Supply and Demand Risks in

Forward and Spot Markets: Implications for Agriculture

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Abstract

Laboratory methods are used to investigate the impacts of supply and/or demand risks on prices, quantities traded, and earnings within forward and spot market institutions. Results suggest that the spot or forward trading institution itself has a greater influence on market outcomes than supply/demand risks within the institution.

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I. Institutional Description

Concerns about risk management in agriculture have been heightened by changes in the 1996 farm legislation that are designed to reduce agricultural subsidies and decouple government income payments to producers from market prices and production. In place of government guarantees, forward contracts are a well-known means by which to mitigate price risk, and are becoming increasingly common in agriculture [Barkema, Drabenstott, and Welch (1991); Boehlje (1996)]. One effect of increased forward trading is fewer trades in the spot or cash market. The spot market becomes smaller. But it is not obvious that forward contracting, when there is risk, is better than spot trading for buyers and sellers as a group. Our work shows that sellers fare better, in the sense that earnings are higher, when they trade in a spot market, and this happens in spite of large random moves in demand and costs. This paper empirically describes the behavior of agents facing alternative sources of risk in forward and spot market institutions.

The literature sometimes refers to a forward market, in its simplest form, as production-to-demand. That is, price and quantity are determined before production is completed. The seller in such an institution faces risk because costs at the time of the agreement may be uncertain. The buyer also faces risk in a forward market. A food processor for example, as a forward buyer has locked in the input price but still faces an uncertain final demand schedule.

In the traditional spot market costs and final demand are known, but the price and quantities exchanged are not known in advance of the trade time. The spot market is a cash and carry institution. The literature refers to it as a cash market or advance production. Before trades are made the production is held in inventory. The spot supply schedule is perfectly inelastic when there is inventory carryover. So no more than what is produced can be sold, and sellers may suffer the loss of unsold inventory, or take losses on units sold at prices below their cost of production. Thus, inventory generates risk for the seller.

The objective of this research is to compare the impacts of supply and/or demand risks within forward (production-to-demand) and spot (advance production) markets as distinct trading institutions. That is, the effects of the same random movements in supply and demand are assessed in a forward only market and also in a spot only market. Attention is directed toward measuring the impacts of alternative sources of risk on relative trade prices and quantities traded in these two market types. We collect data from computerized laboratory markets. A laboratory approach is warranted because data from many forward and spot transactions in naturally occurring markets are unavailable. Moreover, it would be difficult to isolate and analyze the impacts of alternative sources of risk from data in natural markets, because outcomes can result from a variety of uncontrolled and interacting factors, making it difficult to identify the influence of one factor.

We begin with the premise that all features of the real-world cannot be incorporated into an economic model or duplicated in a laboratory setting. Thus, we recognize that the study of the forward and spot markets in isolation simplifies the actual marketplace. Moreover, our basic

definitions of forward and spot institutions do not strictly conform to those in naturally occurring markets. There are, for example, many varieties of forward contracts, and inventory carryover is possible in some spot markets. The intent, however, is to initially observe behavior in a very controlled setting that captures the essential features of spot and forward trading and the behavior of economic agents trading in these institutions. This approach also allows us to obtain baseline results that can be compared with field data or other experimental designs that add selected elements of naturally occurring markets.

II. Experimental Methods and Procedures

Laboratory experimental methods [Plott (1982); Smith (1982)] are used to investigate differences in trade prices and quantities traded under alternative sources of demand and supply uncertainty in a spot market and a forward market. A separate forward laboratory market and a spot laboratory market with fixed supply and demand schedules are control treatments. Random supply, random demand, and both random supply and demand are test treatments for the two market institutions. The basic design of the experiments follows Krogmeier, et al. (1997) and is summarized in

Figure 1.

