8 THE DEMAND FOR TRANSPORTATION SERVICES IN NATURAL GAS MARKETS–THE MARKET POWER OF A NATURAL GAS PIPELINE

8.1 Introduction

Koch Gateway Pipeline (Koch) is an interstate natural gas transmission system operating over 9,000 miles of pipeline. The system extends from South Texas through Louisiana, Mississippi, southern Alabama, and southern Florida. Koch is located in one of the nation's largest natural gas producing areas and is tied into a number of the largest gas producing regions. The Koch system is best visualized as a giant hub rather than a traditional longline interstate pipeline.

In 1996, Koch applied before the Federal Energy Regulating Commission (FERC) for market-based rates for its transportation services. Before that filing Koch, like other interstate pipelines, had been subject to regulation under a cost of service rate schedule. Koch argued before the FERC that it operates in a highly competitive environment which disciplines its pricing behavior. Koch presented evidence of its market power using traditional market concentration studies and by identifying specific pipeline alternatives to its system at metering points. Koch offered evidence of its historical discounting behavior which demonstrated the conditions under which it discounted historical rates in order to raise revenues. Additionally, Koch presented an elasticity of demand study to examine the likelihood that absent regulation it would be more likely to raise prices rather than to lower them. Finally, Koch presented evidence that its system functions as a swing or peaking system and that the capacity held by marketers and other gas suppliers competed with Koch in the marketplace. Koch's filing was the first of its kind and broad in scope.

In this chapter I discuss the elasticity and discounting analysis performed for the Koch Gateway Pipeline Company. I estimate the historical demand for Koch's transportation service and an econometric model of Koch's historical discounting behavior. In these analyses I rely on the actual transactions occurring on the Koch system for the period from April 1989 through December 1994. This time period effectively covers Koch's transition from a pipeline offering a bundled product, consisting of natural gas sales and transportation, to one offering primarily a transportation service.

The empirical analysis proceeds in two steps. First, I specify and estimate binary logit models to predict Koch's discounting practices for interruptible transportation rates (i.e., spot rates) in four markets. The results derived from the logit models are then used in the second part of my analysis, a market demand regression analysis. The second part of my analysis is used to estimate the mean demand elasticity faced by Koch for its transportation services in four primary markets. Those markets are: natural gas deliveries to industrial firms and power plants; receipts from "upstream" pipelines; deliveries to "downstream" pipelines; and, receipts from production fields.

As demonstrated below, for the 1989-1994 period, these segments comprised 91 percent of the firm (contract based) and interruptible (spot based) transportation volume through Koch's system (industrials/power plants with 20 percent; pipelines receipts with 21 percent; pipeline deliveries with 25 percent; and production fields with 25 percent). The remaining 9 percent includes aspects of Koch's business such as sales to government facilities and other pipelines using gas for compressors and storage facility operations. I further break transportation services into firm and interruptible transportation. As I show below, for the 1989 through 1994 period, of the firm transportation and interruptible transportation transactions analyzed, 71 percent of the volume is interruptible and 29 percent of the volume is firm.

In the next section I discuss issues of theory and model specification. I then review the data sources and present the econometric results. Finally I present results for the models of Koch's historical discounting behavior and for the demand for Koch's transportation services.

8.2 Theory

In economic theory, elastic demand operates as the primary constraint on a firm's market power. Elasticity measures a firm's ability to raise prices without losing sales. Even if a firm is the sole producer of a good or service, it will not have significant market power if demand for that good or service is sufficiently elastic. For example, many products are protected by patents which establish a legal monopoly. However, patents differ enormously in the amount of market power that they confer upon their holders because the elasticity of demand for products varies.

The market in which Koch operates is not perfectly competitive, very few markets are. However, the relevant issue is not whether the market is perfectly competitive, but whether demand is sufficiently elastic to prevent Koch from raising prices significantly and sustaining those price increases. The answer to this question depends on the elasticity of demand for Koch transportation services.

For a pipeline such as Koch which has high fixed costs and low variable costs, price increases which decrease the pipeline's total revenues are unlikely to be profitable. An elasticity coefficient greater than one indicates that increases in unit sales prices are more than offset by decreases in unit sales quantities. Therefore, increasing prices decreases total revenue. In conjunction with the high fixed to variable cost ratio, elastic demand effectively prevents Koch from raising prices.

Econometrically analyzing a firm's demand elasticity in its product and geographic markets requires collecting transaction-level historical data for the firm. Potential price endogeneity in the demand analysis requires that the analysis control for the firm's behavior with respect to the discounts it offers on its historically regulated tariff prices.

The basic demand equation has the form:

$$Q = Z\gamma_i + v \tag{1}$$

where Q = quantity of transportation services demanded, Z = vector of explanatory factors affecting the quantity demanded, γ_i = vector of parameters associated with the explanatory factors when the firm is discounting prices ($i = 1$) or when the firm is not discounting ($i = 0$), and v = random disturbance affecting the quantity demanded.

The vector Z includes those factors which influence demand such as transportation prices, industrial production indices, the economic agent procuring service (power plants versus industrials), and so forth.

A discrete-choice model for Koch's decision to discount and the continuous demand model specified in equation (1) form a discrete-continuous system. To allow for a potential correlation between the unobservable factors that influence the decision to discount (e.g., unobservable influences affecting market competitiveness) and the unobservable factors that influence demand, the conditional expectation $E[v|i]$ can be estimated and included as an additional explanatory factor in the demand model. Dubin and McFadden (1984) have shown that this will yield consistent estimates of the parameters with ordinary least squares regression. Following Dubin and McFadden and assuming that the probability model for P_1 is logistic, I obtain:

$$\begin{aligned} E[v|i] &= [(P_1 - \delta_1)] \cdot \log \mathrm{P}_1/(1 - \mathrm{P}_1) \\ &- [(1 - P_1) - (1 - \delta_1)] \cdot \log(1 - \mathrm{P}_1)/\mathrm{P}_1 \\ &= (P_1 - \delta_1) \cdot \frac{[P_1 \log \mathrm{P}_1 + (1-\mathrm{P}_1)\log(1-\mathrm{P}_1)]}{[P_1 \log \mathrm{P}_1 + (1-\mathrm{P}_1)\log(1-\mathrm{P}_1)]/P_1(1-P_1)} \end{aligned}$$

where P_1 = probability of discounting, and δ_1 = indicator for discounting, which is one if a discount is offered and zero otherwise.

The term $E[v|i]$ is estimated using the predicted probabilities from the logit model. Including the selectivity correction factor in the regression model transforms equation (1) into:

$$Q = Z\gamma_i + E[v|i] + \tilde{v}. \tag{2}$$

Ordinary least squares, when applied to equation (2), will yield consistent estimates of the parameters γ_i. The probability model is estimated by maximum likelihood. In the next section I present the data used in estimating the discrete-continuous demand system.

8.3 Data

The data used to conduct this analysis can be broken down into three categories: Koch system data, which includes historical transaction data and descriptive data on individual metering points on the Koch system; market concentration data, which includes information on Koch and competitive pipelines and shippers organized according to several different market definitions; and ancillary data used to model large-scale trends in the demand for natural gas services, including macroeconomic and climatic data series.

8.3.1 Koch's Historical Transaction Data

I use historical transportation transaction data for the period from April 1989 through December 1994. The data is organized by year, month, station location number (SLN), and contract type. Each SLN is a single metering point on the Koch system. Each observation in the analysis represents an aggregation of all transactions of a specific contract type occurring at an SLN during one month. Thus, in the majority of cases, this is equivalent to aggregating across distinct shippers at an SLN. Contract types are defined by the unique combination of the discrete variables listed in table 8.1.

A summary of the historical transaction data file is provided in table 8.2.

