The Effect of Bargaining on Price and Profit: A Case Study on a U.S. Steel Service Center *

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DRAFT: comments welcome

Abstract

The steel service center of this case study decentralizes sales and delegates sales agents to deal with steel buyers. Each sales agent bargains with buyers on a transaction-by-transaction basis and earns commissions based on the accounting profit he/she makes over historical purchase cost of steel. This paper models an alternating-offer bargaining game between the sales agents and the steel buyers and explains the price dispersion observed among different steel buyers and over time. I find that the trade surplus is divided between the buyers and the sales agents in a five-to-three ratio. Large quantity buyers, buyers who pay more in freight, buyers located in States that are more remote from the SSC, buyers in the Wholesale Industry, and buyers with a worse credit rating have a lower reservation value on steel than others and therefore get a more favorable deal. A buyer also gets a more favorable deal when the historical cost is low. Finally, I estimate what the sales quantity and revenue would be if the SSC were to impose a fixed markup over accounting cost for all transactions instead. I conclude that the SSC makes a higher profit from bargaining than from a fixed markup if the markup rate is not greater than 15%.

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1 Introduction

Despite an extensive theoretical literature on bargaining since the seminal work of Nash [24, 25][1], empirical work on bargaining has remained limited in scope. The main bulk of empirical work is on collective bargaining between labor unions and employers. The existence of large-scale data sets on collective bargaining has allowed econometricians to explore the factors determining the probability of strikes, the duration of strike, and the negotiated wage (see Card [7]). Econometricians have also conducted empirical analyses to study bargaining in household allocation decisions. McElroy and Horney [21], Horney and McElroy [15], and McElroy [20] build and estimate a Nash bargaining model of decision making for a two-person household. Merlo [22], on the other hand, estimates a bargaining model of government formation in postwar Italy. He evaluates the effects of changes in the bargaining procedure on the duration of negotiations and government durations. Recently, econometricians have performed empirical studies on bargaining between buyers and sellers in the trade of goods. Ayres and Siegelman [1] and Goldberg [13] investigate the factors leading to different negotiated prices in new car purchases. While Ayres and Siegelman find evidence of raical and gender discrimination, Goldberg concludes that model, market-specific, and purchase transaction variables, not consumer-specific charateristics, explain the differences in negotiated prices. Chipty and Snyder [9] examine the effect of a buyer merger on the buyer's bargaining position and empirically determine that cable operators merge to realize efficiency gain rather than to enhance their bargaining power. Kauf [17] estimates a reduced form equation explaining the discount in childhood vaccines and concludes that the government obtains a larger discount than private buyers because of stronger bargaining power.

Nevertheless, bargaining is a much more significant phenomenon than what the scope of the current empirical literature suggests. In the United States, bargaining takes place in the trade of commodities such as houses, automobiles, and musical instuments in the retail market and many commodities in the wholesale market. When bargaining does not take place in the trade of a commodity, it is usually because the owner of the commodity has delegated a third-party to conduct the trade and the third party does not have the power to alter the terms of trade. In countries where it is more common for owners to deal directly with buyers, bargaining takes place even in the trade of daily necessities like food and grocery items.

The thin size of literature on empirical work in bargaining is mostly due to lack of information and data. First, we do not always have complete knowlege of the rules of a bargaining game,

[1] For recent surveys see Binmore et al. [4] and Thomson [30].

making it difficult for us to build an appropriate model. Second, solving a bargaining model requires detailed information on preferences and characteristics of the players as well as other institutional information that constitues the game. Such information is often hard to find. Third, the outcome of a bargaining may not be totally observable by econometricians. Most bargaining games that researchers would like to study involve bargaining over the terms of trade. Nonetheless, it is not always plausible for econometricians to learn the agreed terms of trade. While average sale price is readily available for many commodities, the availability of sale price at transaction level is quite restricted. It is even more difficult to obtain data on the terms of trade other than price. Examples include product bundling, warranty, and delivery time. Econometricians seldom observe bargaining outcome other than terms of trade, such as the number of rounds of offer for all players in an alternating-offer bargaining game to reach an agreement. Finally, some data, such as private information of the players in a game with incomplete information, are unobservable by definition. In reaction to the problem of data limitations, many researchers resort to the experimental approach. Forsythe et al. [12] initiate experiments to study the role of incentive-efficient strikes in collective bargaining with one-sided private information. Binmore et al. [6] and Kahn and Murnighan [16] study the effect of the outside option on the bargaining outcome. Ochs and Roth [26] test the accuracy of the predictions from the perfect equilibrium of a sequential bargaining game. Other reseachers respond to the lack of empirical data by implementing simulation studies. Kennan and Wilson [18] compare the predictions about the incidence, mean duration, and settlement rates of strikes and the terms of wage settlements simulated from various strategic bargaining models with empirical data. Cramton and Tracy [10] use their private-information model of union contract negotiation to reproduce key features they observe from strike and holdout data through simulation.

This paper takes advantage of a rich data set on steel sales provided by a steel intermediary and the opportunity to talk to people working in the steel intermediary to empirically estimate a bargaining model. The steel intermediary, a steel service center (SSC)[2], acts as the middleman between steel producers and steel buyers. This paper concentrates on the transactions between the SSC and steel buyers because I only have limited data on purchases of the SSC. The SSC, like its competitors, does not post or advertise steel price. Buyers have to call for a price quote with a sales agent and they can then bargain with the sales agent. The SSC provides incentives for the sales agents to bargain for a high price by giving them commissions based on the profit they make over the historical cost of the inventory[3]. As a result, considerable price dispersion is observed in steel

[2] See Chan [8] for a description of the SSC industry and the SSC of this study.

[3] The accounting book of the SSC keeps track of the cost at which the SSC purchased the inventory. The book-

sales across buyers and over time[4] According to the Sales Manager of the SSC, the buyer accepts the initial price quote in the majority of successful transactions. If the buyer is not satisfied with the initial price quote, he/she may either suggest a lower price immediately on the phone, or call back later to bargain. A typical transaction is completed within twenty-four to forty-eight hours since the first price quote.

The data provided by the SSC, combined with data from Reference USA and Yellow Pages, shed light on the terms of trade and the characteristics of the sales agents and the buyers. The ability to actually talk to people in the SSC allows me to understand the bargaining process. With these pieces of information, I model the bargaining game between a sales agent and a buyer. The estimation results of the bargaining model show that the trade surplus is divided between the buyer and the sales agent in a five-to-three ratio. Large quantity buyers, buyers who pay more in freight, buyers located in States that are more remote from the SSC, buyers in the Wholesale Industry, and buyers with a worse credit rating have a lower reservation value on steel than others and therefore get a more favorable deal. A buyer also buys at a lower price when the historical cost is low. The estimation results also enable me to assess the effect of bargaining on the profit of the SSC. I estimate what the sales quantity and revenue would be if the SSC were to impose a fixed markup over accounting cost for all transactions, instead of letting sales agents determine the price for each transaction separately through bargaining. Without information on the true economic cost of steel, I exploit the difference in sales quantity and revenue over the entire sample period to calculate the critical per unit cost that makes the profit from bargaining the same as that from a fixed markup. Contrasting the critical cost to the mean purchase cost of steel, I conclude that the SSC makes a higher profit from bargaining than from a fixed markup if the markup rate is not greater than 15%.

The rest of the paper is organized as follows. Section 2 formulates the bargaining model that captures the bargaining process between a sales agent and a steel buyer. Section 3 describes the data used for estimating the bargaining model and Section 4 presents the estimation results and the prediction on profitability if the sales agents worked against the appropriate incentive. Section 5 offers the conclusion.

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keeping is on a first-in-first-out basis, so the historical cost of a steel product sold is the cost at which the first unit of the steel product in the inventory was bought.

[4] See Chan [8].

2 Model

This paper examines the bargaining game between a sales agent of a steel service center (SSC) and a steel buyer on the trade of a steel product. I impose the following simplifying assumtpions for tractability:

1. *All transactions involve the trading of a homogenous steel product*[5].
2. *Price is the only term of trade to be negotiated*[6].
3. *Indepdence among transactions—Each transaction constitutes a bargaining game that is independent of all other transactions.*
4. *The sales agent's utility gain from each transaction is solely derived from the commission he/she earns. The amount of commission is determined by applying a fixed commission rate, CM, to the profit over historical purchase cost of inventory.*
5. *There exists a potential gain of trade, i.e., the reservation price of the buyer is higher than that of the sales agent.*
6. *Quantity demanded by the buyer is fixed and determined exogenously.*
7. *Both the sales agent and the buyer are risk neutral.*
8. *Complete Information—the preferences and characteristics of the sale agent and the buyer relevant to the bargaining game are common knowledge.*
9. *The bargaining game is an alternating-offer game, with the sales agent making the first offer. At any round when the sales agent (the buyer) makes the offer and the buyer (the sales agent) rejects it, there is a probability p^S (p^B) that the bargaining process would end. The break-down probabilities p^S and p^B remain constant in all transactions.*
10. *The probabilities of break-down, p^S and p^B, are close to zero*[7].

[5] This is a simplifying assumption because different units of the same steel product may still vary in quality. Some steel may be older or rustier and therefore has a lower quality. Steel produced by certain steel mills may carry a better quality than others. However, I do not observe the quality of steel.

[6] The actual terms of trade also include delivery time. Buyers generally are willing to pay a premium for faster delivery. Unfortunately I do not have data on delivery time.

