is by logical necessity unpredictable; a model requires regularity in economic activity, and regularity in turn necessitates predictability.

The second case of instability is one where the entire volume traded on the gasoline market is covered by hedge contracts. Going to the opposite extreme from the previous case, a completely hedged market eliminates the variability of the price instantaneously, extending – consequently – the period between price swings to infinity.

A state of complete hedging comes with expectations of zero price variability. A regular state of demand on the C-Hedge market cannot accomplish this combination; the cause is a rise in the risk aversion preference of consumers towards infinity. The curve is now completely vertical, meaning that consumers are willing to accept any rate of hedging offered by producers. It is not a necessary condition that any change takes place in supply of C-Hedges – the $\hat{q}_H$ volume is not, we remember, identical to the actual production volume, but only a largest desirable hedge volume as identified by the producers. If the hedging volume sought by consumers at period i is $q_{H(i)} < \hat{q}_H$, then we have a state where the entire consumer market for gasoline is hedged.

It is not entirely obvious how this situation would come about. It does require that consumers are extremely sensitive to any expectation of price volatility, while it does not require (nor, we should notice, does it prohibit) a similarly extreme reaction in the risk aversion preference of gasoline producers. A necessary condition is asymmetry in information, but this is only a logical necessity – in the real world it is reasonable to assume that the risk preferences of buyers and sellers on the C-Hedge market respond symmetrically to generally known information. If market institutions are properly designed, asymmetric advantages in access to information can be expected to reduce cases such as the one we have just discussed to a very small set of extreme outcomes.

Why, then, is a state of complete hedging less stable than a state of partial hedging? The reason is to be found in the nature of time. Complete hedging means consumers have devoted all of their spending on gasoline to one mode of consumption: one price and one total volume (any part of the C-Hedge that is not spent is, we remember, the property of the gasoline seller) implies that there is no flexibility whatsoever in spending should contingencies arise. Theoretically, events that regularly would cause consumers minor inconvenience can now become serious threats to their regular spending. They are not free to reduce spending a few periods into the future to meet, e.g., increased income taxes. The result is an accumulation of needed changes in the spending pattern that will be effectuated once current C-Hedge contracts mature.

Conclusion and perspectives

This paper is of a preliminary kind, obviously not containing a complete analysis. What has been said so far, though, is that hedging instruments tailored for specific consumer markets may help stabilize product prices and motivate consumers to increase overall spending as uncertainty about their future is reduced. Introduction of a hedging instrument on, e.g., the gasoline market requires a delicate balancing of the interests of consumers and producers, respectively. The common interest in reduction of uncertainty, shared by both sides of the gasoline market, constitutes a groundwork for such balancing.

The following topics will be included in further work with this paper:

A fall in money income. If economic agents commonly are interested in balancing their cash flows in space *as well as* in time, then any increase in income variability is likely to motivate consumers and firms to reduce contractual engagements in order to avoid having expense commitments they cannot cover. Therefore, it is important to expand our analysis to incorporate changes in money income (both nominal and in terms of variability).

Introduction of a sales tax. Taxes have allocative effects on markets that depend heavily on their design. The impact of a sales tax on gasoline will encourage or discourage consumption hedging. A tax on the C-Hedge itself will also be analyzed.

Second hand market for C-Hedge contracts. The most important institutional amendment to the above analysis is the introduction of a second hand market for the hedge contracts. This will make the hedge market complete, in terms of liquidity, and open for more efficient hedging strategies among consumers.

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