Table 8.1. Koch's Contract Types

Variable	Name	Description
year	Year	Year of transaction
month	Month	Month of transaction
coflow	Contract Flow	Indicates whether transaction was a receipt or delivery
ratesc	Rate Schedule	Distinguishes between firm and interruptible rate types
gathdi	Gathering Discount Indicator	Indicates discounted gathering rate
comddi	Commodity Discount Indicator	Indicates discounted commodity rate
gathtp	Gathering Take-or-Pay Indicator	Indicates take-or-pay credit on gathering rate
comdtp	Commodity Take-or-Pay Indicator	Indicates take-or-pay credit on commodity rate
tier	Tier	Indicates the rate schedule tier for the transaction

The number of transactions and corresponding volumes are given in tables 8.3, 8.4, and 8.5.

Some features of the summaries provided in tables 8.3 through 8.5 should be noted. First, 1989 is a partial year, commencing in April. Thus, the totals represent data for five years and nine months, and the annual figures listed for 1989 are only partial totals. Second, there is a double counting issue inherent in this data summarization. In the Koch accounting system, natural gas flowing on Koch's system is counted, or metered, once when it is received by Koch and once when it is delivered. This means, in effect, that the volumes shown in these tables are nearly double the actual gas volumes which moved through the Koch system.[1]

[1]Some gas which is received by Koch is consumed in compressors and for other uses. Therefore, the "double counting" does not result in an exact doubling of the volume received by

Table 8.2. Historical Transaction Data Set

Variable	Name	Description
sln	Station Location Number (SLN)	The number designation assigned by Koch to each point on the system for accounting or measurement purposes
coflow	Contract Flow	A code that indicates whether Koch contractually received or delivered gas through an SLN for a contract: R = receipt, D = delivery
ratesc	Rate Schedule	The rate schedule used to determine the commodity charge: ITS = interruptible transportation service, FTS = firm transportation service
year, month	Production Date	The calendar year and month of the transaction
gathdi	Gathering Discount Indicator	Indicates whether the gathering rate, if applicable, was discounted.
comddi	Commodity Discount Indicator	This indicates whether the commodity rate, if applicable, was discounted.
gathtp	Gathering Take-or-Pay Indicator	This indicates whether the gathering rate includes a take-or-pay credit.
comdtp	Commodity Take-or-Pay Indicator	This indicates whether the commodity rate includes a take-or-pay credit.

Within the data I analyze, firm and interruptible transportation services are represented by 90,468 transactions. Of these, 20,235 are delivery transactions, representing 22 percent of total transactions and 70,233 are receipt transactions, representing 78 percent of all transactions. Firm service accounts for 2,477 of the delivery transactions or 3 percent of all transactions. Interruptible service accounts for 17,758 of the delivery transactions, or 20 percent of all transactions. Firm service accounts for 18,230 of the receipt transactions, or 20 percent of all transactions. Interruptible service accounts for 52,003 of the receipt transactions, or 57 percent of all transactions. Thus, firm service totals

Koch. Also, this data includes only natural gas volumes associated with the firm and interruptible transportation services analyzed, and excludes deliveries to local delivery companies (LDCs) altogether. For these reasons, the summarization is not an exact "double counting."

Table 8.2. (continued) Historical Transaction Data Set

Variable	Name	Description
tier	Tier	This indicates the length of haul for a transaction and is used to determine the appropriate commodity rate from the rate schedule: 1 0-100 miles 2 101-200 miles 3 201-300 miles 4 301-400 miles 5 401-500 miles 6 >500 miles 0 Not related to any rate type
mcf	MCF @ 14.73 psi	Volume of gas in transaction (million cubic feet)
mmbtu	MMBTU	Heating value of gas in transaction (million British thermal units)
gathrt	Gathering Rate	The rate charged for gathering services, if applicable (dollars per MMBTU)
comdlp	Commodity Rate with Add-ons	The effectively charged rate, including any GRI or AGA dues (dollars per MMBTU)
demdlf	Demand Rate 100% Load Factor	The effectively charged demand rate, not including GRI or AGA dues at 100% load factor (dollars per MMBTU)

Table 8.3. Firm and Interruptible Transportation Volumes

Year	Transactions	Volume (mmbtu)
1989	12,470	747,334,000
1990	18,157	1,076,850,000
1991	16,232	812,517,000
1992	15,268	831,636,000
1993	14,195	949,623,000
1994	14,146	972,535,000
Total	90,468	5,390,490,000

20,707 transactions, or 23 percent of all transactions. Interruptible transportation service totals 69,761 transactions, or the remaining 77 percent of the total firm and interruptible transactions.

The transaction data also show which transactions had been discounted by Koch. For the 1989-1994 period, Koch discounted 5,578 of its interruptible

Table 8.4. Firm Transportation Volumes

Year	Transactions	Volume (mmbtu)
1989	1,978	164,915,000
1990	3,961	336,613,000
1991	4,253	248,118,000
1992	3,459	230,228,000
1993	3,530	254,228,000
1994	3,526	319,610,000
Total	20,707	1,553,710,000

Table 8.5. Interruptible Transportation Volumes

Year	Transactions	Volume (mmbtu)
1989	10,492	582,419,000
1990	14,196	740,237,000
1991	11,979	564,399,000
1992	11,809	601,408,000
1993	10,665	695,394,000
1994	10,620	652,925,000
Total	69,761	3,836,780,000

(deliveries) transactions and 14,009 of its interruptible (receipts) transactions. Therefore, 21 percent of all transactions during this period were discounted interruptible transportation. Similarly, Koch discounted 1,740 of its firm (deliveries) transactions and 13,203 of its firm (receipts) transactions. Therefore, 17 percent of all transactions during this period were discounted firm transactions.

In volumetric terms, firm and interruptible transportation transactions total 5,390,490,000 mmbtu. Deliveries represent 47 percent of this volume and receipts represent 53 percent. Interruptible transportation (deliveries) constitute 33 percent and firm transportation (deliveries) constitute 14 percent of the total volume. Interruptible services (receipts) constitute 38 percent and firm services (receipts) constitute 15 percent of the total volume.[2]

[2]The volumetric data also reveal the discounting behavior. For the 1989-1994 period, Koch discounted 60 percent of the total firm and interruptible gas volume it transported. Koch discounted 79 percent of its firm (deliveries) volume and 74 percent of its firm (receipts) volume. Similarly, 57 percent of its interruptible (deliveries) and 50 percent of its interruptible (receipts) volumes were discounted. This data indicates that although Koch discounted 38

8.3.2 SLN Specific Data

Along with the transaction data, I obtained supplemental information from Koch for each SLN appearing in the transaction data. The population of SLNs for which this additional data are available excludes several categories of points on the Koch system. Excluded SLNs include: local delivery company (LDC) delivery points, SLNs locked on location, SLNs with meters removed, offsystem lateral SLNs, and SLNs flowing company-used gas. There are 1,588 SLNs represented in this analysis. A summary of this information is provided in table 8.6.

Using the Koch indicator known as Main Flow Designator Code (mfd), SLNs were classified into four primary groups for further analysis: industrials and power plants (deliveries), pipeline receipts, pipeline deliveries, and production fields (receipts). The total number of SLNs in each group is presented in table 8.7.

These four groups represent 96 percent of all delivery and receipt SLNs contained in the SLN data. There are certain SLNs which do not fall into one of these four categories. This remaining 4 percent of SLNs, labeled "Other" in the table, include delivery points at government facilities, receipt and delivery points at storage facilities, and receipt and delivery points at gas processing plants. This group of SLNs, which were not analyzed in this study, corresponds to 9 percent of the total firm and interruptible volumes on the Koch system during the period from 1989 to 1994.

8.3.3 Market Concentration Data

Koch prepared a data file containing Koch's diameter-squared flow capabilities (the cross-sectional area of the pipe) at the SLN and data on all "alternative" pipelines within a five mile radius of the SLN. This data is shown in table 8.8. Each record in this file corresponds to a single Koch SLN and contains information on as many as fifteen alternative pipelines passing within five miles of the SLN. Data for each alternative pipeline includes: its company code, its diameter-squared flow capabilities, its distance from the Koch SLN, and an estimated cost to connect the SLN to the alternative pipeline.