[7] Formally, let $1 - p^S = (1-\epsilon)^{\gamma^S}$ and $1 - p^B = (1-\epsilon)^{\gamma^B}$, ϵ is close to zero. The General Manager of the SSC claims that more than 70% of the price quotes lead to successful transactions. Under the assumption of complete information, the remaining transactions fail to go through probably because there does not exist any potential gain of trade. For example, the buyer may have found an alternative supplier that quotes a price lower than the best price the sales agent can offer. Since I only study transactions with potential gain of trade and my data set is a selected sample that consists of successful deals, the assumption of close to zero break-down probabilities is reasonable.

Myerson [23][8] proves that under assumptions 8 - 10, the unique subgame-perfect equilibrium of this alternating-offer bargaining game converges to the generalized Nash bargaining solution with the ratio of the bargaining power parameters equal to the ratio of the break-down probabilities as the break-down probabilities converge to zero[9]. I proceed with estimating the generalized Nash solution.

Let i represent buyer and t denote business day. When trade occurs between a sales agent and buyer i on day t for steel weighted Q_{it} at a per ton price of P_{it}, the sales agent and the buyer can gain utility of $U^S(P_{it}, HC_{it}, Q_{it}, CM)$ and $U^B(P_{it}, V_{it}, Q_{it})$ respectively. The utility of the sales agent depends on the price net of freight[10], P_{it}, the historical purchase cost of inventory, HC_{it}, weight sold, Q_{it}, and the commission rate, CM. The utility gain of the buyer depends on the price net of freight, P_{it}, the value of steel to the buyer at P_{it}, V_{it}, and the weight of steel bought, Q_{it}. V_{it} measures the average value of steel to the buyer. Should the buyer's marginal value on steel vary with Q_{it}, V_{it} would vary with Q_{it} as well. V_{it} takes into account freight to be paid in addition to the net price. V_{it} would increase (decrease) when freight decreases (increases).

Besides dealing with each other, the sales agent and the buyer may go for outside alternatives. These outside alternatives become their threat points. There is a possibility, especially when the inventory level is low, that selling to buyer i on day t would preclude the sales agent from selling to future incoming buyers. With INV_t denoting the inventory level on day t, let $U_o^S(INV_t, Q_{it}, CM)$ represent the expected utility that the sales agent gets from future sales that are lost due to the current sale. On the other hand, the buyer may buy steel from alternative suppliers. Let $U_o^B(AP_{it}, AV_{it}, Q_{it})$ stand for the highest utility the buyer may achieve among all alternative suppliers, where AP_{it} and AV_{it} are the price net of freight the buyer has to pay and the buyer's value on steel when the buyer purchases from the best alternative source.

The generalized Nash solution is obtained by maximizing the generalized Nash product:

$$\max_{P_{it}} \left[U^S(P_{it}, HC_{it}, Q_{it}, CM) - U_o^S(INV_t, Q_{it}, CM)\right]^{\gamma^S} \left[U^B(P_{it}, V_{it}, Q_{it}) - U_o^B(AP_{it}, AV_{it}, Q_{it})\right]^{\gamma^B} \tag{1}$$

[8] See also Binmore et al. [5] and Binmore [2].
[9] Using the same notation as that in footnote 7, $\epsilon \to 0$.
[10] In a small fraction of transactions, the buyer would pick up the steel bought at the door of the SSC. Otherwise, the SSC would make delivery through an indepently operated transportation company located next to the SSC. Hence freight paid by the buyer is never earned by the SSC and hence does not enter into the utility function of the sales agent. Note that freight nonetheless affects the reservation value of the buyer.

where γ^S and γ^B are the bargaining power parameters and $\frac{\gamma^S}{\gamma^B} \approx \frac{p^S}{p^B}$, subject to the incentive constraint for the sales agent

$$U^S(P_{it}, HC_{it}, Q_{it}, CM) - U_o^S(INV_t, Q_{it}, CM) \geq 0 \tag{2}$$

and the incentive constraint for the buyer

$$U^B(P_{it}, V_{it}, Q_{it}) - U_o^B(AP_{it}, AV_{it}, Q_{it}) \geq 0 \tag{3}$$

Assumption 5 translates into the assumption that a solution to the system of equations (1) - (3) exists. In addition to assumption 7, I further assume that the utility functions of the sales agent and the buyer have the following forms:

$$U^S(P_{it}, HC_{it}, Q_{it}, CM) = CM(P_{it} - HC_{it})Q_{it} \tag{4}$$

$$U_o^S(INV_t, Q_{it}, CM) = CM[\kappa \exp(INV_t \phi) + \mu_{it}]Q_{it} \tag{5}$$

$$U^B(P_{it}, V_{it}, Q_{it}) - U_o^B(AP_{it}, AV_{it}, Q_{it}) = (-P_{it} + X_{it}\beta + PC_t\alpha + \nu_{it})Q_{it} \tag{6}$$

where κ, ϕ, β, and α are unknown parameters, μ_{it} and ν_{it} are disturbances unobserved by the econometrician, X_{it} is a vector that includes customer and transaction characteristics which affect the average value of steel to the buyer, and PC_t is the cost at which the SSC may purchase steel[11]. I assume that the outside alternative of the seller is an exponential function of the inventory level. I expect $\kappa > 0$ and $\phi < 0$ so that as the inventory level grows to infinity, the value of the seller's outside alternative converges to zero. When the inventory level is very high, it becomes unlikely that selling to the current buyer would prevent the sales agent from selling to future buyers because of stockout, leading to a zero value on the seller's outside alternative.

Since I only observe PC_t when the SSC actually makes a purchase on day t, I further assume that PC_t follows a random walk process:

$$PC_t = PC_{t-1} + \omega_t \tag{7}$$

I assume that conditional on $RHS_{it} = \{X_{it}, INV_t, HC_{it}\}$ for all i, $\omega_t \sim \text{IID}(0, \sigma_\omega^2)$. Let $\tau(t)$ be the business day on which the SSC made the most recent purchase and RPC_t be the purchase cost of that most recent purchase (i.e., $RPC_t = PC_{\tau(t)}$). Then PC_t can be expressed as a linear function of RPC_t and a disturbance term:

$$PC_t = RPC_t + \eta_t \tag{8}$$

$$\eta_t = \begin{cases} 0 & \text{if} \quad t = \tau(t) \\ \sum_{t'=\tau(t)+1}^{t} \omega_{t'} & \text{if} \quad t > \tau(t) \end{cases} \tag{9}$$

[11] PC_t is correlated with AP_{it}.

Let $DFRP_t = t - \tau(t)$. The error term η_t has the following distribution:

$$E(\eta_t | RHS_{it}, \forall i) = 0 \quad \forall t \tag{10}$$

$$E(\eta_t \eta_{t'} | RHS_{it}, RHS_{it'}, \forall i) \quad = \quad \begin{cases} \sigma_\omega^2 \min(DFRP_t, DFRP_{t'}) & \text{if} \quad \tau(t) = \tau(t') \\ 0 & \text{if} \quad \tau(t) \neq \tau(t') \end{cases} \tag{11}$$

Substituting equations (4) - (6) and (8) into equations (1) - (3), the objective function of the maximization problem reduces to

$$\max_{P_{it}} \left[CM(P_{it} - HC_{it} - \kappa \exp(INV_t \phi) + \mu_{it})Q_{it}\right]^{\gamma^S} \left[(-P_{it} + X_{it}\beta + RPC_t \alpha + \nu_{it} + \eta_t \alpha)Q_{it}\right]^{\gamma^B} \tag{12}$$

and the incentive constraints are simplified as

$$HC_{it} + \kappa \exp(INV_{it}\phi) + \mu_{it} \leq P_{it} \leq X_{it}\beta + RPC_t \alpha + \nu_{it} + \eta_t \alpha \tag{13}$$

The lower and the upper bound of P_{it} in equation (13) represents the reservation price of the sales agent and that of the buyer respectively. The solution of the maximization problem is

$$P_{it} = (1 - \gamma)[HC_{it} + \kappa \exp(INV_{it}\phi)] + \gamma(X_{it}\beta + RPC_t \alpha) + \epsilon_{it} \tag{14}$$

where

$$\gamma \quad = \quad \frac{\gamma^S}{\gamma^S + \gamma^B} \tag{15}$$

$$\epsilon_{it} \quad = \quad (1 - \gamma)\mu_{it} + \gamma(\nu_{it} + \alpha \eta_t) \tag{16}$$

Note that by definition $0 \leq \gamma \leq 1$. Recall that the ratio of the bargaining power parameters approximately equals to the ratio of the break-down probabilities. The larger the break-down probability of the sales agent (buyer), the larger γ^S (γ^B) becomes and the larger (smaller) γ leads to a higher (lower) transaction price. Hence a player enhances his/her bargaining position when the possibility of break-down after the rejection of his/her offer increases. Note that when the break-down probability of the sales agent is zero while the break-down probability of the buyer is non-zero ($\gamma = 0$), the net price of sale is the reservation price of the sales agent. Such occasion of minimal bargaining power for the seller corresponds to perfect competition. Similarly, when the break-down probability of the buyer is zero but the sales agent's break-down probability is positive ($\gamma = 1$), the buyer has minimal bargaining power and the net price equals to the buyer's maximum willingness to pay, corresponding to the perfectly price-discriminating monopoly situation. I expect the break-down probabilities of both the buyer and the sales agent to be positive so that the reservation price of both the seller and the buyer influence the transaction price.