Three replications were conducted for each of the control and test treatments. Thus, a total of 24 laboratory market sessions were completed. Consistent with previous studies [Krogmeier, et al. (1997); Mestelman, Welland and Welland (1987); Noussair, Plott, and Reizman (1995)] four buyers and four sellers participated in each

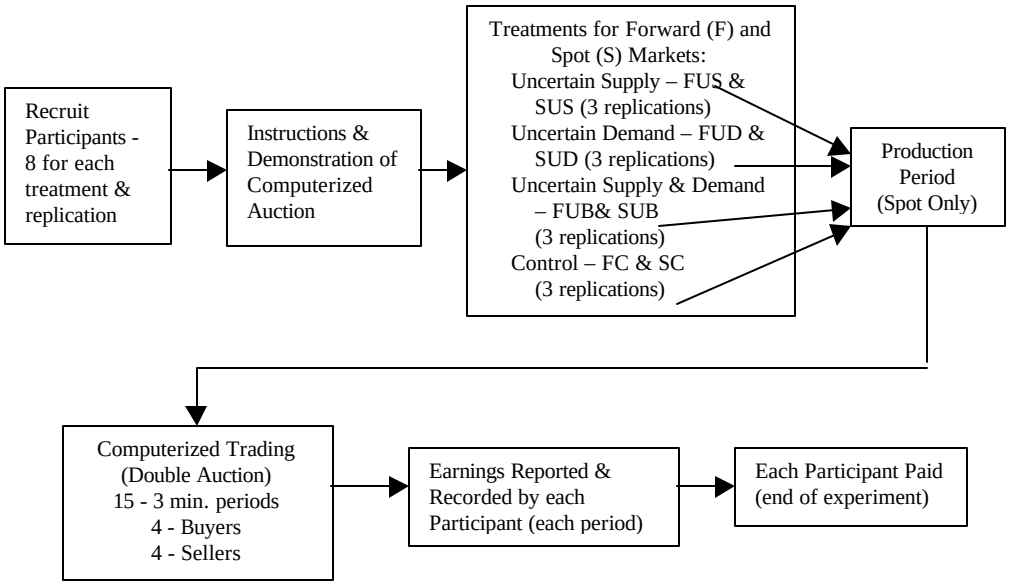

Figure 1. Mechanics of the Experiments.

market session. Trading in each of these sessions was conducted for 15 three-minute periods. Participants were not told the number of periods over which trading would occur, to mitigate the possibility of "unusual" behavior in the last periods. Fifteen periods were deemed sufficient to maximize subject experience, learning, and the chances of behavior settling down into a stable pattern. The trading mechanism, identical under all treatments, was a double auction. This trading mechanism has been used extensively in laboratory research and does not require a large number of participants to generate competitive outcomes [Davis and Holt (1993)]. A total of 192 students recruited primarily from economics and business classes participated.

Relying upon induced value theory [Smith (1976), (1982)], the values and costs listed in Table 1 constitute individual supply and demand for each trading period. When summed horizontally (over four sellers and four buyers) the aggregate supply and demand curves shown in Figure 2 are derived. Competitive price theory predicts an equilibrium

Table 1. Unit values and unit costs (tokens) for the control treatments.

Unit	Unit values (Buyer)	Unit cost (Seller)
1	130	30
2	120	40
3	110	50
4	100	60
5	90	70
6	80	80
7	70	90
8	60	100