There are 1,448 SLNs in the "alternative" pipeline data set. This represents all SLNs present in the transaction data set described earlier, less those SLNs which are interconnection points between Koch and other pipelines. Koch did not conduct field surveys or compile data from digitized mapping systems for these interconnect SLNs. There were eighty-nine distinct pipelines appearing in the data set. The maximum number of alternative pipelines present at a single SLN is fifteen, the minimum is zero, and the average is just under five.

Using the diameter-squared flow capability data for all pipelines present within each SLN's five-mile radius, I calculate market shares for Koch and all

percent of its total firm and interruptible transactions, these transactions account for 60 percent of Koch's firm and interruptible transportation volume.

Table 8.6. SLN Data

Variable	Name	Description
sln	Station Location Number (SLN)	The number designation assigned by Koch to each point on the system for accounting or measurement purposes
state	State	The state in which the SLN is located
mfd	Main Flow Designator (MFD)	A code which represents the primary source/disposition of the gas flowing through the SLN
slncus	SLN Custody	A code which represents the primary customer at the SLN
field	Field Code	A code which represents the producing field, if applicable, from which the SLN is receiving gas
curta	Capacity Allocation Area Code	A code which represents an area on Koch's pipeline which is used in scheduling gas on Koch's system
slnfl	Delivery Point Type Code	A code that indicates whether Koch receives or delivers gas through the SLN: R = receipt, D = delivery
pmcf89	Peak Volume 1989	The largest volume which passed through the SLN on any day during the calendar year 1989 in MCF 14.73 psi
pmcf90	Peak Volume 1990	The largest volume which passed through the SLN on any day during the calendar year 1990 in MCF 14.73 psi
pmcf91	Peak Volume 1991	The largest volume which passed through the SLN on any day during the calendar year 1991 in MCF 14.73 psi
pmcf92	Peak Volume 1992	The largest volume which passed through the SLN on any day during the calendar year 1992 in MCF 14.73 psi
pmcf93	Peak Volume 1993	The largest volume which passed through the SLN on any day during the calendar year 1993 in MCF 14.73 psi
pmcf94	Peak Volume 1994	The largest volume which passed through the SLN on any day during the calendar year 1994 in MCF 14.73 psi

Table 8.7. Grouping of Koch's SLNs

Group	Description	Number of SLNs	Percent
1	Industrials/Power Plants	198	12
2	Pipeline Receipts	80	5
3	Pipeline Deliveries	60	4
4	Production Fields	1,183	75
	Other	67	4
Total		1,588	100

alternatives at each SLN. Additionally, I create a Hirschman-Herfindahl concentration index (HHI) for the area within a five-mile radius of the SLN as the sum of the squares of all market shares.[3] The HHI at each SLN is represented by the variable sln_hhi. Koch's market share at an SLN is represented by the explanatory variable ksln_shr.

Using the distance and connection cost data, variables are calculated measuring the average distance (avg_dis) and minimum distance (min_dis) from each SLN to an alternative pipeline and the minimum estimated cost to connect an SLN to an alternative pipeline. Similarly, the variable min_cos is set equal to the smallest estimated connection cost at each SLN.

Shipper-level market concentration measures are calculated using the same source data used to compile the SLN-level measures. Shippers on Koch include all non-pipeline and non-LDC shippers or customers served by Koch at any location on the Koch system. A single SLN on Koch's system might handle business for multiple shippers. In other words, multiple customers can flow gas through a single metering point. Multiple shipper-level market concentration measures are combined at a single point by calculating a weighted average shipper HHI. The gas volumes moved through the SLN by each shipper are used to calculate a weighting factor. The volumes of all shippers using the SLN constitutes this fraction's denominator. The numerator is created by an individual shipper's volume.[4]

The weighted flow capabilities for each alternative pipeline that could serve a shipper are then summed to arrive at total flow capabilities for the shipper's market. Market shares are calculated by dividing the total flow capabilities of

[3]For a review of the Hirschman-Herfindahl index of other measures of concentration, see Encaoua and Jaquemin (1980), Saving (1970), Ordover et al. (1982), Hause (1977), and Dansby and Willig (1979).

[4]Thus, to calculate the HHI for an individual shipper, first the group of relevant SLNs on the Koch system where a specific shipper moved gas is determined. Second, the flow capabilities of Koch and all pipelines within a five-mile radius of each of these SLNs is weighted by the ratio of the volume moved by the shipper through the SLN to that moved by the shipper at all points on Koch's system. Volume weights are calculated for the period January 1990 through December 1994.

Table 8.8. Alternative Pipeline Data Set

Variable	Description
sln	Koch station location number
koch_cap	Koch diameter-squared flow capability at SLN, in square inches
alt1...20	Code for alternative pipelines within 5 miles of SLN (maximum of 20)
dist1...20	Distance from SLN to alternative pipelines within 5 miles of SLN, in feet
cap1...20	Diameter-squared flow capability of alternative pipelines within 5 miles of SLN, in square inches
cost1...20	Cost to connect SLN to alternative pipelines, in dollars
avg_dis	Average distance from SLN to alternative pipelines, in feet
min_dis	Minimum distance from SLN to alternative pipelines, in feet
min_cos	Minimum cost to connect SLN to alternative pipelines, in dollars
num_alt	Total number of alternative pipelines within 5 miles of SLN
ksln_shr	Koch share of total flow capability within 5 miles of SLN
sln_hhi	Flow capability-based HHI for area within 5 miles of SLN

Variable	Obs	Mean	Min	Max
avg_dis	1,325	11,973	0	26,388
min_dis	1,325	5,326	0	26,388
min_cos	1,325	118,809	0	1,554,360
num_alt	1,448	4.95	0	15
koch_cap	1,448	429	4	3,284
ksln_shr	1,448	28.57	0.08	100
sln_hhi	1,448	4,486	1,012	10,000

each competing pipeline by the total flow capabilities of all pipelines within the shipper's market. Using these market shares, an HHI is calculated for each shipper. This weighted average HHI, calculated for each SLN, is represented by the explanatory variable shp_hhi.

8.3.4 Ancillary Data

To model large-scale trends in natural gas transportation demand and to control for changes in the derived demand for natural gas transportation services, I utilize macroeconomic and climatic data.

To capture the weather's effect on the demand for Koch's transportation services and on Koch's discounting behavior, a data series of monthly, statewide, heating degree days prepared by the National Climatic Data Center's (NCDC) staff is used.[5] This series covers the period from January 1989 through December 1994. Heating degree day values are calculated from a base temperature of sixty-five degrees Fahrenheit. State averages are obtained by weighting heating degree day figures recorded by individual NOAA divisional stations within the state by the corresponding state population percentage. Each record in the data file provided by NCDC includes year, month, state, and average heating degree days. The heating degree data explanatory variable is denoted heat_dd.

To measure variations in production levels across different customer classes and the consequent effect on the derived demand for natural gas transportation services, a series of Industrial Production Indices prepared by the U. S. Federal Reserve Board is used. These industry-wide monthly indices are prepared along Standard Industrial Classification (SIC) code groupings, with a base year of 1987. Data series for relevant industries are identified and extracted using a software package developed by the Interindustry Economic Research Fund. Monthly series are extracted for fifteen industrial classes for the period from 1989 through 1994. A combined factor, ip, is defined for each transaction according to the industry classification contained in the main flow designator code for each transaction.

To develop an average transportation rate on interstate pipelines, historical data from FERC Form 11 filings are used. The data are compiled from line sixteen, "Revenues From Transportation of Gas of Others (489)," of the Form 11 filings for the monthly period from 1989 through 1994. Revenues and volumes for companies operating in Koch's territory are summed across the interstate pipelines by month. An average transportation rate is then calculated and is denoted by tranpric.