To complete the specification of the model for empirical estimations, I make the following assumptions about the unobserved disturbances μ_{it} and ν_{it}:

$$E(\mu_{it}|RHS_{it}) = E(\nu_{it}|RHS_{it}) = 0 \quad \forall i, t \tag{17}$$

$$E(\mu_{it}\nu_{i't'}|RHS_{it}, RHS_{i't'}) = 0 \quad \forall i, i', t, t' \tag{18}$$

$$E(\mu_{it}\eta_{t'}|RHS_{it}, RHS_{i't'}, \forall i') = E(\nu_{it}\eta_{t'}|RHS_{it}, RHS_{i't'}, \forall i') = 0 \quad \forall i, t, t' \tag{19}$$

$$E(\mu_{it}\mu_{i't'}|RHS_{it}, RHS_{i't'}) = \begin{cases} \sigma_\mu^2 + Z_{it}\delta_\mu + \xi_{it}^\mu & \text{if} \quad i = i', t = t' \\ 0 & \text{otherwise} \end{cases} \tag{20}$$

$$E(\nu_{it}\nu_{i't'}|RHS_{it}, RHS_{i't'}) = \begin{cases} \sigma_\nu^2 + Z_{it}\delta_\nu + \xi_{it}^\nu & \text{if} \quad i = i', t = t' \\ 0 & \text{otherwise} \end{cases} \tag{21}$$

where Z_{it} is a vector consists of variables affecting the variance of μ_{it} and ν_{it}. Conditional on Z_{it}, $\xi_{it}^\mu \sim IID(0, \sigma_{\xi^\mu}^2)$ and $\xi_{it}^\nu \sim IID(0, \sigma_{\xi^\nu}^2)$. Then ϵ_{it} is both serially correlated and heteroskedastic with the following distribution:

$$E(\epsilon_{it}|X_{it}, INV_t, HC_{it}) = 0 \quad \forall i, t \tag{22}$$

$$E(\epsilon_{it}\epsilon_{i't'}|X_{it}, INV_t, HC_{it}) = \begin{cases} \sigma^2 + Z_{it}\delta + DFRP_t\psi + \xi_{it} & \text{if} \quad i = i', t = t' \\ \min(DFRP_t, DFRP_{t'})\psi & \text{if} \quad i \neq i', \tau(t) = \tau(t') \\ 0 & \text{otherwise} \end{cases} \tag{23}$$

where

$$\sigma^2 = (1-\gamma)^2\sigma_\mu^2 + \gamma^2\sigma_\nu^2 \tag{24}$$

$$\delta = (1-\gamma)^2\delta_\mu + \gamma^2\delta_\nu \tag{25}$$

$$\psi = \gamma^2\alpha^2\sigma_\omega^2 \tag{26}$$

$$\xi_{it} = (1-\gamma)^2\alpha^2\xi_{it}^\mu + \gamma^2\alpha^2\xi_{it}^\nu \tag{27}$$

3 Data

This research is based on data provided by a steel service center (SSC) in the United States and supplemental information on its buyers obtained from Reference USA and Yellow Pages. Chan

[8] and Hall and Rust [14] provide exploratory analyses of the data provided by the SSC. The sample period is from June 30, 1997 to September 13, 2000, a total of 810 business days. The SSC traded over 3600 steel products during this period. Chan [8] shows that there exists substantial price variation aross steel products. Without much information on product characteristics, I avoid the need to model product heterogeneity by focusing on a single product, denoted as Product S. I assume that the bargaining games on the trade of Product S are independent of the bargaining games on the trade of other steel products. I choose Product S for two major reasons. First, Product S belongs to a group of steel products, denoted as Group S, whose substitutability with other steel products in production is relatively low. While the SSC may easily transform many steel products into other steel products with the same material but different dimensions, products in Group S are traded in fixed dimensions without any alterations. Therefore, it is likely that the pricing and purchasing decisions of the SSC on any product in Group S is independent of its pricing and purchasing deicisons on other products. Second, Product S is the most frequently traded product of the SSC, yielding the largest number of observations for analyses that involve a single product.

For each purchase of Product S that the SCC made, I have data on price, quantity, and the date when the steel was delivered to the SCC[12]. For each sale of Product S[13], I have data on buyer identity, price, quantity, freight (if the SSC delivers), and the date when the order was made[14]. I also have data on the inventory level of each steel product[15]. For each buyer, I have data on the location of the buyer, line of business represented by SIC Code, employee size, sales volume, ad size, and credit rating. Appendix A provides a list of variables used in this research.

During the sample period, the SSC made 100 purchases and 1323 sales of Product S. Figure 1 contains the plots of the sale price net of freight, the historical purchase cost of inventory, and the purchase cost of Product S over time. The time series of the historical cost of inventory and the purchase cost are smoothed using the local polynomial fitting methodology described in Fan and Gijbels [11]. The SSC has been maintaining a reasonable profit margin over both historical cost of inventory and purchase cost. Considerable dispersion is observed in the net sale price. The

[12] Steel products are usually delivered to the SSC 3 months after they are ordered if they come from a domestic source. The delivery lag is generally 6 months if the products come an internationally source.

[13] I assume that each buyer purchases from the SSC at most once a day. Sales of the same product to the same buyer on the same business day are aggregated to one sale.

[14] 95% of the SSC's orders are delivered to the buyer within a week.

[15] The inventory level is available for fourteen business days only. Assuming no time lag in delivery, daily inventory level of each product is imputed from the inventory level on the first day of the sample period and quantity bought and sold on each day.

Figure 1: Net Sale Price, Historical Cost, and Purchase Cost of Product S Sold

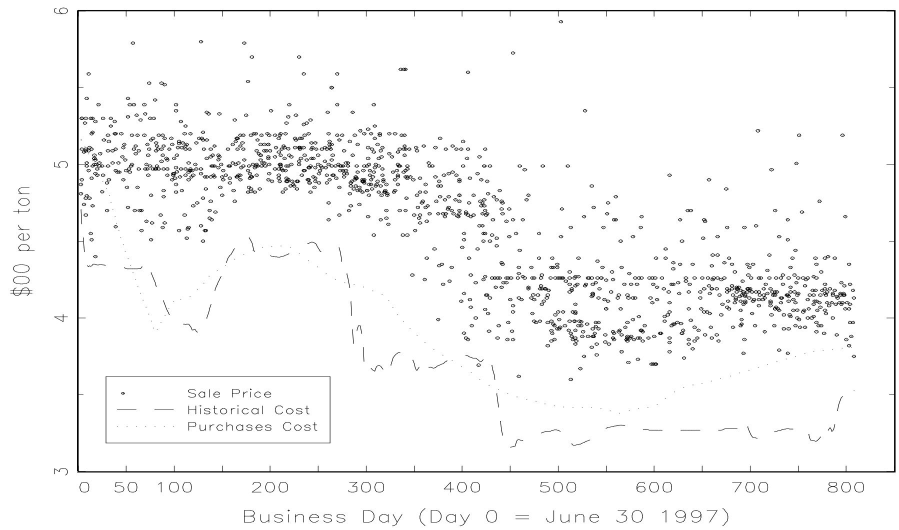
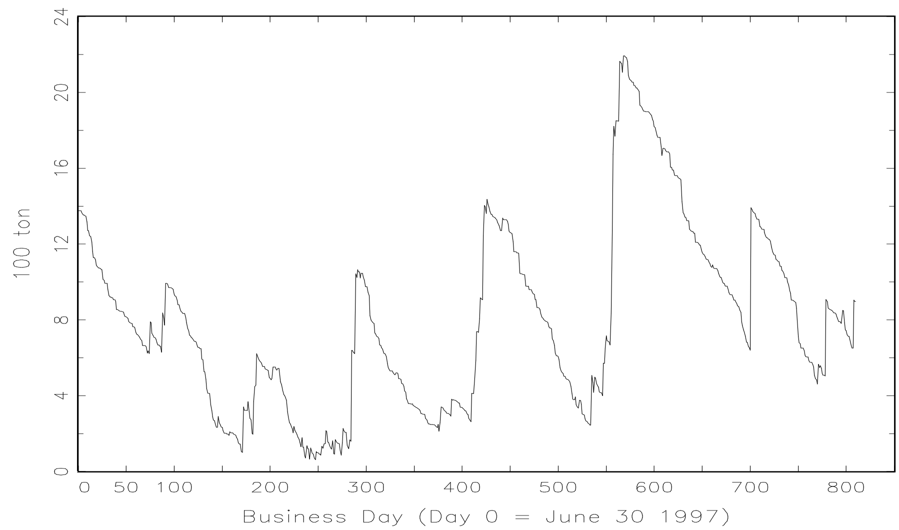


Figure 2: Inventory Level of Product S



profit margin over historical cost varies substantially from around 2% to 87% (see Table 1). Steel price plunged during the period from day 350 (November 1998) to day 450 (March 1999) when the world economy was sluggish and steel imports from countries such as Russia, Japan, and Brazil soared. Figure 2, on the other hand, plots the time series of the inventory level of Product S. The SSC has kept a positive inventory level over the entire sample period. The SSC makes purchases infrequently and often in large quantity, inducing large fluctuations in the inventory level. We also observe that the SSC tends to make larger purchases when the purchase cost is relatively low.

Table 1: Summary Statistics of Variables

Number of Observations: 1323; Number of Customers: 176

Variable	Min	Max	Mean	S.D.
DAY	3.00	808.00	394.63	232.45
P	3.60	5.93	4.61	0.47
HC	2.82	5.30	3.75	0.51
$HMARG$	1.88	87.01	23.93	10.25
$UNIT$	1.00	142.00	9.73	12.44
WT	0.82	115.99	7.95	10.16
$DLVY$	0.00	1.00	0.84	0.37
FRT	0.78	14.00	2.47	1.07
INV	0.62	21.92	7.71	4.69
RPC	3.07	5.07	3.99	0.54
$DFRP$	0.00	75.00	9.48	12.93

Table 1 presents the summary statistics of some variables used in this research[16]. Tables 2 - 7 presents the summary statistics by various buyer characteristics. Table 2 shows summary statistics by buyer location. I order the States by average freight paid[17]. The average freight paid by buyers in a State correlates with their distance from the SSC location. While the SSC is located in Connecticut, buyers are dispersed geographically. In fact I am quite surprised to see buyers from Michigan and Illinois. However, most sales are done with buyers in nearby States. Table 3 summarizes variables by the line of business of buyers. The majority of buyers comes from the Wholesale Trade Industry. Most of such buyers belong to the sub-group "Metals Service Centers and Offices." Hence many buyers purchasing from the SSC are themselves steel intermediaries[18].