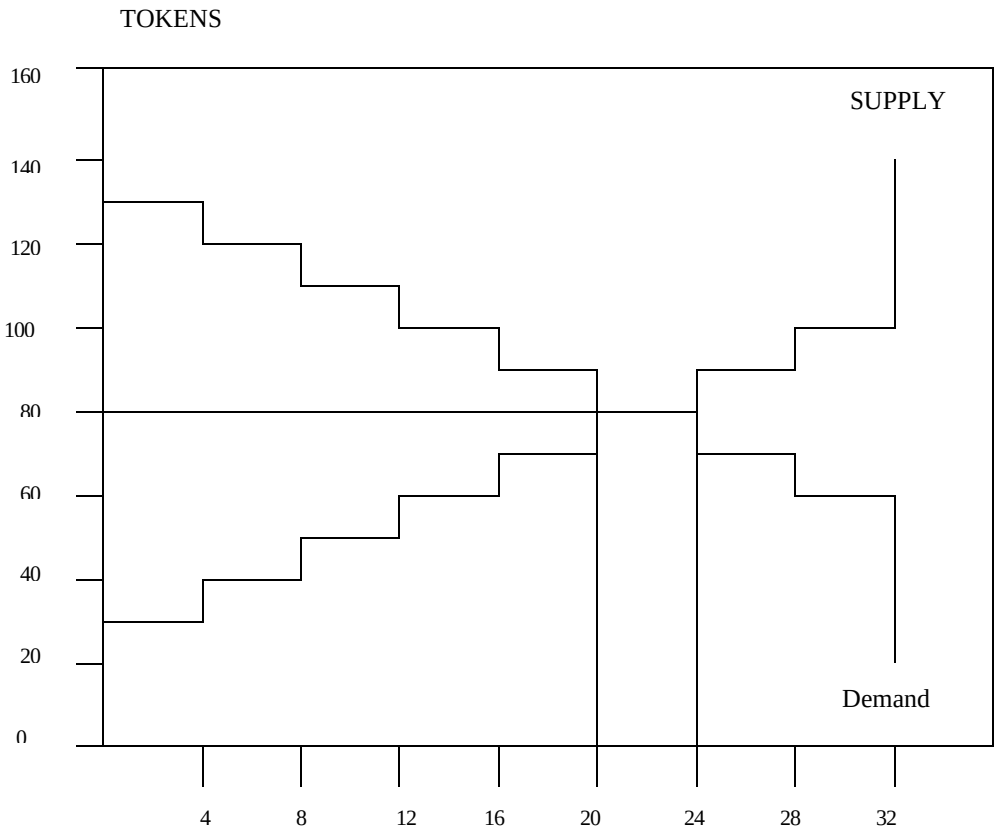

Figure 2. Induced Market Supply and Demand.

price of 80 tokens and units traded between 20 and 24 units per period, as shown in Figure 1. This is the equilibrium for stable demand and supply conditions and represents a baseline against which we can compare behavior when the supply and demand schedules become random.

Treatments incorporating random demand and supply allowed unit resale values, unit costs, or both, to vary by a random amount. Participants facing risky resale values and/or costs were told that these values could range between high and low values of ±10 from the amounts displayed on their record sheets. Subjects were informed that the actual cost and resale value amounts would be chosen randomly by the computer, and had an equally likely chance of taking an integer within the twenty-one token range. The entire schedule for the seller or buyer shifted by the random adjustment (or shift parameter) selected by the computer.

III. Results

The experiments yielded observations on trade prices, quantities traded, and earnings by sellers and buyers. Our statistical tests compare the different treatment means for prices, quantities, and earnings using Duncan's multiple range test.

A. Trade Prices

Duncan's multiple range test was conducted using mean average prices across the three replications from the combined last five trading periods for each treatment.

Results are presented in Table 2. Mean average trade prices across all treatments in the spot market are generally higher, ranging from 85.31 tokens in SUD to 81.72 tokens in SUS, than those in the forward market which range from 81.15 in FUS to 77.59 in FUB. Prices generated in the spot markets and prices in the forward market under supply risk (FUS) are not significantly

different (α=0.10) from each other. Prices in all forward market treatments, along with those from the SUS treatment, are not significantly different. Thus, the impact of supply and/or demand uncertainty on prices within the two market institutions does not appear to be overwhelming.

Spot market prices in all treatments, except for supply risk, are significantly higher than those from the corresponding treatment in the forward market. We believe these differences reflect the importance of the cost associated with risk of inventory loss in the spot market, even when random demand and/or supply shifts can be as much as 25 percent of the expected equilibrium outcome as in our experiments. The presence of supply risk, on the other hand, seems to partially wash out or substitute for the effect of

Table 2. Results of Duncan's multiple range test for average mean period prices (tokens) by treatment, periods 11-15, three replications.

	Treatment Mean Price*			
Trading Institution	Control	Uncertain Demand	Uncertain Supply	Uncertain Both
Spot	84.45^{ab}	85.31^{a}	81.72^{abc}	84.33^{ab}
Forward	77.70^{c}	78.80^{bc}	81.15^{abc}	77.59^{c}

α=0.10, d.f. = 16, MSE = 14.16
Critical range of ranked means (number of means):
5.36 (2); 5.64 (3); 5.81 (4); 5.92 (5); 5.99 (6); 6.05 (7); 6.09 (8)

* Means with the same letter are not significantly different.

inventory risk, as prices between the spot and forward markets with uncertain supply are almost identical. Supply risk prompts sellers to produce less which reduces the possibility of inventory loss.