Fuel oil No. 6 price is used to capture the effect on natural gas transportation demand caused by price variations in alternative fuels. The price for fuel oil No. 6 is identified by the explanatory variable roil6.

[5]The NCDC is a division of the National Oceanic and Atmospheric Administration (NOAA). The series I used is published by the NCDC as "Historical Climatology Series 5-1, Monthly State, Regional and National Heating Degree Days Weighted by Population."

To form real prices, the monthly producer price index (PPI) series, as reported by the Federal Reserve Board for the period 1989 through 1994, is used. This series is organized by year and month with 1987 as the base year. The producer price index is identified by the explanatory variable ppi_ieg. Koch's real transportation price, rkpric, is then created by dividing the effectively charged commodity rate (comdlp) on the transportation transaction by the producer price index. I similarly adjust all other prices in real terms.

In addition to the inflation-adjusted price variables, I create several other explanatory variables. Explanatory variables used in the logit discount models are summarized in table 8.9, while explanatory variables used in the regression demand models are summarized in table 8.10.

8.4 Koch's Historical Discounting Behavior

Koch's decision to charge a rate for its transportation services lower than the full tariff rate was, of course, governed by Koch. This decision was pursued by Koch when deemed to be in its economic interest or because it was an economic necessity.

It should be expected that economic agents purchasing Koch's services face a different economic regime when prices are discounted than when they are not. To test this difference in regimes, a discrete choice model for Koch's propensity to discount as a function of several market characteristics, including the HHI in these markets, is specified and estimated.[6] For example, it is expected that Koch is less likely to discount in markets where the HHI is high and where Koch's market concentration is large. Conversely, it is expected that Koch is more likely to discount its prices in markets where it faces many physically or economically close competitors. These hypotheses are empirically testable.[7] To measure Koch's propensity to discount, a logit model is utilized.

8.4.1 Results of the Logit Analysis

As discussed, the empirical analysis is separated into four categories: industrial and powerplant deliveries, receipts from interconnected pipelines, deliveries to interconnected pipelines, and receipts from fields. I discuss each of these in turn.

Industrials and Power Plants. The summary statistics used in the industrial and power plant discount logit model are presented in table 8.11. The logit model estimates for industrial and power plant deliveries (interruptible transportation) are presented in table 8.12. For these models, several alterna-

[6] The HHI regime approach has been explored by Daskin and Wolken (1989), Dalton and Penn (1976), and White (1976).

[7] Empirical tests of the HHI as a measure of competitiveness have been considered by other authors. See for example, Cohen and Sullivan (1983), Cowling and Waterson (1976), Jones,, Laudadio, and Percy (1973), McFertridge (1973), and Stigler (1964).

Table 8.9. Logit Model Variable Glossary

Variable Name	Description
avg_dis	Average distance to alternative pipelines from SLN
comddi	Commodity discount indicator; true if commodity rate is discounted from full tariff level
curt1	Dummy variable for SLN located in Curtailment Area 1
curt2	Dummy variable for SLN located in Curtailment Area 2
curt3	Dummy variable for SLN located in Curtailment Area 3
curt4	Dummy variable for SLN located in Curtailment Area 4
curt5	Dummy variable for SLN located in Curtailment Area 5
curt6	Dummy variable for SLN located in Curtailment Area 6
curt7	Dummy variable for SLN located in Curtailment Area 7
curt8	Dummy variable for SLN located in Curtailment Area 8
curt9	Dummy variable for SLN located in Curtailment Area 9
curt10	Dummy variable for SLN located in Curtailment Area 10
gathdi	Gathering discount indicator; true if gathering rate is discounted from full tariff level
heat_dd	Heating Degree Days
koch_100	Dummy variable; true if no alternative pipelines are within 5 miles of SLN
ksln_shr	Koch flow capability-based market share at an SLN
min_dis	Minimum distance to alternative pipelines from SLN
min_cos	Minimum cost to connect an alternative pipeline to SLN
num_alt	Number of alternative pipelines within 5 miles of SLN
constant	Constant term = 1
roil6	Real price of fuel oil No. 6
shp_hhi	Weighted-average capacity-based shipper-level HHI at SLN
sln_hhi	Flow capability-based HHI at SLN
state_al	Dummy variable for SLN located in Alabama
state_fl	Dummy variable for SLN located in Florida
state_la	Dummy variable for SLN located in Louisiana
state_ms	Dummy variable for SLN located in Mississippi
state_tx	Dummy variable for SLN located in Texas
tier	Koch rate schedule item corresponding to distance transported
trend	Continuous time-trend variable

Table 8.10. Regression Model Variable Glossary

Variable Name	Description
comddi	Commodity discount indicator; true if commodity rate is discounted from full tariff level
comdlp	Effectively charged rate on the transportation transaction
curt1	Dummy variable for SLN located in Curtailment Area 1
curt2	Dummy variable for SLN located in Curtailment Area 2
curt3	Dummy variable for SLN located in Curtailment Area 3
curt4	Dummy variable for SLN located in Curtailment Area 4
curt5	Dummy variable for SLN located in Curtailment Area 5
curt6	Dummy variable for SLN located in Curtailment Area 6
curt7	Dummy variable for SLN located in Curtailment Area 7
curt8	Dummy variable for SLN located in Curtailment Area 8
curt9	Dummy variable for SLN located in Curtailment Area 9
curt10	Dummy variable for SLN located in Curtailment Area 10
gathdi	Gathering discount indicator; true if gathering rate is discounted from full tariff level
gathrt	Gathering rate
ip_index	Industrial Production Index, matched to primary customer at SLN
mmbtu	Volume transported in mmbtu
constant	Constant term = 1
peakmcf	Annual peak-day volume (Mcf), matched to year of transaction
powrplnt	Dummy variable for SLN connected to an electric generating plant
ppi_ieg	Producer price index
roil6	Real price of fuel oil No. 6
rkpric	Real Koch transportation rate or price
rtrnpric	Real average interstate pipeline transportation rate
state_al	Dummy variable for SLN located in Alabama
state_fl	Dummy variable for SLN located in Florida
state_la	Dummy variable for SLN located in Louisiana
state_ms	Dummy variable for SLN located in Mississippi
state_tx	Dummy variable for SLN located in Texas
trend	Continuous time-trend variable

tive competitiveness measures are considered. The first two measures utilize the interaction of Koch's market share at an SLN with an HHI calculated for the market containing that SLN. Two HHI measures are considered, the first measured with respect to the shipper market (represented by shp_hhi) (table 8.12, model 1) and the second with respect to alternatives present at the SLN (represented by sln_hhi) (table 8.12, model 2). These interactions are denoted by the products (ksln_shr * shp_hhi) and (ksln_shr * sln_hhi), respectively.

Generally, I expected that in markets where the HHI is high and where Koch has a large market share, Koch will act less competitively. In these situations, all other factors held equal, I expect that Koch will be less likely to discount. The estimated results in table 8.12, models 1 and 2, prove this to be the case since the estimated coefficient on the market share HHI factor is negative.

Other competitiveness measures could plausibly explain Koch's propensity to discount. In table 8.12, model 3, Koch's market share (represented by ksln_shr) is negatively related to its discounting probability. Thus, as expected, an increase in Koch's market share at an SLN decreases the likelihood that it will discount. This type of market is less competitive than others where Koch has a lower market share. Similarly, in table 8.12, model 4, more available alternatives (represented by num_alt), equate to a higher probability that Koch will discount because Koch again faces more competition in this particular market situation. An indicator is also constructed for situations in which Koch controls 100 percent of an SLN level market. These are situations in which there are no alternative pipelines within a five-mile radius of an operating Koch SLN. Table 8.12, model 5 demonstrates that in these markets (indicated by the explanatory variable koch_100) Koch is less likely to discount its transportation services.