[16] See Appendix A for notations.

[17] I observe the amount of freight paid only if delivery is arranged by the SSC through an independently operated transportation company located next to the SSC. In the case of Vermont, I do not observe freight paid in the sole transaction during the sample period and hence we cannot order Vermont with other States.

[18] Although the SSC also belongs to the wholesale trade industry, its line of business falls into the sub-group

Table 2: Summary Statistics by State

	# Cust.	# Sales	DAY	P	HC	$HMARG$	WT	$DLVY$	FRT
CT	19	177	436	4.60	3.62	27.67	7.66	0.78	1.43
			(236)	(0.44)	(0.46)	(8.95)	(8.34)	(0.42)	(0.28)
RI	6	57	453	4.51	3.58	26.57	7.15	0.65	2.05
			(221)	(0.41)	(0.44)	(8.09)	(6.46)	(0.48)	(0.29)
ME	6	112	374	4.58	3.73	23.33	6.91	0.71	2.08
			(231)	(0.51)	(0.49)	(8.69)	(5.71)	(0.46)	(0.32)
NJ	18	131	418	4.53	3.67	24.17	8.02	0.98	2.39
			(224)	(0.41)	(0.46)	(12.21)	(10.11)	(0.12)	(0.39)
MA	28	239	375	4.70	3.78	25.19	3.63	0.81	2.41
			(221)	(0.44)	(0.49)	(9.91)	(2.83)	(0.40)	(0.34)
NH	9	155	365	4.67	3.79	24.21	4.29	0.85	2.43
			(232)	(0.47)	(0.52)	(10.33)	(3.35)	(0.36)	(0.26)
VA	8	20	458	4.56	3.72	23.50	7.80	0.75	2.57
			(233)	(0.37)	(0.52)	(9.61)	(6.83)	(0.44)	(0.37)
NY	26	140	378	4.63	3.82	21.89	7.39	0.91	2.77
			(246)	(0.49)	(0.54)	(9.40)	(6.18)	(0.28)	(0.52)
MD	8	13	423	4.77	3.74	28.63	4.90	0.85	2.86
			(244)	(0.43)	(0.52)	(12.81)	(3.53)	(0.38)	(1.78)
PA	33	167	390	4.59	3.76	22.85	11.37	0.89	2.88
			(238)	(0.52)	(0.52)	(9.64)	(15.38)	(0.31)	(1.08)
DE	5	83	370	4.57	3.95	16.87	22.40	0.92	3.28
			(237)	(0.53)	(0.61)	(9.14)	(17.08)	(0.28)	(2.55)
WV	2	4	491	4.77	3.51	38.51	1.23	0.25	4.30
			(313)	(0.64)	(0.54)	(31.00)	(0.47)	(0.50)	(N/A)
IN	1	3	298	4.98	4.60	9.21	23.14	0.33	4.50
			(54)	(0.65)	(0.85)	(7.61)	(19.44)	(0.58)	(N/A)
SC	2	2	472	4.05	3.46	17.73	15.93	1.00	4.59
			(100)	(0.20)	(0.30)	(16.16)	(17.90)	(0.00)	(0.13)
NC	3	12	436	4.38	3.75	17.72	9.19	1.00	4.71
			(201)	(0.29)	(0.51)	(9.80)	(5.32)	(0.00)	(2.70)
MI	1	7	468	4.43	3.80	16.91	23.45	0.57	6.00
			(257)	(0.61)	(0.62)	(5.57)	(16.16)	(0.53)	(1.09)
VT	1	1	513	3.90	3.17	22.99	4.90	0.00	N/A
			(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)

Table 3: Summary Statistics by Line of Business

	# Cust.	# Sales	DAY	P	HC	$HMARG$	WT	$DLVY$	FRT
WST	85	810	399	4.59	3.73	24.14	6.15	0.83	2.30
			(234)	(0.45)	(0.50)	(9.32)	(5.55)	(0.38)	(0.60)
CSTR	42	278	406	4.55	3.79	21.16	14.15	0.88	2.88
			(233)	(0.52)	(0.55)	(10.82)	(15.69)	(0.32)	(1.60)
MANU	41	209	370	4.72	3.76	26.48	5.69	0.82	2.57
			(220)	(0.44)	(0.48)	(11.64)	(9.17)	(0.38)	(1.39)
SRV	4	10	199	5.46	4.17	32.25	1.06	0.30	2.73
			(155)	(0.29)	(0.43)	(15.46)	(0.39)	(0.48)	(0.15)
TPU	1	4	305	4.98	3.67	35.69	32.88	1.00	1.23
			(8)	(0.03)	(0.04)	(1.66)	(33.76)	(0.00)	(0.32)

Table 4: Summary Statistics by Employee Size

EMP	# Cust.	# Sales	DAY	P	HC	$HMARG$	WT	$DLVY$	FRT
1-4	9	45	433	4.55	3.71	23.85	7.73	0.91	2.86
			(219)	(0.49)	(0.52)	(16.00)	(10.45)	(0.29)	(1.79)
5-9	21	96	383	4.69	3.76	25.84	5.85	0.69	2.53
			(212)	(0.45)	(0.51)	(11.31)	(8.42)	(0.47)	(0.99)
10-19	27	221	391	4.65	3.81	22.82	10.58	0.88	2.80
			(234)	(0.50)	(0.54)	(10.64)	(14.17)	(0.33)	(1.68)
20-49	55	430	403	4.59	3.74	23.56	6.40	0.80	2.55
			(234)	(0.47)	(0.51)	(9.65)	(9.09)	(0.40)	(0.85)
50-99	33	287	368	4.64	3.77	23.87	7.49	0.83	2.43
			(228)	(0.47)	(0.49)	(9.16)	(8.09)	(0.38)	(0.57)
100-249	19	184	423	4.51	3.65	24.31	9.78	0.92	1.94
			(237)	(0.42)	(0.49)	(9.91)	(9.08)	(0.27)	(0.84)
250-499	4	40	350	4.83	3.76	29.62	5.57	0.97	2.21
			(236)	(0.43)	(0.52)	(11.52)	(5.21)	(0.16)	(0.46)
500-999	1	1	137	4.65	3.88	19.81	40.84	1.00	2.00
			(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)

Table 5: Summary Statistics by Sales Volume

$SVOL$	# Cust.	# Sales	DAY	P	HC	$HMARG$	WT	$DLVY$	FRT
<0.5	4	28	424	4.54	3.70	24.25	10.24	0.96	2.66
			(225)	(0.51)	(0.52)	(18.77)	(12.46)	(0.19)	(2.11)
0.5-1	4	14	317	4.99	3.90	28.93	16.45	0.50	2.86
			(142)	(0.66)	(0.60)	(14.61)	(15.73)	(0.52)	(1.76)
1-2.5	9	30	428	4.47	3.78	18.94	7.00	1.00	3.04
			(211)	(0.47)	(0.52)	(9.48)	(6.17)	(0.00)	(0.99)
2.5-5	15	56	479	4.54	3.69	23.74	10.30	0.93	3.35
			(227)	(0.51)	(0.52)	(10.26)	(19.94)	(0.26)	(2.82)
5-10	27	138	432	4.65	3.68	27.26	4.04	0.83	2.43
			(224)	(0.40)	(0.47)	(10.52)	(4.86)	(0.37)	(0.61)
10-20	35	330	379	4.60	3.77	22.64	9.30	0.85	2.62
			(230)	(0.49)	(0.53)	(9.76)	(12.72)	(0.36)	(1.02)
20-50	43	357	418	4.55	3.67	24.71	7.29	0.83	2.14
			(235)	(0.45)	(0.48)	(9.21)	(7.41)	(0.38)	(0.71)
50-100	14	190	338	4.74	3.88	23.15	5.95	0.85	2.41
			(224)	(0.43)	(0.53)	(9.83)	(5.03)	(0.36)	(0.47)
100-500	12	135	375	4.63	3.75	24.60	9.11	0.80	2.36
			(237)	(0.48)	(0.52)	(11.03)	(8.48)	(0.40)	(0.54)
500-1000	1	7	168	4.97	4.09	21.83	5.48	0.29	2.85
			(151)	(0.32)	(0.28)	(8.75)	(5.25)	(0.49)	(0.49)

Table 6: Summary Statistics by Ad Size

	# Cust.	# Sales	DAY	P	HC	$HMARG$	WT	$DLVY$	FRT
$NOAD$	35	281	401	4.63	3.68	26.89	7.22	0.90	2.18
			(231)	(0.42)	(0.47)	(10.63)	(9.49)	(0.30)	(1.40)
$ADREG$	78	575	388	4.60	3.78	22.73	9.57	0.87	2.65
			(231)	(0.49)	(0.52)	(10.24)	(12.31)	(0.33)	(1.12)
$ADBLD$	13	118	384	4.57	3.73	23.19	7.49	0.83	2.18
			(231)	(0.50)	(0.50)	(9.32)	(8.24)	(0.38)	(0.41)
$ADCOL$	20	167	402	4.58	3.75	22.96	6.53	0.77	2.40
			(236)	(0.45)	(0.52)	(9.25)	(5.25)	(0.42)	(0.46)
$ADDPY$	24	164	404	4.68	3.78	24.89	4.29	0.68	2.67
			(233)	(0.47)	(0.54)	(10.39)	(3.69)	(0.47)	(0.66)

