MARKET CHOICE, ENTRY REGULATION AND JOINT PRODUCTION

by

Wesley W. Wilson

UGPTI Staff Paper No. 81

September 1991

Market Choice, Entry Regulation,

and

Joint Production

by

Wesley W. Wilson*

September 1991

Department of Economics Working Paper Series

WP-115

and

Upper Great Plains Transportation Institute

Staff Paper No. 81

---

* Department of Economics, University of Oregon. The author benefitted from discussions with and comments from Kenneth L. Casavant, Frank Dooley, Gene C. Griffin, Lissa Takeyama Johnson, Steven Haynes, Larry Singell Jr., Joe A. Stone and participants of the Applied Microeconomics Workshop at the University of Oregon. Research assistance and financial support from the Upper Great Plains Transportation Institute is gratefully acknowledged. The paper was written while the author was visiting the Upper Great Plains Transportation Institute in the Summer of 1991.

Market Choice, Entry Regulation, and Joint Production

ABSTRACT

Firms can jointly serve multiple markets in a set and can serve one of several mutually exclusive sets. Firms choose the set and the particular markets of the set in which to produce. Entry regulation influences these decisions by restricting access to some but not all markets. Entry restrictions directly affect the regulated market but also spills over to other markets in the same and different sets of markets. Using a discrete choice model with market and firm attributes, I estimate market service decisions to evaluate the effects of Interstate Commerce Commission entry regulation and firm attributes on motor carrier decisions to serve particular markets.

TABLE OF CONTENTS

Page

LIST OF TABLES

Page

LIST OF FIGURES

INTRODUCTION

Firms operating in multiple markets commonly face regulation in at least one market or asymmetric regulations across markets. In such cases, regulations may have significant direct effects on the market regulated and may "spillover" into unintended markets.[1] Examples include firms operating in the local and long-distance telephone markets, the exempt and regulated truck markets, in the banking and saving and loan credit markets, etc. In this paper, I develop and estimate a model of firm capacity decisions under conditions of joint production that identifies both direct and spillover effects from entry regulation.

Two types of spillovers are examined. The first type is a direct consequence of entry restrictions on capacity serving multiple markets. Some firms have access to all markets, while other firms have access to only a subset of those markets. The degree of entry regulation together with market conditions establish the level of capacity, the utilization of capacity, and the "share" of capacity costs paid by each market in the set of markets served by the capacity. The second type examined involves firm decisions to provide capacity to different sets of markets. Firms can employ capacity in one of several sets of markets. Firms with access to all markets may choose to provide capacity to a different set of markets than firms with restricted access to markets.

Empirically, two specific regulation spillovers are examined. These spillovers include the degree to which entry regulation results in underutilized and displaced capacity. An empirical model with market and firm attributes (including regulatory

[1] See, for example, Tschirhart (1989) and Baseman (1981).

status) is developed to explain the markets firms serve.[2] The model allows both regulatory effects to be identified and separated from other firm attributes that explain market choices. This model is then estimated using a unique data set of motor carrier firms that jointly serve both regulated and non-regulated markets. The survey and econometric results together suggest that, even though the industry was significantly deregulated in 1980,[3] Interstate Commerce Commission entry regulation significantly influences not only the utilization of capacity but also the placement of capacity. In the context of this model, removal of the remaining restrictions would reduce industry costs and payments by users of the non-regulated markets.[4]

THEORY

In the model developed here, the provision of capacity to one market necessarily implies the provision of capacity to at least one other market. However, production in each market occurs only after incurring added costs termed access costs. For example, the costs a trucker incurs in traveling in round trips between locations A and B unloaded are capacity costs, while the costs associated with securing loads (e.g., search costs, pickup

---

[2] There are a wealth studies involving the discrete modelling of shipper (receiver) decisions to use alternative modes of transportation. For recent surveys see Winston (1983; 1985) and for a recent example see Inaba and Wallace (1989). Recent studies involving entry into markets have found that entry decisions are commonly made by diversifying firms in the industry. Studies by Berry (1987), Lane (1989), Shapiro and Khemani (1987) are examples.