Similarly, in table 8.12, model 6, average distance to alternatives in the five-mile circle around the SLN is considered. This factor can only be examined when Koch faces some competition from alternative pipelines within the five-mile radius circle around an SLN. Therefore, the average distance factor is introduced into the logit model as the interaction of the koch_100 indicator when it is zero and the avg_dis factor. I find that as the average distance to a competitor increases, Koch's propensity to discount decreases. Similarly, when Koch possesses 100 percent of a specific SLN level market, Koch also shows a lessened propensity to discount. Therefore, as Koch's competitors become more distant in a physical or economic sense, Koch faces lower competition and is, therefore, less likely to discount.

Similarly, factors for minimum distance to a competitor (min_dis) and minimum cost to connect (min_cos) are considered. Table 8.12, models 7 and 8 produce qualitatively similar results.

Table 8.11. Logit Model Variables: Industrial and Powerplant Deliveries

Variable	Obs	Mean	Min	Max	Std. Dev.
comddi	9,727	0.33	0.00	1.00	0.47
constant	9,727	1.00	1.00	1.00	0.00
(ksln_shr*shp_hhi)	9,727	73,589	126	313,085	63,351
state_al	na	na	na	na	na
state_fl	9,727	0.10	0.00	1.00	0.30
state_la	9,727	0.52	0.00	1.00	0.30
state_ms	9,727	0.23	0.00	1.00	0.42
state_tx	9,727	0.07	0.00	1.00	0.26
roil6	9,727	0.0301	0.0213	0.0451	0.0052
heat_dd	9,727	155.45	0.00	853.00	192.85
tier	9,727	2.64	1.00	6.00	1.58
trend	9,727	92.39	89.25	94.92	1.62
Additional Variables					
koch_100	9,739	0.22	0.00	1.00	0.41
(!koch_100*avg_dis)	9,739	6,713	0	25,145	6,434
(!koch_100*min_dis)	9,739	3,475	0	25,145	5,482
(!koch_100*min_cos)	9,739	88,713	0	1,554,360	233,702
(ksln_shr*sln_hhi)	9,739	373,508	752	100,000	380,870
ksln_shr	9,739	50.47	0.08	100.00	35.82
num_alt	9,739	2.53	0.00	10.00	2.47

Table 8.12. Industrial and Powerplant Logit Models

Model 1: Probability of Discounting Industrial and Power Plant Deliveries Dependent Variable: comddi

Variable	Coefficient	t-Stat
constant	-3.32E+00	-1.990
(ksln_shr*shp_hhi)	-1.52E-06	-3.867
state_al	na	na
state_fl	1.92E-01	1.689
state_la	6.22E-01	6.425
state_ms	6.26E-01	0.631
state_tx	1.34E-01	1.080
roil6	-1.38E+01	-2.588
heat_dd	-5.00E-04	-4.119
tier	8.10E-02	5.631
trend	2.84E-02	1.688
Observations		9,727
% Correctly Predicted		67
% Discounted		33

Model 2: Probability of Discounting Industrial and Power Plant Deliveries Dependent Variable: comddi

Variable	Coefficient	t-Stat
constant	-2.02E+00	-1.206
(ksln_shr*sln_hhi)	-8.96E-07	-12.185
state_al	na	na
state_fl	-6.11E-02	-0.526
state_la	1.44E-01	1.387
state_ms	-2.19E-01	-2.125
state_tx	-3.08E-01	-2.373
roil6	-1.49E+01	-2.770
heat_dd	-5.15E-04	-4.213
tier	8.48E-02	5.864
trend	2.10E-02	1.237
Observations		9,739
% Correctly Predicted		67
% Discounted		33

Model 3: Probability of Discounting Industrial and Power Plant Deliveries Dependent Variable: comddi

Variable	Coefficient	t-Stat
constant	-3.07E+00	-1.838
ksln_shr	-4.22E-03	-5.813
state_al	na	na
state_fl	1.99E-01	1.759
state_la	5.22E-01	5.274
state_ms	2.32E-02	0.233
state_tx	3.21E-02	0.254
roil6	-1.41E+01	-2.653
heat_dd	-5.06E-04	-4.170
tier	8.34E-02	5.806
trend	2.76E-02	1.637
Observations		9,739
% Correctly Predicted		67
% Discounted		33

Model 4: Probability of Discounting Industrial and Power Plant Deliveries Dependent Variable: comddi

Variable	Coefficient	t-Stat
constant	-3.02E+00	-1.807
num_alt	1.04E-01	9.229
state_al	na	na
state_fl	1.74E-01	1.539
state_la	3.35E-01	3.292
state_ms	4.76E-02	0.485
state_tx	1.03E-02	0.083
roil6	-1.38E+01	-2.584
heat_dd	-4.91E-04	-4.033
tier	7.58E-02	5.247
trend	2.30E-02	1.359
Observations		9,739
% Correctly Predicted		66
% Discounted		33

Model 5: Probability of Discounting
Industrial and Power Plant Deliveries
Dependent Variable: comddi

Variable	Coefficient	t-Stat
constant	-1.75E+00	-1.040
koch_100	-1.12E+00	-14.794
state_al	na	na
state_fl	-6.21E-01	-4.823
state_la	-1.29E-01	-1.172
state_ms	-5.20E-01	-4.729
state_tx	-6.37E-01	-4.687
roil6	-1.48E+01	-2.737
heat_dd	-5.21E-04	-4.241
tier	8.99E-02	6.199
trend	1.98E-02	1.166
Observations		9,739
% Correctly Predicted		67
% Discounted		33

Model 6: Probability of Discounting
Industrial and Power Plant Deliveries
Dependent Variable: comddi

Variable	Coefficient	t-Stat
constant	-8.10E-01	-0.477
koch_100	-1.57E+00	-18.832
(!koch_100*avg_dis)	-5.87E-05	-12.326
state_al	na	na
state_fl	-9.92E-01	-7.424
state_la	3.95E-02	0.356
state_ms	-4.58E-01	-4.132
state_tx	-3.93E-01	-2.851
roil6	-1.47E+01	-2.713
heat_dd	-4.94E-04	-3.980
tier	8.71E-02	5.959
trend	1.40E-02	0.815
Observations		9,739
% Correctly Predicted		68
% Discounted		33

Model 7: Probability of Discounting
Industrial and Power Plant Deliveries
Dependent Variable: comddi

Variable	Coefficient	*t*-Stat
constant	-3.11E-01	-0.182
koch_100	-1.41E+00	-18.165
(!koch_100*min_dis)	-7.30E-05	-14.809
state_al	na	na
state_fl	-8.63E-01	-6.612
state_la	-8.32E-02	-0.757
state_ms	-4.65E-01	-4.222
state_tx	-4.16E-01	-3.028
roil6	-1.55E+01	-2.835
heat_dd	-4.71E-04	-3.785
tier	8.02E-02	5.450
trend	7.57E-03	0.439
Observations		9,739
% Correctly Predicted		67
% Discounted		33

Model 8: Probability of Discounting
Industrial and Power Plant Deliveries
Dependent Variable: comddi

Variable	Coefficient	*t*-Stat
constant	-6.90E-01	-0.407
koch_100	-1.26E+00	-16.359
(!koch_100*min_cos)	-1.23E-06	-10.013
state_al	na	na
state_fl	-7.44E-01	-5.739
state_la	-1.38E-01	-1.255
state_ms	-5.00E-01	-4.548
state_tx	-6.32E-01	-4.642
roil6	-1.55E+01	-2.850
heat_dd	-4.89E-04	-3.955
tier	8.14E-02	5.565
trend	1.02E-02	0.598
Observations		9,739
% Correctly Predicted		67
% Discounted		33

Several additional explanatory variables are included in the logit models to control for factors other than market concentration and competitiveness. For instance, as fuel oil No. 6 prices (represented by roil6) increased, Koch was less likely to discount its service. Here, we see that as the real cost of fuel oil increased, the demand for natural gas increased. This led to a concomitant increase in demand for transportation services. Faced with stronger underlying demand, Koch was less likely to discount its services.