Table 7: Summary Statistics by Credit Rating

	# Cust.	# Sales	DAY	P	HC	$HMARG$	WT	$DLVY$	FRT
$CRVG$	80	637	403	4.59	3.71	24.58	8.32	0.86	2.34
			(233)	(0.45)	(0.49)	(9.51)	(10.20)	(0.34)	(0.82)
$CRGD$	80	637	387	4.62	3.79	22.97	7.51	0.81	2.59
			(230)	(0.49)	(0.53)	(10.47)	(10.01)	(0.39)	(1.22)
$CRSF$	3	3	474	4.64	3.70	25.71	1.36	0.67	6.85
			(343)	(0.61)	(0.45)	(13.21)	(0.47)	(0.58)	(5.87)
Unknown	7	28	339	4.88	3.72	32.67	4.35	0.93	2.70
			(235)	(0.44)	(0.49)	(15.90)	(3.93)	(0.26)	(1.17)

Besides the wholesale trade industry, most buyers come from the construction and the manufacturing industry. About 56% of the 209 sales conducted with buyers in the manufacturing industry come from fabricated metal products manufacturers. Another 20% originate from manufactures in primary metal industries. Tables 4 - 6 summarize variables by characteristics related to firm size – employee size, sales volume, and ad size. Ad size also measures the advertisement effect per se. It appears that most buyers are mid-size firms with a small extent of advertising. Lastly, I compare summary statistics by the credit rating of buyers in Table 7. Since the credit rating comes from Reference USA but not the SSC, it reflects buyers' overall financial credibility but not the credibility in the trade with the SSC. Most buyers with a known credit rating are rated as either very good or good.

4 Results

Using the transaction level data on the sales of Product S provided by the SSC and supplemental data on the buyers from Reference USA and Yellow Pages, I estimate the bargaining model represented by regression equation (14) by feasible generalized nonlinear least squares (FGNLS). The estimations results are summarized in Tables 8 and 9.

4.1 First Stage NLS Regression

Columns (a) - (d) of Table 8 present the results from the first stage nonlinear least squares (NLS) regression. The NLS estimates, though not as efficient than the FGNLS estimates, are consistent estimates of the unknown parameters in the regression model. Column (a) lists the variables included in the regression[19]. $I(\cdot)$ is the indicator function that carries the value of one if the statement in the paranthesis is true and zero otherwise. Columns (b) - (d) report the coefficient estimates as well as the standard errors and p-values of these estimates.

Variables determining the reservation value of the buyer, X_{it}, include a constant, the weight of steel sold, a dummy that equals to one if the SSC arranges the delivery and zero otherwise, the amount of freight paid if the SSC arranges the delivery, line of business dummies, State dummies, a credit rating dummy, ad size dummies, employee size dummies, and sales volume dummies[20].

"Importer." The personnel at the SSC also suggest that they purchase frequently from international sources. Such international shipments are cheaper but involve a longer delivery time.

[19] See Table A for detailed description of the variables.

[20] The dummies $SRV \cup TPU$, $IN \cup MI$, $CRGD \cup CRSF$, $NOAD$, $I(EMP \geq 50)$, and $I(SVOL > 50)$ are omitted to avoid multicollinearity.

Table 8: Regression Results

Variable	NLS			FGNLS		
Variable	Estimate	Std. Err.	P-Value	Estimate	Std. Err.	P-Value
(a)	(b)	(c)	(d)	(e)	(f)	(g)
Bargaining Power γ	0.3610	0.0184	0.0000	0.3870	0.0192	0.0000
Buyer's Reservation Value β						
Constant	6.7993	0.5405	0.0000	6.3425	0.5035	0.0000
WT	-0.0242	0.0026	0.0000	-0.0216	0.0022	0.0000
$DLVY$	-0.1965	0.0800	0.0142	-0.1867	0.0793	0.0187
$FRT \times DLVY$	-0.0789	0.0237	0.0009	-0.0756	0.0266	0.0045
WST	-1.6107	0.2241	0.0000	-1.2901	0.1879	0.0000
$CSTR$	-1.2565	0.2246	0.0000	-0.9923	0.1899	0.0000
$MANU$	-1.4172	0.2375	0.0000	-1.1454	0.1975	0.0000
CT	1.0817	0.4169	0.0096	0.9359	0.3894	0.0164
RI	1.0027	0.4221	0.0177	0.8134	0.3930	0.0387
ME	1.0996	0.4201	0.0090	0.8872	0.3912	0.0235
NJ	0.9042	0.4147	0.0294	0.7238	0.3866	0.0614
MA	1.1859	0.4155	0.0044	0.9761	0.3874	0.0119
$NH \cup VT$	1.0389	0.4154	0.0125	0.8417	0.3878	0.0302
$VA \cup WV$	0.9954	0.4330	0.0217	0.7389	0.4000	0.0649
NY	1.1856	0.4184	0.0047	0.9698	0.3899	0.0130
MD	1.4566	0.4557	0.0014	1.1249	0.4167	0.0070
PA	1.0846	0.4127	0.0087	0.8685	0.3850	0.0243
DE	0.6253	0.4164	0.1335	0.4954	0.3886	0.2026
$NC \cup SC$	0.4121	0.4488	0.3586	0.2570	0.4209	0.5416
$CRVG$	0.1625	0.0721	0.0245	0.1191	0.0605	0.0492
$ADREG$	-0.3676	0.0937	0.0001	-0.3119	0.0775	0.0001
$ADBLD$	-0.6389	0.1251	0.0000	-0.4890	0.1065	0.0000
$ADCOL$	-0.4932	0.1138	0.0000	-0.4089	0.0951	0.0000
$ADDPY$	-0.6052	0.1219	0.0000	-0.5057	0.0999	0.0000
$I(1 \leq EMP \leq 19)$	0.6905	0.1053	0.0000	0.5773	0.0867	0.0000
$I(20 \leq EMP \leq 49)$	0.2863	0.0782	0.0003	0.2488	0.0661	0.0002
$I(SVOL \leq 5)$	-0.7957	0.1280	0.0000	-0.5975	0.1161	0.0000
$I(5 < SVOL \leq 50)$	-0.4639	0.0720	0.0000	-0.3743	0.0624	0.0000
RPC	0.1858	0.0424	0.0000	0.1951	0.0443	0.0000
Seller's Outside Alternative Value κ, ϕ						
Scaling Factor κ	-0.0021	0.0027	0.4376	-0.0003	0.0008	0.6928
INV	0.2491	0.0605	0.0000	0.3348	0.1186	0.0048
# Observations	1244			1244		
R-squared	0.7248			0.9710		

With the exception of two State dummies[21], all coefficients on X_{it} are significantly different from zero at the 3% level.

The scaling factor of the exponential function that determines the value of the sales agent's outside alternative, κ, is highly insignificant. As long as we cannot reject the null hypothesis that κ is zero, we cannot reject the null hypothesis that the sales agent's outside alternative, $\kappa \exp(INV_t \phi)$, is zero, no matter what the value of ϕ is [22]. It is probable that in fact the sales agent's outside alternative has a value of zero for most, if not all, transactions during the sample period. The inventory level of Product S has remained reasonably high during the entire sample period. (See Figure 2.) Hence it is likely that in most transactions the sales agent is not jeopoardizing the opportunity to fullfil future demand. If the buyer decides not to buy from the sales agent, the sales agent simply loses a sale.

The bargaining power parameter, γ, is estimated to be 0.3610. Hence $\frac{p^S}{p^B} \approx \frac{\gamma^S}{\gamma^B} = \frac{0.3610}{1-0.3610} \approx \frac{3}{5}$. The buyer has a stronger bargaining position than the sales agent does because the buyer can threaten a break-down probability that is about two-thirds bigger than that of the sales agent. Such break-down probability ratio between the buyer and the sales agent is intuitive. In each bargaining game, the buyer may discontinue further negotiations and search for an alternative source of supply. Similarly, the sales agent may declare break-down of bargaining and sell the steel to another buyer. Given the high inventory level that the SSC has maintained during the sample period, the break-down threat of the sales agent is very weak. On the other hand, the buyer's threat of searching for another supplier is more convincing given the existence of many alternative steel suppliers.

4.2 Second Stage Variance Estimation

I have derived in Section 2 that

$$E(\epsilon_{it}^2) = \sigma^2 + Z_{it}\delta + DFRP_t\psi + \xi_{it} \tag{28}$$

In the second stage estimation, the squared residuals from the first stage NLS regression are regressed on a constant, $DFRP_t$, and Z_{it} using ordinary least squares (OLS) to obtain consistent estimates of the unknown parameters in equation (28). I first estimate the variance equation

[21] DE and $NC \cup SC$.

[22] Note that both κ and ϕ carry the wrong sign. However, the wrong signs do not constitute a problem when κ is not significantly different from zero.

by including X_{it} and INV_t in Z_{it}. Then I eliminate variables with insignificant coefficients and re-estimate the variance equation. Table 9 reports the results.