[3] See Freas (1966) for a rationale of price and entry regulation in motor carrier markets, and see Mabley and Strack (1982) and Moore (1986) for concise and brief overviews of deregulation and its effects in the industry.

[4] Under appropriate conditions, competitive markets under joint production, will minimize industry costs with multiple output firms and provide lower prices than with single output firms. See also Baumol, Panzer, and Willig (1982).

and delivery costs, brokerage costs etc.) are access costs. The framework allows firms to serve only a subset of markets that all may be jointly served by the *same* unit of capacity. I begin with a model for the case where capacity potentially serves N markets when firms are identical (e.g., Felton (1981), Kahn (1971), Mohring (1976)).[5] Into this model, I introduce entry regulation where the regulatory authority requires a firm to have a license to access to a set of markets, and the license is given to only a subset of firms. The result allows the consequences of entry regulation to be evaluated when regulation applies to firms asymmetrically. The final case introduces alternative uses for capacity in the firm model. Capacity can jointly serve one of several mutually exclusive sets of markets. Firms choose the level of capacity and the particular set of markets where it is employed. Entry regulation and heterogeneity in costs across firms likely result in different capacity employment decisions, and forms the basis for the empirical model estimated.

Capacity Level and Market Participation

Let C(K) be the cost of providing K units of capacity to a set of N markets, and let $C(Q_1,...,Q_N;K)$ be the access costs associated with providing Q_i units of output to each of the N different demand systems in which the firm may employ the capacity. The capacity cost function is assumed to be increasing and convex in Q ($C'>0$, $C''>0$). Access costs are taken as constant and proportional to the level of capacity but dependent on the market

[5] These studies concern the distributional and efficiency of joint production in transport markets. Generally, these papers focus on the need or lack of need for regulation to prevent destructive competition in motor carriage. Two general results are that prices adjust to costs of providing the round trip. However, other research (e.g., Nicholson (1958) and Wilson (1987)) considers prices adjusting to marginal firms which is the firm that travels empty on one leg of the round trip.

served. Thus, for N markets, capacity costs can be written as $C(Q_1,...,Q_N;K)=\Sigma_i a_i Q_i=\Sigma_i a_i K$ if all N markets are served.

The particular markets served from the set of N markets depend on prices and access costs in each individual market. Specifically, for the firm to provide service to any given market, prices must exceed the costs of accessing that market. If access costs are prohibitive (i.e., $P_i<a_i k$) the firm will not serve that particular market. Define Ω as the set of N markets potentially served by capacity, and let Ω^* be a subset of Ω such that $P_i-a_i k\geq 0$. Total costs for the firm are given by $C = \Sigma_{i\in\Omega^*} a_i kK + C(K)$. The associated profit maximization problem and first order condition for profit maximization are given by:

(1) $$\underset{K}{\text{MAX}}\ \pi = \Sigma_{i\in\Omega^*}(P_i-a_i k)K - C(K); \text{ and}$$

(2) $$\partial\pi/\partial K = \Sigma_{i\in\Omega^*} (P_i - a_i k) - C_K \leq 0.$$

From equation (2), marginal revenue consists of the sum of prices received from all markets served by the firm's capacity; marginal cost of using K units of capacity consists of the marginal cost of providing capacity and the sum of access costs incurred in applying that capacity to the markets served. When equation (2) holds in the interior, the firm provides the market set with capacity, and the sum of prices compensates the firm for access costs and marginal capacity costs.

Given Ω^* remains constant, comparative statics follow directly from equation (2). Profit maximizing capacity is increasing in prices P_i, decreasing in access costs ($a_i k$), and factors negatively influencing C(K). However, the members of Ω^* may change with changes in these exogenous variables. As demand conditions improve or access costs decrease, markets that did not receive service may begin to be served. Conversely, as demand conditions deteriorate or access costs increase, markets that did receive service may no longer receive service.