Similarly, Koch was less likely to discount as the weather became more severe. Colder days (represented by increases in heat_dd) increased the demand for natural gas and, consequently, increased the demand for natural gas transportation. Again, faced with stronger demand, Koch was less likely to discount its services.

Additionally, the haul length (represented by tier) was a significant factor influencing the discounting decision. Higher tier values are associated with longer hauls by Koch. Koch, therefore, tended to provide lower prices to its customers when hauls were longer.

Trends over time (represented by trend) show that Koch was more likely to discount its transactions over time, all other factors held constant. Geographic differences in the propensity to discount are controlled by the state indicators state_al, state_fl, state_la, state_ms and state_tx. As a normalization the indicator for Alabama was excluded from the set of treatment indicators.

Pipeline Receipts and Deliveries. The summary statistics used in the logit models for pipeline receipts are presented in table 8.13, and the summary statistics for Pipeline deliveries are presented in table 8.14. The logit models are presented in table 8.15, models 1-2. Table 8.15, models 1 and 2 show the discounting probability for the upstream and downstream pipeline markets. Receipts and deliveries are considered separately in these tables.

The results obtained are similar to those for the power plant and industrials market. An increase in the real price of fuel oil No. 6 (represented by roil6) decreases the likelihood that Koch will discount its transportation services. An increase in heating degree days (represented by heat_dd) also decreases the discounting probability. An increase in discounting, over time, is evidenced by the positive trend coefficient. The tier factor shows that longer hauls (an increase in tier) resulted in greater discounting. The state indicators (represented by state_al, state_fl, state_la, state_ms and state_tx), control for geographic differences in the propensity to discount.[8]

Production Fields. The logit model developed for the discounting likelihood for field receipts is constructed in a fashion similar to that previously described for both power plants and industrials and pipelines. There are two exceptions.

[8]A competitiveness measure, such as the one used for the power plant and industrials market, was not used in these models as Koch did not collect survey-type data for pipeline interconnect points.

Table 8.13. Logit Model Variables: Pipeline Receipts

Variable	Obs	Mean	Min	Max	Std. Dev.
comddi	4,105	0.52	0.00	1.00	0.50
constant	4,105	1.00	1.00	1.00	0.00
state_al	na	na	na	na	na
state_fl	na	na	na	na	na
state_la	4,105	0.42	0.00	1.00	0.49
state_ms	na	na	na	na	na
state_tx	4,105	0.39	0.00	1.00	0.49
heat_dd	4,105	171.76	0.00	853.00	198.60
roil6	4,105	0.0298	0.0213	0.0451	0.0048
tier	4,105	2.92	1.00	6.00	1.64
trend	4,105	92.53	89.25	94.92	1.56

Table 8.14. Logit Model Variables: Pipeline Deliveries

Variable	Obs	Mean	Min	Max	Std. Dev.
comddi	4,220	0.45	0.00	1.00	0.50
constant	4,220	1.00	1.00	1.00	0.00
state_al	na	na	na	na	na
state_fl	na	na	na	na	na
state_la	4,220	0.67	0.00	1.00	0.47
state_ms	4,220	0.20	0.00	1.00	0.40
state_tx	4,220	0.13	0.00	1.00	0.33
heat_dd	4,220	192.81	0.00	827.00	200.21
roil6	4,220	0.0302	0.0213	0.0451	0.0051
tier	4,220	2.60	1.00	6.00	1.49
trend	4,220	92.38	89.25	94.92	1.63

First, rather than use state indicators, capacity allocation area indicators control for geographic effects. There are ten definable capacity allocation areas on the Koch system. These are identified with the indicators curt1 through curt10. Given that the model contains a constant term, the capacity allocation indicators measure the separate effect of each curtailment area relative to one baseline category, which in this analysis is curt10. Similar normalization with respect to the state indicators appears in the other logit models.

The second difference in this model is that the dependent variable is defined based upon whether either the commodity charge, comddi, or the gathering indicator, gathdi, reveals discounting. While this is not a logical concern in the other logit models, when considering receipts from fields, it is necessary to examine discounting if either the commodity rate component, comddi, or the gathering rate component, gathdi, reveals discounting. The dependent variable is therefore defined by (comddi | gathdi), indicating that discounting had occurred for either of these reasons.

Table 8.15. Pipeline Logit Models

Model 1: Probability of Discounting Pipeline Receipts Dependent Variable: comddi

Variable	Coefficient	t-Stat
constant	-6.44E+00	-2.596
state_al	na	na
state_fl	na	na
state_la	2.09E-01	2.359
state_ms	na	na
state_tx	3.24E-01	3.474
roil6	-1.76E+01	-2.202
heat_dd	-3.38E-04	-2.105
tier	-5.90E-04	-0.026
trend	7.47E-02	2.975
Observations		4,105
% Correctly Predicted		55
% Discounted		53

Model 2: Probability of Discounting Pipeline Deliveries Dependent Variable: comddi

Variable	Coefficient	t-Stat
constant	-1.65E+01	-5.834
state_al	na	na
state_fl	na	na
state_la	1.74E+00	1.607
state_ms	1.73E+00	1.600
state_tx	1.69E+00	1.558
roil6	-1.44E+01	-1.711
heat_dd	-9.17E-04	-5.595
tier	2.49E-01	11.163
trend	1.58E-01	5.989
Observations		4,220
% Correctly Predicted		61
% Discounted		45

The summary statistics used in the field level receipts logit model are presented in table 8.16. The logit analysis is presented in table 8.17. The results are again similar to those obtained in the previously discussed market segments.

The market share-HHI factor (identified by (kslnshr*shp_hhi)) is again negative and significant in this model. This demonstrates that as competitiveness declined in a production field area, as measured by the market share-HHI interaction, Koch was less likely to discount its price for transportation services. Conversely, as competitiveness increased in an area, Koch was more likely to discount its prices.

Table 8.16. Logit Model Variables: Production Field Receipts

Variable	Obs	Mean	Min	Max	Std. Dev.
(comddi|gathdi)	36,217	0.28	0.00	1.00	0.45
constant	36,217	1.00	1.00	1.00	0.00
(ksln_shr*shp_hhi)	36,217	34,463	34,463	331,300	43,523
curt1	36,217	0.04	0.00	1.00	0.19
curt2	36,217	0.02	0.00	1.00	0.13
curt3	na	na	na	na	na
curt5	36,217	0.05	0.00	1.00	0.22
curt6	na	na	na	na	na
curt7	36,217	0.15	0.00	1.00	0.36
curt8	36,217	0.44	0.00	1.00	0.50
curt9	36,217	0.09	0.00	1.00	0.29
curt10	na	na	na	na	na
roil6	36,217	0.0317	0.0213	0.0451	0.0059
heat_dd	36,217	154.30	0.00	1,358.00	194.93
tier	36,217	3.00	1.00	6.00	1.77
trend	36,217	91.59	89.25	94.92	1.60

8.4.2 Discussion

The analysis of Koch's historical discounting demonstrates that Koch faces competition in the markets in which it operates. In each of the market segments I analyze, I find that the more concentrated the market or the longer that Koch was in that market, the less likely Koch was to discount. Historically, over fifty percent of Koch's transportation volume has been discounted. Discounting is generally inconsistent with inelastic demand. If demand were generally inelastic, Koch would have had little incentive to discount its prices below the maximum tariff. With inelastic demand, a price decrease does not increase volume enough to increase total revenues. As long as variable costs are not negative, higher volumes increase total cost, so discounting can only decrease profits. In the next section I turn to the empirical determination of Koch's demand elasticity.