Table 9: Variance Estimation

Variable	Estimate	Std. Err.	P-Value
Constant	0.1275	0.0276	0.0000
$DFRP$	0.0004	0.0003	0.1663
$DLVY$	-0.0310	0.0126	0.0140
$FRT \times DLVY$	0.0090	0.0034	0.0085
$CRVG$	-0.0093	0.0067	0.1667
$ADDPY$	-0.0195	0.0100	0.0529
$I(5 < SVOL \leq 50)$	-0.0164	0.0070	0.0192
RPC	-0.0114	0.0061	0.0641
# Observations	1244		
R-squared	0.0185		

The estimation results from the second stage illustrate that the variance of the error term, ϵ_{it}, is smaller when:

- *Day t is closer to the day on which the SSC made the most recent purchase.* The variable that correlates with the buyer's reservation value is the SSC's purchase cost on day t, PC_t. Since I only observe PC_t if the SSC actually made a purchase on that day, I often have to use the SSC's most recent purchase cost, RPC_t as a proxy. With PC_t evolving as a random walk process, the variance of the error originating from using RPC_t as the proxy for PC_t is smaller when day t is closer to the most recent purchase day.

- *The transportation of steel is arranged by the SSC.* I only have data on freight paid if the transportation is arranged by the SSC. As we can see from the NLS estimation results, freight paid significantly explains the reservation value of the buyer. Without the information on freight paid, the error term includes the noise due to freight paid and therefore has a larger variance.

- *The buyer pays less freight.*

- *The buyer has a better credit rating.*

- *The sales volume of the buyer is very high.*

- *The cost of the most recent purchase made by the SSC is higher.* One possible explanation is that the variance of the disturbance term is smaller for buyers with a more inelastic demand.

Since the SSC's purchase cost, PC_t, is correlated with the price at which the buyers may purchase steel from the SSC or an alternative supplier, a high PC_t signals a high cost for the buyers to purchase. Only buyers with more inelastic demand would buy from the SSC when PC_t is high, leading to a smaller variance in the error term.

4.3 Third Stage FGNLS Regression

Using the consistent estimates of parameters determining the covariance matrix of the errors, I obtain FGNLS estimates of the parameters in the regression model (14). Columns (e) - (g) of Table 8 present the results.

Comparing columns (e) - (g) to columns (b) - (d) in Table 8, the estimation results from the FGNLS regression are not quite different from the estimation results from the NLS regression. I perform the Hausman's specification test to test the null hypothesis that the difference between the FGNLS estimates and the NLS estimates is zero. The chi-squared statistic, with thirty degrees of freedom, is 41.7065[23], which is not insignificantly different from zero at the 10% level.

The FGNLS estimates of the scaling factor of the exponential function, κ, and the coefficient on INV_t differ considerably from the corresponding NLS estimates. However, note that both the FGNLS and the NLS estimates of κ are not significantly different from zero. Hence both the FGNLS and the NLS regressions predict that the outside alternative of the sales agent has zero value.

Figures 3 and 4 plot the estimated sale price series using the NLS and the FGNLS estimates. I also plot the smoothed curves of historical purchase cost of inventory and spot purchase cost as in Figure 1. The two figures look very similar. In fact, the absolute difference between the estimated sale price using the FGNLS estimates and that using the NLS estimates is less than 1% of the estimated sale price from the NLS estimates in 93% of the sales. Figures 3 and 4 demonstrate a similar dispersion of the sale price to that observed in Figure 1. Nonetheless, the dispersion we observe in empirical data is larger than what Figures 3 and 4 suggest.

4.4 Effect of Bargaining on Price

Bargaining allows the sales agent to price discriminate according to the cost of steel and the buyer's reservation value. The outcome of the bargaining game, a negotiated price, depends on factors related to the reservation value of the sales agent, the reservation value of the buyer, and the relative strength of the bargaining positions of the buyer and the sales agent.

[23] The p-value is 0.1170.

Figure 3: Estimated Net Sale Price from NLS Regression

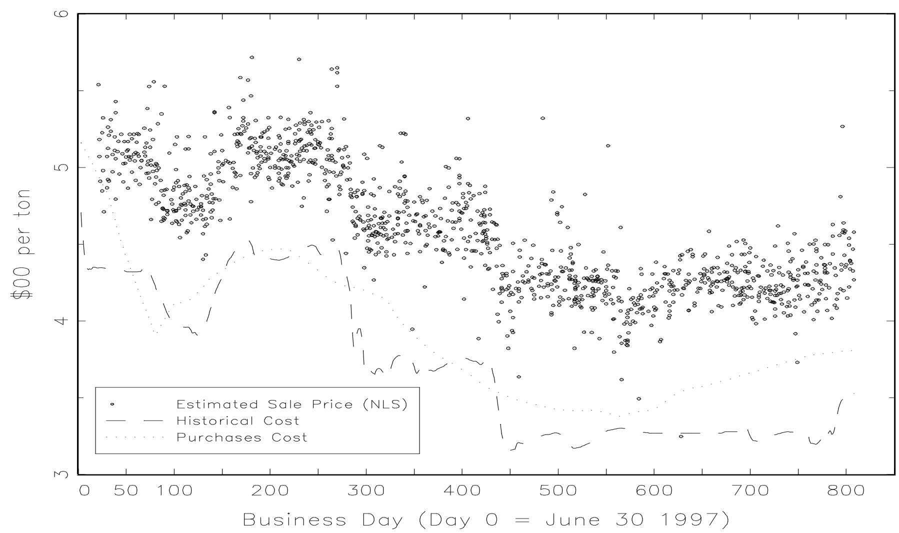
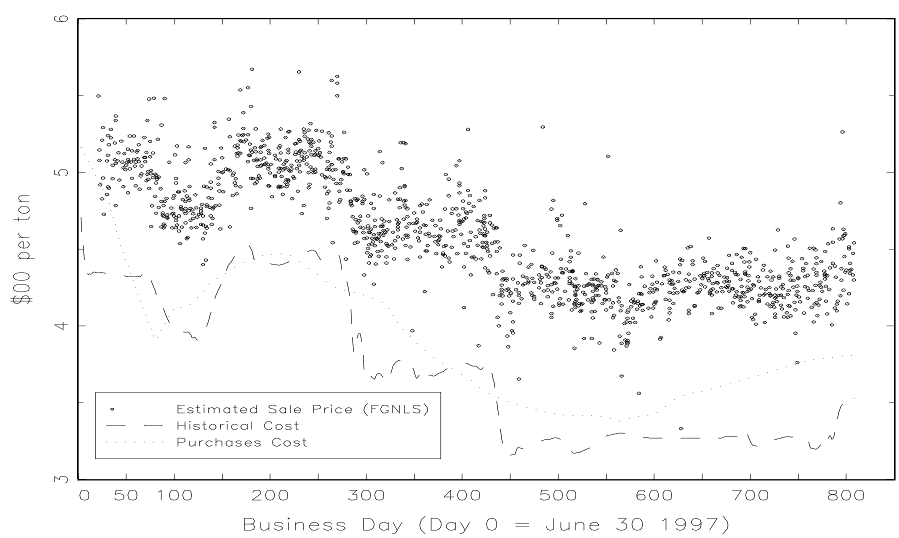


Figure 4: Estimated Net Sale Price from FGNLS Regression



The negotiated price increases with the sales agent's reservation value. The reservation value of the sales agent varies positively with the historical purchase price of inventory and the outside alternative value. However, the estimation results show that the sales agent's outside alternative value is zero. Hence only historical purchase cost affects the negotiated price through changing the sales agent's reservation value.

The negotiated price also increases with the buyer's reservation value. My estimation results suggest that the following buyers have a lower reservation value and therefore pay a lower negotiated price:

- *Large quantity buyers.* If there is diminishing marginal returns to the steel input, the average return of steel will be smaller for buyers purchasing larger quantity.

- *Buyers who pay more freight and buyers located in States that are more remote from the SSC.* Given the cost of transportation, the SSC has certain extent of monopoly power over nearby buyers. Nearby buyers pay less for transportation and therefore place more value on the steel product.

- *Buyers in the Wholesale Industry.* Buyers of steel in the Wholesale Industry are mostly steel intermediaries who in turn sell steel to end users. Steel intermeidaries' value on steel is derived from, and probably less than, the value end users put on steel.

- *Buyers with a worse credit rating.* Credit rating is a proxy for the firm's profitability. Less profitable firms value inputs of production less. If the credit rating dummy, which capture the buyers' overall credit rating, correlates highly with the buyers' credibility in trading with the SSC, buyers with a worse credit rating may have a lower reservation value for another reason. The SSC has a credit department that monitors the credit history of each buyer and communicates such information with the sales agents. Although default is not a problem for the SSC, it takes a much longer time for some buyers to pay their bills then others. Buyers that have a history of not paying bills on time generally will not be able to receive shipments until the SSC has cashed out their checks. Hence, the credit rating of a buyer may be a proxy for delivery time of the steel product purchased, a variable that I do not observe. Fast delivery, valued by buyers, may only be possible for buyers with a good credit standing.

- *Buyers with more extensive advertising.* Advertisement captures two effects. First, advertisement itself is likely to increase the value of the buyer's product and therefore increase the reservation value on the steel input. Second, advertisement is a proxy for firm size which may increase (decrease) the value on the steel input if larger firms are more (less) efficient. My result that buyers with more advertising have a lower reservation value implies that the effect of firm size on the buyer's reservation value is negative and it offsets the positive effect from advertisement per se.

- *Buyers with a larger employee size.* With employee size being a proxy for firm size, this result signals a negative correlation between the firm size and the reservation value on the steel input.
- *Buyers with a smaller sales volume.* With sales volume being a proxy for firm size, this suggests a positive correlation between the firm size and the reservation value on the steel input.