B. Quantities Traded

Table 3 reports average quantities traded over three replications for periods 11 through 15 combined for each treatment. Units traded range from 21.73 in the forward control treatment to 17.87 in the spot market with both supply and demand risks. Quantities traded, consistent with prices, appear to be more affected by trading institution than by supply and/or demand risks within either the forward or spot market. Average quantities traded in the forward market over the last five periods ranged from 19.67 (FUB) to 21.73 (F Control). Average quantities traded in the spot market over the same period ranged from 17.87 (SUB) to 20.13 (S Control).

The results of Duncan's multiple range test suggest that units traded in the forward market with demand risk (FUD) are significantly (α=0.10) greater than units traded in the demand risk treatment in the spot market (SUD). Similarly, trades are

Table 3. Results of Duncan's multiple range test for mean period quantities traded by treatment, periods 11-15, three replications.

	Treatment Mean Quantities Traded*			
Trading Institution	Control	Uncertain Demand	Uncertain Supply	Uncertain Both
Spot	20.13^{abc}	18.47^{cd}	19.13^{bcd}	17.87^{d}
Forward	21.73^{a}	20.67^{ab}	20.20^{abc}	19.67^{bc}

α=0.10, d.f. = 16, MSE = 1.23
Critical range of ranked means (number of means):
(2); 1.66 (3); 1.71 (4); 1.74 (5); 1.76 (6); 1.78 (7); 1.79 (8)

* Means with the same letter are not significantly different.

significantly greater in FUB than in SUB. The effect of risk on quantities traded in the spot market in the case of both supply and demand risks (SUB), in fact, is greater than the effects of all risk scenarios on units traded in the forward market. Risk increases the marginal costs for both risk

averse buyers and sellers. This results in lower equilibrium quantities traded under the conditions of uncertain supply and/or demands, as generally observed from the experimental data. The additional cost associated with the risk of inventory loss in the spot market further increases costs and reduces quantities traded (although not significantly), as compared to the forward market.

A result which emerges from the analyses of price and quantity data generated from the experiments is that the influence of trading institution is more dominant than the random shifts in supply and/or demand. That is, there generally is a significantly greater difference in prices and quantities traded between forward and spot markets under corresponding sources of risk than within each institution with different risks. Thus, the cost associated with the risk of inventory loss in the spot market seems to dominate the costs of supply and/or demand risks, even when demand and/or supply shifts can be as much as 25 percent of the expected equilibrium outcome. An exception to this general conclusion is the case of supply risk, where the interdependence of the risk of inventory loss and supply risk tends to offset their combined influences.

C. Buyer and Seller Earnings

A source of earnings variability in the test treatments is due to the random shifts in unit values and/or unit costs. This source of variance must be removed, in order to compare the earnings data across treatments. Total surpluses in the spot market, in general, are less than in the forward market. Earnings under alternative sources of risk in each market institution as a percent of total possible earnings (1200 tokens from Figure 1) range from about 94 percent in the SUB treatment to about 99 percent in the FUD and F Control treatments. Total earnings in the FUD and F Control treatments are significantly (α=0.10) higher than earnings in the S Control and SUB

treatments. The forward market tends to be more efficient than the spot market regardless of the source of risk. The influence of the combined risks associated with supply and demand, as expected, has the greatest impact on total earnings in each market type, as compared to individual supply or demand risks.

Average adjusted earnings for periods 11 through 15 and three replications for buyers and sellers (Table 4) range from 118.03 (buyer - SUD) to 169.30 (seller - SUD). Buyers fare significantly better in the F Control, FUB and FUD treatments than in corresponding spot market treatments. Seller earnings between corresponding market and risk treatments are not significantly different. Sellers fare significantly better than buyers in the SUD, S Control and SUB treatments. Seller earnings, in general, are higher when they trade in a spot market, even when there are large random moves in demand and supply and demand.