8.5 Koch's Historical Demand for Transportation Service

I construct regression models for industrial and power plant deliveries, pipeline receipts, pipeline deliveries, and field receipts. The summary statistics for the regression models for industrial and power plant deliveries are presented in

Table 8.17. Probability of Discounting Field Receipts–Dependent Variable: comddi | gathdi

Variable	Coefficient	t-Stat
constant	1.94E+00	2.111
(ksln_shr*shp_hhi)	-1.79E-06	-5.793
curt1	-4.09E-02	-0.505
curt2	na	na
curt3	3.26E-01	5.936
curt4	na	na
curt5	7.49E-01	10.856
curt6	na	na
curt7	3.12E-01	5.640
curt8	1.23E-01	2.453
curt9	3.45E-02	0.547
curt10	na	na
roil6	-4.22E+01	-16.106
heat_dd	6.45E-05	1.050
tier	5.59E-02	7.424
trend	-2.06E-02	-2.188
Observations		36,217
% Correctly Predicted		72
% Discounted		28

table 8.18; for pipeline receipts in table 8.20; for pipeline deliveries in table 8.22; and for production field receipts in table 8.24. The regression models for industrial and power plant deliveries are presented in table 8.19; for pipeline receipts in table 8.21; for pipeline deliveries in table 8.23; and for production field receipts in table 8.25.[9]

Table 8.19 presents the estimated regression model for industrial and power plant interruptible transportation deliveries. The dependent variable in this model is the demand for transportation services. Each observation in the regression analysis represents the demand for interruptible transportation by an industrial firm or a power plant at an SLN in a particular year and month. The estimated model shows that the price Koch charged for its interruptible transportation services is negatively related to the demand for its services.

[9]The four estimated probability models, (table 8.12, model 1; table 8.15, model 1; table 8.15, model 2; and table 8.17), are used to predict the probability that Koch would discount. These predicted probabilities are then used to estimate the selection correction term $E[v|i]$ described above. The selection correction terms, denoted by H, are included in each of the corresponding regression models.

The coefficient of the explanatory variable rkpric is used to calculate the mean elasticity.[10]

Natural gas volumes delivered to power plants (powrplnt), controlling for all other factors, were lower than volumes delivered to industrials. Discounted transactions (comddi) are found to result in higher demand. The real price of fuel oil No. 6 (roil6), and the real transportation cost (rtrnpric), measure the effect of substitution possibilities. I find that as alternative fuel prices or other transportation service prices increased, Koch's service became relatively more attractive and the demand for its services increased.

Transactions in which the industrial production index, ip_index, is greater leads to higher demand. Additionally, the trend in demand for Koch interruptible transportation services is decreasing (shown by the coefficient on trend). A variable is included (represented by peakmcf) for the annual peak-day volume at an SLN to capture absolute magnitude differences in volumes across SLNs. As should be expected, this variable has a positive and significant influence on demand. Finally, the model includes a constant term and state indicators to control for geographic differences.

The estimated mean elasticity for Koch's transportation service, with respect to the effective transportation price, is measured at -3.182 and is statistically significant. This result will be discussed further below.

The estimated models presented in tables 8.21 (pipeline receipts) and 8.23 (pipeline deliveries) are similar to table 8.19. The estimated mean elasticity for Koch's transportation service, with respect to the effective price of its transportation service, is measured at -1.119 for pipeline receipts and -2.860 for pipeline deliveries. Again, the estimated price elasticities are statistically significant.

The results presented in table 8.25 for the field receipts demand model are also similar to those for tables 8.19, 8.21, and 8.23. The estimated mean elasticity for Koch's transportation services, with respect to the effective price of its transportation service, is measured at -3.106. Again, the price effect is statistically significant. In other respects, the model in table 8.25 quantitatively produces similar results to those reported in tables 8.19, 8.21, and 8.23.[11]

[10] In constructing the econometric models, the very smallest transactions, which taken together account for only 0.25 percent of the interruptible volume, are not used. This exclusion rule is enforced in each of the product markets. Thus, 6,741 production field transactions, 768 pipeline receipt transactions, 807 pipeline delivery transactions, and 2,324 industrial and power plant transactions are excluded. Some observations are also left out due to missing data. Thus, an additional 148 production field transactions and 12 industrial and power plant transactions are excluded. Typically, these small quantity transactions represented accounting adjustments rather than actual volumes transported.

[11] The regression model for field receipts is specified in a manner similar to those for power plants/industrials and pipelines. There are three exceptions to this general statement. First, discounting is identified by either discounted commodity rates or gathering rates as indicated by the explanatory factors comddi and gathdi. This parallels the development in the logit model for field receipts. Second, the price variable is defined as the full cost of transportation services price for field receipts. This is achieved by summing the commodity rate and the gathering rate (comdlp+gathrt). This sum is then converted to real terms using the price

A selectivity correction variable is included in each regression model. This variable, which controls for the potential simultaneity of the discounting decision, is significant in the power plant/industrials model, insignificant in the pipeline receipts and delivery models, and insignificant in the field receipt model. The signs on the selectivity correction factor are identical across the models and indicate that, all other things being equal, Koch was more likely to discount when it expected demand to be below average. However, once the discount was offered, the customer had increased demand.

Table 8.18. Demand Regression Variables: Industrial and Power Plant Deliveries

Variable	Obs	Mean	Min	Max	Std. Dev.
mmbtu	9,727	92,820	2,532	2,442,250	170,846
rkpric	9,727	0.0019	0.0000	0.0053	0.0010
constant	9,727	1.00	1.00	1.00	0
powrplnt	9,727	0.20	0	1.00	0.40
comddi	9,727	0.33	0	1.00	0.47
state_al	na	na	na	na	na
state_fl	9,727	0.10	0	1.00	0.30
state_la	9,727	0.52	0	1.00	0.30
state_ms	9,727	0.23	0	1.00	0.42
state_tx	9,727	0.07	0	1.00	0.26
roil6	9,727	0.0034	0.0213	0.0451	0.0006
rtrnpric	9,727	0.0342	0.0225	0.0511	0.0006
ip_index	9,727	110.98	81.18	128.93	6.88
H	9,727	0.0003	-1.4067	2.8299	1.3404
trend	9,727	92.39	89.25	94.92	1.62
peakmcf	9,727	27,360	0	190,331	37,805

deflator ppi_ieg. The resulting variable appears in the first row of table 8.25. Third, the field level model employs capacity allocation indicators (curt1 through curt 10) as opposed to state indicators for geographic effects. Again, this corresponds to the development in the field logit model.

Table 8.19. Demand for Transportation: Industrial and Power Plant Deliveries–Dependent Variable: mmbtu

Variable	Coefficient	t-Stat
rkpric	-2.09E+07	-9.076
constant	1.17E+06	7.742
powrplnt	-3.46E+04	-5.819
comddi	1.74E+05	4.443
state_al	na	na
state_fl	9.06E+03	1.171
state_la	4.97E+03	0.579
state_ms	2.00E+04	3.175
state_tx	9.39E+03	1.179
roil6	1.13E+06	2.918
rtrnpric	9.48E+06	2.454
ip_index	1.28E+03	4.582
H	-4.46E+04	-3.216
trend	-1.47E+04	-8.434
peakmcf	2.00E+00	31.639
Observations		9,727
R-Squared		0.248
Mean Elasticity		-3.182
Mean of Dep. Variable		92,820