Note that the three sets of dummies that may be used as proxies for firm size – ad size, employee size, and sales volume, provide conflicting conclusions to the relationship between firm size and firm effciency, and hence the correlation between the firm size and the reservation value on the steel input. Coefficients on ad size and employee size dummies suggest that larger firms place a smaller value on steel purchased, while coefficients on sales volume dummies imply the opposite. Such conclusions remain unchanged even if I remove any one or two sets of dummies from the regression. The mixed result may signal that there does not exist a deterministic relationship between firm size and firm efficiency. The mixed result may also be due to the fact that some or all of these three sets of dummies are only noisy proxies of firm size.

Finally, the negotiated price is lower when the buyer has a stronger bargaining position. The estimation results show that the buyer's bargaining position is stronger than the seller's, resulting in the split of trade surplus between the buyer and the seller in a five-to-three ratio.

4.5 Effect of Bargaining on Profit

While the bargaining mechanism allows the sales agents to price discriminate more effectively on a transaction-by-transaction basis, it also offers the opportunity for the buyers to negotiate for a lower price. To understand whether the benefits brought by bargaining outweigh the costs, I compare the profitibility of the SSC under the current bargaining mechanism with that under a fixed markup scheme. In the fixed markup scheme, the SSC imposes a fixed markup over the historical purchase cost of inventory for all transactions, instead of letting the sales agents negotiate the price for each transaction separately. Without information on the true economic cost of steel, I exploit the differences in sales quantity and revenue over the entire sample period to calculate the critical per unit cost that makes the profit from bargaining the same as that from the fixed markup scheme. I then draw the conclusion on whether bargaining or a fixed markup brings a higher profit to the SSC by contrasting the critical cost to the average purchase cost over the entire sample period.

Suppose that on each business day the same set of buyers come to the SSC with the same demand when the SSC replaces the bargaining mechanism with a fixed markup scheme. I do not have a complete record of all incoming buyers because I only have data on successful transactions. I do not have any information on price quotes that do not lead to a transaction. A buyer who walks away without purchasing under the bargaining mechanism has a reservation value lower than the sales agent's reservation value. The sales agent's reservation value is the sum of the historical cost of inventory and the sales agent's outside alternative value. If the outside alternative value is zero, then the reservation value of a buyer who walks away is lower than the historical cost of inventory and is therefore lower than the price under the fixed markup scheme. I assume that the sales agent's outside alternative value is small enough so that incoming buyers who do not purchase from the SSC under the bargaining scheme also would not purchase under the constant markup scheme. Therefore the information on incoming buyers who come to the SSC for a price quote but leave without any purchase is irrelevant to this analysis.

Under the fixed markup scheme with a rate of markup m, the sales quantity (TQ_m) and revenue (TR_m) are

$$TQ_m = \sum_{\forall i,t} Q_{it} \times I\left[(1+m)HC_{it} \leq X_{it}\beta + RPC_t\alpha + \nu_{it} + \eta_t\alpha\right] \quad (29)$$

$$TR_m = \sum_{\forall i,t} (1+m) \times HC_{it} \times Q_{it} \times I\left[(1+m)HC_{it} \leq X_{it}\beta + RPC_t\alpha + \nu_{it} + \eta_t\alpha\right] \quad (30)$$

where $I[\cdot]$ is the indicator function. Denote TQ_0 and TR_0 as the sales quantity and revenue under the bargaining mechanism. Define $RQ_m \equiv TQ_0 - TQ_m$ and $RR_m \equiv TR_0 - TR_m$ as the reduction in sales quantity and revenue respectively.

Since $TQ_0 = \sum_{\forall i,t} Q_{it}$, it must be true that $RQ_m >= 0$. If $RR_m < 0$ then it is clear that the SSC earns a larger profit under the fixed markup system. On the other hand, if $RQ_m = 0$ and $RR_m > 0$ then the SSC definitely earns a smaller profit under the fixed markup scheme. When $RQ_m > 0$ and $RR_m > 0$, whether the SSC's profit has increased or decreased under the new fixed markup scheme is ambiguous. Let $CC_m = RR_m/RQ_m$ be the critical purchase cost of the SSC at which the SSC's profit under the markup scheme is the same as its profit under the bargaining regime. If the SSC can purchase the additional steel sold under the bargaining mechanism at a cost lower than CC_m, then we conclude that the SSC is better off under bargaining because the additional revenue earned is more than enough to cover the extra cost. I use the mean purchase cost over the entire sample period, $MPC = 3.89$, as the benchmark cost for comparison. I define the dummy RPD_m as follows:

$$RPD_m = \begin{cases} 1 & \text{if } MPC \leq CC_m \\ 0 & \text{otherwise} \end{cases} \tag{31}$$

I estimate the percentage of reduction in demand, $PRQ_m = 100 \times \frac{RQ_m}{TQ_0}$, the percentage of reduction in revenue, $PRR_m = 100 \times \frac{RR_m}{TR_0}$, and RPD_m using the estimation results in Tables (8) and (9).

First, I simulate random samples of $\theta = \{\beta, \alpha\}$ and $e_{it} = \nu_{it} + \eta_t \alpha$. Let $\hat{\theta}$ and $\hat{V}_{\hat{\theta}}$ be the estimates of θ and the variance covariance matrix of θ in the FGNLS regression. Random samples of θ can be drawn from the asymptotic normal distribution $N(\hat{\beta}, \hat{V}_{\hat{\beta}})$.

To obtain random samples of e_{it}, I combine random draws of ν_{it} and η_t. Recall that η_t is the sum of random walk errors if $t > \tau(t)$ and zero if $t = \tau(t)$. (See equation (9).) I have assumed that the random walk errors, ω_t, are i.i.d. with variance σ_ω^2. I further assume that the distribution is normal. Define Δ_t as the number of business days between the SSC's most recent purchase and the SSC's next purchase, so that the next purchase the SSC makes after day t is on day $\tau(t) + \Delta_t$. Then one can show that for $t > \tau(t)$, the distribution of ω_t conditional on $\Delta PC_t \equiv PC_{\tau(t)+\Delta_t} - PC_{\tau(t)}$ is $N\left(\frac{\Delta PC_t}{\Delta_t}, \sigma_\omega^2\left(1 - \frac{1}{\Delta_t}\right)\right)$[24]. Results from the second stage variance estimation provide a consistent estimate of the only unknown parameter in the conditional normal distribution, σ_ω^2. Hence we can

[24] Since $\Delta PC_t \equiv PC_{\tau(t)+\Delta_t} - PC_{\tau(t)} = \sum_{t'=1}^{\Delta_t} \omega_{\tau(t)+t'}$ and ω_t is normal with mean zero for all t, ΔPC_t is also normal with mean zero. We can then decompose ω_t as

$$\begin{aligned} \omega_t &= \frac{E(\omega_t \Delta PC_t)}{E(\Delta PC_t^2)} \Delta PC_t + \zeta_t \\ &= \frac{\Delta PC_t}{\Delta_t} + \zeta_t \end{aligned}$$

for some ζ_t that is normal, has mean zero, and is independent of ΔPC_t. Furthermore, the variance of ζ_t is

$$\begin{aligned} E(\zeta_t^2) &= E(\omega_t^2) - \frac{E(\Delta PC_t^2)}{\Delta_t^2} \\ &= \sigma_\omega^2 (1 - \frac{1}{\Delta_t}) \end{aligned}$$

Therefore $\omega_t | \Delta PC_t \sim N\left(\frac{\Delta PC_t}{\Delta_t}, \sigma_\omega^2\left(1 - \frac{1}{\Delta_t}\right)\right)$.

Table 10: Comparison of Demand, Revenue, and Profitability

	Assume $\sigma_\mu^2 = \delta_\mu = 0$			Assume $\sigma_\nu^2 = \delta_\nu = 0$		
m (%)	PRQ (%)	PRR (%)	RPD	PRQ (%)	PRR (%)	RPD
5.00	29.47	38.83	1.0000	29.17	38.57	1.0000
	(37.22)	(32.91)	(0.0000)	(37.70)	(33.36)	(0.0000)
10.00	30.96	37.33	1.0000	30.64	37.05	1.0000
	(38.08)	(35.26)	(0.0000)	(38.65)	(35.80)	(0.0000)
15.00	32.51	36.01	1.0000	32.21	35.73	1.0000
	(38.88)	(37.61)	(0.0000)	(39.54)	(38.26)	(0.0000)
20.00	34.12	34.89	0.6637	33.82	34.59	0.5750
	(39.62)	(39.96)	(0.4725)	(40.38)	(40.75)	(0.4943)
25.00	35.79	33.97	0.4849	35.49	33.65	0.4667
	(40.28)	(42.28)	(0.4998)	(41.15)	(43.22)	(0.4989)
30.00	37.53	33.26	0.4599	37.21	32.92	0.4574
	(40.84)	(44.54)	(0.4984)	(41.81)	(45.61)	(0.4982)
35.00	39.32	32.78	0.4535	39.01	32.43	0.4529
	(41.31)	(46.73)	(0.4978)	(42.33)	(47.91)	(0.4978)
40.00	41.16	32.51	0.4493	40.88	32.19	0.4514
	(41.68)	(48.83)	(0.4974)	(42.75)	(50.11)	(0.4976)
45.00	43.06	32.46	0.4481	42.83	32.19	0.4517
	(41.94)	(50.83)	(0.4973)	(43.05)	(52.18)	(0.4977)
50.00	44.99	32.62	0.4492	44.78	32.39	0.4524
	(42.10)	(52.71)	(0.4974)	(43.22)	(54.11)	(0.4977)
55.00	46.97	33.00	0.4517	46.75	32.76	0.4538
	(42.15)	(54.45)	(0.4977)	(43.29)	(55.92)	(0.4979)
60.00	48.96	33.57	0.4548	48.78	33.36	0.4566
	(42.10)	(56.06)	(0.4980)	(43.24)	(57.56)	(0.4981)
65.00	50.98	34.33	0.4602	50.85	34.20	0.4628
	(41.95)	(57.52)	(0.4984)	(43.08)	(59.03)	(0.4986)
70.00	53.00	35.25	0.4676	52.91	35.18	0.4713
	(41.71)	(58.83)	(0.4989)	(42.82)	(60.34)	(0.4992)
75.00	55.02	36.33	0.4790	54.96	36.32	0.4839
	(41.39)	(59.99)	(0.4996)	(42.47)	(61.48)	(0.4997)
80.00	57.02	37.54	0.4913	57.05	37.66	0.4968
	(40.99)	(61.00)	(0.4999)	(42.03)	(62.46)	(0.5000)
85.00	58.99	38.87	0.5007	59.09	39.09	0.5079
	(40.52)	(61.87)	(0.5000)	(41.53)	(63.30)	(0.4999)
90.00	60.93	40.28	0.5128	61.10	40.62	0.5235
	(39.98)	(62.61)	(0.4998)	(40.96)	(64.00)	(0.4994)
95.00	62.81	41.76	0.5267	63.04	42.19	0.5366
	(39.40)	(63.21)	(0.4993)	(40.35)	(64.59)	(0.4987)
100.00	64.64	43.29	0.5376	64.93	43.82	0.5485
	(38.76)	(63.69)	(0.4986)	(39.69)	(65.05)	(0.4976)