IV. Summary and Implications

A key distinction between a spot market and a forward market is the presence of risk of inventory loss in the former market type. The results of this study suggest that this risk, in general, has a greater impact on trade prices and quantities traded than risks associated with variation in supply and/or demand, at least when the two market types are in isolation. Sellers in a spot market seek higher prices for their product, as compared to sellers in a forward market, to offset costs associated with the risk of loss. The impacts of this risk also are observed in the form of lower quantities in the spot market relative to

Table 4. Results of Duncan's multiple range test of mean period earnings (tokens) by treatment for buyers and sellers, periods 11-15, three replications.

Treatment Mean Unadjusted Earnings*

Trading Institution	Control		Uncertain Demand		Uncertain Supply		Uncertain Supply & Demand	
	Buyer	Seller	Buyer	Seller	Buyer	Seller	Buyer	Seller
Spot	123.58^{bc}	163.25^{a}	112.68^{bc}	169.30^{a}	138.47^{abc}	159.32^{a}	121.48^{bc}	159.88^{a}
Forward	159.92^{a}	137.42^{abc}	170.90^{a}	143.50^{abc}	141.62^{abc}	147.92^{ab}	168.27^{a}	123.25^{bc}

α=0.10, d.f.=32, MSE=473.04

Critical range of ranked means (number of means): 30.08 (2); 31.74 (3); 32.79 (4); 33.53 (5); 34.08 (6); 34.50 (7); 34.83 (8); 35.10 (9); 35.31 (10); 35.49 (11); 35.63 (12); 35.25 (13); 35.84 (14); 35.92 (15); 35.98 (16)

Treatment Means Adjusted Earnings**

	Control		Uncertain Demand		Uncertain Supply		Uncertain Supply & Demand	
	Buyer	Seller	Buyer	Seller	Buyer	Seller	Buyer	Seller
Spot	123.58^{cd}	163.25^{ab}	118.03^{d}	169.30^{a}	138.47^{bcd}	154.03^{ab}	121.53^{cd}	161.27^{ab}
Forward	159.92^{ab}	137.42^{bcd}	154.50^{ab}	143.50^{abcd}	141.62^{abcd}	150.72^{abc}	158.00^{ab}	133.83^{bcd}

α=0.10, d.f.=32, MSE=341.40

Critical range of ranked means (number of means): 25.55 (2); 26.96 (3); 27.86 (4); 28.49 (5); 28.95 (6); 29.31 (7); 29.59 (8); 29.82 (9); 30.00 (10); 30.15 (11); 30.27 (12); 30.37 (13); 30.45 (14); 30.51 (15); 30.57 (16)

* Unadjusted mean earnings reflect the effects of the random shift variables for supply and/or demand. Means with the same letter are not significantly different.

** Adjusted mean earnings remove the effects of the random shift supply and/or demand shift variables. Again, means with the same letter are not significantly different.

the forward. Buyers potentially react to the fixed and inelastic supply in the spot market by increasing competitive bidding and driving prices up [Krogmeier, et al. (1997)].

The analysis of relative buyer and seller earnings across market types for the same treatment suggests buyers tend to fare better in the forward market than in the spot market. Seller earnings, on the other hand, are not significantly different between the forward and spot markets under corresponding risk treatments. Seller earnings, however, tend to be higher in the spot market than earnings for buyers in the spot market. The forward market generally is more efficient than the spot market, as measured by the percent of total surplus extracted relative to the total possible surplus.

Structural change and risk are two interrelated issues facing agriculture. Increased forward contracting and higher vertical coordination is occurring in almost all sectors of the food industry. Changes in farm legislation to shift risk bearing from the public sector to the private sector, along with increased globalization, will contribute to increased risk faced by individual agents. The results of this study, at least for the levels of risk associated with supply and/or demand, suggest a greater influence due to structural change issues than from risk. That is, there seems to be a greater impact on market prices, quantities, and earnings between the forward and spot institutions than among the risk sources within an institution type. Results also suggest reduced margins for sellers in a forward market dominated agriculture.

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