Table 8.20. Demand Regression Variables: Pipeline Receipts

Variable	Obs	Mean	Min	Max	Std. Dev.
mmbtu	4,105	1,638	6,004	5,511,720	359,422
rkpric	4,105	0.00164	0.00005	0.00520	0.00099
constant	4,105	1.00	1.00	1.00	0
comddi	4,105	0.53	0	1.00	0.50
state_al	na	na	na	na	na
state_fl	na	na	na	na	na
state_la	4,105	0.42	0	1.00	0.49
state_ms	na	na	na	na	na
state_tx	4,105	0.39	0	1.00	0.49
roil6	4,105	0.02984	0.02130	0.04506	0.00482
rtrnpric	4,105	0.00344	0.00225	0.00511	0.00056
ip_index	4,105	113.67	98.31	128.93	6.13
H	4,105	0	-1.75	1.91	1.38
trend	4,105	92.53	89.25	94.92	1.56
peakmcf	4,105	359,824	0	6,514,120	900,264

Table 8.21. Demand for Transportation: Pipeline Receipts–Dependent Variable: mmbtu

Variable	Coefficient	t-Stat
rkpric	-1.88E+07	-2.311
constant	3.92E+06	5.550
comddi	5.55E+05	1.610
state_al	na	na
state_fl	na	na
state_la	-2.28E+05	-9.305
state_ms	na	na
state_tx	-2.10E+05	-6.537
roil6	4.14E+06	2.143
rtrnpric	9.68E+07	6.688
ip_index	1.73E+03	1.439
H	-1.47E+05	-1.189
trend	-4.83E+04	-4.892
peakmcf	2.25E-02	3.601
Observations		4,105
R-Squared		0.100
Mean Elasticity		-1.119
Mean of Dep. Variable		194,438

Table 8.22. Demand Regression Variables: Pipeline Deliveries

Variable	Obs	Mean	Min	Max	Std. Dev.
mmbtu	4,220	180,495	5,516	5,708,170	362,799
rkpric	4,220	0.00158	0.00003	0.00516	0.00094
constant	4,220	1.00	1.00	1.00	0
comddi	4,220	0.45	0	1.00	0.50
state_al	na	na	na	na	na
state_fl	na	na	na	na	na
state_la	4,220	0.67	0	1.00	0.47
state_ms	na	na	na	na	na
state_tx	4,220	0.20	0	1.00	0.40
roil6	4,220	0.03022	0.02130	0.04506	0.00507
rtrnpric	4,220	0.00342	0.00225	0.00511	0.00057
ip_index	4,220	113.96	98.31	128.93	6.48
H	4,220	0	-2.19	2.99	1.37
trend	4,220	92.38	89.25	94.92	1.63
peakmcf	4,220	202,059	0	6,514,120	440,561

Table 8.23. Demand for Transportation: Pipeline Deliveries–Dependent Variable: mmbtu

Variable	Coefficient	t-Stat
rkpric	-4.89E+07	-5.483
constant	6.28E+06	11.050
comddi	1.46E+05	2.632
state_al	na	na
state_fl	na	na
state_la	6.06E+04	3.824
state_ms	2.46E+05	12.716
state_tx	na	na
roil6	1.69E+06	1.216
rtrnpric	1.10E+08	8.548
ip_index	1.94E+03	1.861
H	-2.10E+04	-0.992
trend	-7.40E+04	-11.156
peakmcf	3.74E-02	3.093
Observations		4,220
R-Squared		0.144
Mean Elasticity		-2.860
Mean of Dep. Variable		180,495

Table 8.24. Demand Regression Variables: Production Field Receipts

Variable	Obs	Mean	Min	Max	Std. Dev.
mmbtu	36,217	27,228	833	3,740,500	90,430
(comdlp+gathrt) /ppi_ieg	36,217	0.00221	0.00007	0.00533	0.01283
constant	36,217	1.00	1.00	1.00	0
comddi	36,217	0.25	0	1.00	0.43
gathdi	36,217	0.08	0	1.00	0.27
curt1	36,217	0.04	0	1.00	0.19
curt2	na	na	na	na	na
curt3	36,217	0.15	0	1.00	0.36
curt4	na	na	na	na	na
curt5	36,217	0.05	0	1.00	0.22
curt6	na	na	na	na	na
curt7	36,217	0.15	0	1.00	0.36
curt8	36,217	0.44	0	1.00	0.50
curt9	36,217	0.09	0	1.00	0.29
curt10	na	na	na	na	na
roil6	36,217	0.03	0.02	0.05	0.01
rtrnpric	36,217	0	0	0.01	0
ip_index	36,217	107.80	101.44	115.33	3.19
H	36,217	0	-1.53	3.14	1.31
trend	36,217	91.59	89.25	94.92	1.60
peakmcf	36,217	6,050	0	876,709	28,948

Table 8.25. Demand for Transportation: Field Receipts–Dependent Variable: mmbtu

Variable	Coefficient	t-Stat
((comdlp+gathrt)/ppi_ieg)	-5.28E+06	-13.263
constant	3.61E+05	9.652
comddi	4.21E+03	1.277
gathddi	7.70E+03	3.659
curt1	6.39E+03	2.316
curt2	na	na
curt3	1.50E+04	7.612
curt4	na	na
curt5	9.37E+04	35.953
curt6	na	na
curt7	-2.29E+03	-1.157
curt8	-9.26E+03	-5.269
curt9	-7.18E+03	-3.276
curt10	na	na
roil6	5.15E+04	0.494
rtrnpric	9.11E+05	0.929
ip_index	8.54E+02	3.653
H	-1.09E+03	-0.934
trend	-4.66E+03	-8.543
peakmcf	7.80E-01	49.365
Observations		36,217
R-Squared		0.177
Mean Elasticity		-3.106
Mean of Dep. Variable		27,228

8.6 Conclusions

Roughly one-third of all industrial and power plant transactions were historically discounted. We have learned from the logit analysis that observations which occur at discounted prices generally indicate the presence of competition. For those transactions which did not occur at discount, I am able to calculate the percentage of cases that the demand model determined were in the elastic portion of the demand curve. For the industrial and power plant market segment, I find that a substantial fraction of the transactions that did not occur at a discount are classified as elastic. In total, 90 percent of all transactions were either discounted historically or had elastic demand.[12]

Thus a substantial fraction of Koch's historical sales have occurred at discount (i.e., below tariff prices). As demonstrated in my analysis of Koch's discounting decision, Koch historically granted discounts for a variety of reasons including the extent and prevalence of competition. I show that whether competitiveness is measured by the presence of a competitor within five miles, the cost of connecting the next closest competitor, the number of competitors within five miles, or by a Herfindahl measure that reflects the fact that Koch does business with the same shipper at many points on its system, competition was a key factor in determining the likelihood that Koch would offer a discount. Even when Koch did not discount, it was often faced with elastic demand. Taken together, the picture that emerges is one of a workably competitive environment with a substantial fraction of the system either transacting at discount or in a range of price elasticity in which substantial, sustained price increases are unlikely.

Of course, it is not possible to conclude that Koch would never raise its prices at any point on its system or at any time absent regulation. However, the preponderance of the data for the interruptible segment of Koch's market indicates that competition will constrain Koch from systematically raising its prices. Moreover, in those instances in which Koch does attempt price increases, it is unlikely that they will be sustainable given that inelasticity on its system is frequently synonymous with peak-load demand.[13]

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[12] For Industrials and Power Plants, 90 percent of transactions or 74 percent of the volume was provided at discount or was provided at no discount but elastically demanded. For Production Fields, these percentages were 74 percent of transactions or 44 percent of volume. For Pipeline Receipts the percentages were 87 percent of transactions, or 77 percent of volume. And for Pipeline Deliveries, 68 percent of transactions, or 66 percent of volume.

[13] Koch's market is characterized by users who swing onto and off the system. These users, as opposed to being captive by Koch, apparently find readily available alternatives to using Koch's transportation system. The transactions that I have analyzed do not record the transactions of the swing customers when they swing off the system. In effect, these customers present zero demand to Koch. While I cannot calculate demand elasticity at zero quantities and while these zero quantity customers would receive no weight in a volumetric comparison, they nonetheless reveal very large elasticity of demand for Koch's services.