Notes: Standard errors in paranthesis.

draw random samples of η_t from the conditional normal distribution.

Assuming that the conditional distribution of ν_{it} to be normal, we can draw random samples of ν_{it} from a normal distribution with variance as specified in equation (21). If we have consistent estimates of σ_ν^2 and δ_ν, then a consistent estimate of the variance of ν_{it} is $\hat{\sigma^2}_\nu + Z_{it}\hat{\delta}_\nu$. However, as we can see from equations (23) - (27), we can neither identify σ_ν^2 nor δ_ν in the model. I resolve the problem by presenting results under each of the two extreme assumptions: $\sigma_\mu^2 = \delta_\mu = 0$ and $\sigma_\nu^2 = \delta_\nu = 0$.

Let $\tilde{\theta}_1, \tilde{\theta}_2, \ldots, \tilde{\theta}_{N_\theta}$ and $\tilde{\mathbf{e}}_1, \tilde{\mathbf{e}}_2, \ldots, \tilde{\mathbf{e}}_{N_\mathbf{e}}$ be the random draws of θ and $\mathbf{e} = \{e_{it}, \forall i, t\}$. To estimate PRQ_m, first calculate the mean and variance of PRQ_m conditional on each simulation sample of θ, $\tilde{\theta}_j$, for $j = 1, 2, \ldots, N_\theta$:

$$PRQ_m(\tilde{\theta}_j) = \frac{1}{N_\mathbf{e}} \sum_{k=1}^{N_\mathbf{e}} PRQ_m(\tilde{\theta}_j, \tilde{\mathbf{e}}_j) \tag{32}$$

$$\sigma^2_{PRQ_m}(\tilde{\theta}_j) = \frac{1}{N_\mathbf{e}} \sum_{k=1}^{N_\mathbf{e}} (PRQ_m(\tilde{\theta}_j, \tilde{\mathbf{e}}_j) - PRQ_m(\tilde{\theta}_j))^2 \tag{33}$$

The point and variance estimates of PRQ_m are

$$\widehat{PRQ}_m = \frac{1}{N_\theta} \sum_{j=1}^{N_\theta} PRQ_m(\tilde{\theta}_j) \tag{34}$$

$$\widehat{\sigma^2}_{PRQ_m} = \frac{1}{N_\theta} \sum_{j=1}^{N_\theta} [(PRQ_m(\tilde{\theta}_j) - \widehat{PRQ}_m)^2 + \sigma^2_{PRQ_m}(\tilde{\theta}_j)] \tag{35}$$

The point and variance estimates of PRR_m and RPD_m are calculated similarly. Table 10 presents the simulation results for various values of the markup rate m with $N_\theta = N_\mathbf{e} = 1000$.

The simulation results under the assumption that $\sigma_\mu^2 = \delta_{mu} = 0$ are similar to the results assuming $\sigma_\nu^2 = \delta_\nu = 0$. In general the point estimates are very noisy. When the markup rate is less than or equal to 15%, my estimates suggest that the SSC's profit has definitely reduced when the fixed markup scheme is used. However, when the markup rate is more than 15%, my estimates can neither reject $H_0 : RPD = 1$ nor $H_0 : RPD = 0$. Hence I cannot draw a conclusion of whether the profit earned under bargaining or the fixed markup scheme is higher.

5 Conclusion

Using a rich data set on steel sales, this paper estimates an alternating-offer bargaining game over steel price. The estimation results allow me to identify the factors that determine the negotiated price of steel and to ask if the SSC earns a larger profit from bargaining than from a fixed markup.

The negotiated price correlates positively with the strength of the bargaining position of the sales agent relative to that of the buyer, the reservation value of the seller, and the reservation value of the buyer. My estimation results show that the bargaining power of the sales agent is weaker than that of the buyer because the buyer can threaten a larger probability of break-down if the sales agent rejects the buyer's offer. As a result, the trade surplus is split between the buyer and the sales agent in a five-to-three ratio. My results also suggest that the sales agent's outside alternative value is not significantly different from zero. Hence, the sales agent's reservation value is just the historical purchase cost of inventory. The negotiated price increases with the historical cost of inventory. Finally, I find that large quantity buyers, buyers who pay more in freight, buyers located in States that are more remote from the SSC, buyers in the Wholesale Industry, and buyers with a worse credit rating have a lower reservation value on steel and therefore get a more favorable deal. My estimates produce a series of estimated sale price that varies over time and across customers, explaining the price dispersion we observe in empirical data. However, the dispersion of price in empirical data is larger than the dispersion predicted by my estimates.

To understand the effect of bargaining on the SSC's profitability, I simulate what the sales quantity and revenue would be if the SSC were to impose a fixed markup over accounting cost, instead of asking the sales agents to negotiate the price for each transaction separately. Without information on the true economic cost of steel, I exploit the differences in sales quantity and revenue over the entire sample period to calculate a critical per unit cost that makes the profit from bargaining the same as that from a fixed markup. Contrasting the critical cost to the mean purchase cost, I conclude that the SSC earns a higher profit from bargaining than the fixed markup scheme with a markup rate no greater than 15%. However, I am not able to draw a conclusion on whether bargaining or the fixed markup rate brings a higher to the SSC when the markup rate is larger than 15%.

The estimation results in the paper are based on a bargaining model under the assumptions stated in Section 2. Some of these assumptions represent important deviations from the reality. For example, the sales agent (buyer) generally does not know the reservation value of the buyer (sales agent)[25] and a sales agent usually have repeated interactions with the same buyer, introducing dependancy among transactions if the sales agent maximize his/her total utility gain from the same buyer over time[26]. Further analyses can be pursued to examine bargaining models without these unrealistic assumptions.

[25] Violation of assumption 8.

[26] Violation of assumption 3.

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A List of Variables

Variable	Acronym
Number of business days from 6/30/97	DAY
Price, net of freight, of Product S sold to buyer i at time t ($00/ton)	P
Number of units of Product S sold to buyer i at time t	$UNIT$
Weight of Product S sold to buyer i at time t (ton)	Q
Total Weight of Product S sold at time t (ton)	TQ
= 1 if the sale is a delivery; 0 if it is a buyer pickup	$DLVY$
Freight for the delivery of Product S sold to buyer i at time t ($0/ton)[2]	FRT
Historical cost of Product S sold to buyer i at time t ($00/ton)	HC
Profit margin over historical cost from sale to buyer i at time t (%)[1]	$HMARG$
Cost at which the SSC bought Product S in the most recent purchase ($00/ton)	RPC
Number of business days from the SSC's most recent purchase of Product S	$DFRP$
Inventory of Product S at time t (00 ton)	INV
= 1 if line of business of buyer i is wholesale trade; 0 otherwise[3]	WST
= 1 if line of business of buyer i is construction; 0 otherwise[3]	$CSTR$
= 1 if line of business of buyer i is manufacturing; 0 otherwise[3]	$MANU$
= 1 if line of business of buyer i is services; 0 otherwise[3]	SRV
= 1 if buyer i is in the transportation & public utilities industry; 0 otherwise[3]	TPU
Employee size of buyer i	EMP
Sales volume ($million) of buyer i	$SVOL$
= 1 if buyer i does not have any ad listing in Yellow Pages; 0 otherwise	$NOAD$
= 1 if ad size of buyer i is regular listing; 0 otherwise	$ADREG$
= 1 if ad size of buyer i is bold listing; 0 otherwise	$ADBLD$
= 1 if ad size of buyer i is in-column; 0 otherwise	$ADCOL$
= 1 if ad size of buyer i is display; 0 otherwise	$ADDPY$
= 1 if credit rating of buyer i is very good; 0 otherwise	$CRVG$
= 1 if credit rating of buyer i is good; 0 otherwise	$CRGD$
= 1 if credit rating of buyer i is satisfactory; 0 otherwis	$CRSF$

Notes: 1. $MARGH = 100 * (P - HC)/HC$. 2. FRT is available only if the SSC arranges the transportation ($DLVY = 1$). 3. According to Marjor Industry Group of the Primary SIC Code. 4. Missing for $DAY \leq 20$.