In long-run equilibrium, there are two sets of markets: Those markets which receive service ($i \in \Omega^*$) and those that do not ($i \notin \Omega^*$). Equilibrium requires that markets clear. That is, $D_i(P_i) = MkK_i$ ($\forall\ i \in \Omega^*$) where M is the number of firms and $\{D_i(P_i) = 0$ ($\forall$ $i \notin \Omega^*$)$\}$. Equilibrium also requires that firms profit-maximize (equation 2 holds); and that no firms earn non-negative profits. This latter condition along with no entry restrictions implies a zero profit condition ($\Sigma_{i \in \Omega^*}(P_i - a_i k)K - C(K) = 0$).

Equilibrium follows the normal model of competitive equilibrium where $\Sigma_{i \in \Omega^*}(P_i - a_i k)$ takes the role of price. Equilibrium results in each of the M firms producing K^* units resulting in MK^* supplied at the market level. Given MK^* units of capacity, total industry revenue is given by $\Sigma P_i(MK^*)MK^*$ where $P_i(\bullet)$ is the inverse demand schedule for the ith market. Total industry cost is given by $\Sigma_i a_i MK^* + C(K^*)M$. Prices in each individual market are determined by the level of capacity (determined by the sum of all prices). As is noted by Miklius and DeLoach (1965), Kahn (1971), and others, there is no need for the price in any one market to compensate capacity costs. Rather, the vertical summation of individual inverse demand schedules (net of access costs in this model) together with the capacity supply schedule determine individual market prices. In the long-run, in the absence of entry restrictions, the individual markets "share" capacity costs (Kahn, Felton, and Miklius and DeLoach) and firms do not earn profits. However, with sufficient demand imbalances, prices in the low demand market may be bid to access costs (Nicholson and Felton). Prices in the high demand market then must compensate access costs and the capacity costs. In such cases, it is conceivable that some capacity is not utilized by the low demand market (Felton).

Capacity Level, Market Participation, and Entry Regulation

Entry regulation restricts the markets firms may serve, and regulation affects firms asymmetrically. In this model, some firms may employ capacity in all markets, while entry regulation restricts other firms from serving specific markets. For example, in a set of two markets sharing capacity, there may be two types of firms: Firms that serve only one market and are prohibited from serving the second market by regulation; and Firms that serve all markets.

Let R denote a "regulated" firm which has a license to operate in all markets it desires. Thus, the set of markets served by a regulated firm (Ω^R) is no different from the set of markets satisfying the market access condition (Ω^*). Let N denote a "non-regulated" firm which is limited in the markets it can serve. Therefore, the set of markets it chooses to serve is a subset of the regulated firms markets (i.e., $\Omega^N \subset \Omega^R = \Omega^*$). As before, equilibrium is characterized by a set of market clearing conditions. These include a market clearing condition for the non-regulated markets, $D_i(P_i) = M^R K^R k + M^N K^N k$ ($\forall\ i \in \Omega^N$) and for the regulated markets, $D_i(P_i) = M^R K^R k$ ($\forall\ i \in \Omega^R$ such that $i \notin \Omega^N$). The non-regulated markets receive service from both regulated (R) and non-regulated firms (N), while the regulated markets receive service from only the regulated firms. This equilibrium then has shared capacity, from the regulated firms, across two types of markets--those markets requiring licenses and those markets that do not require licenses.

Profit maximization conditions for each type of firm are given by

(3) $\partial\pi/\partial K^N = \Sigma_{i \in \Omega N} (P_i - a_i k) - C_K(K^N) = 0$

(4) $\partial\pi/\partial K^R = \Sigma_{i \in \Omega R} (P_i - a_i k) - C_K(K^R) = 0$

Since Ω^N is a subset of Ω^R and since $P_i - a_i k \geq 0$ for all i, $K^R \geq K^N$ with a strict inequality holding if $P_i - a_i k > 0$ for at least one i in the regulated markets (i.e., $i \in \Omega^R$, $i \notin \Omega^N$), firms with access to all markets (R-firms) are larger than firms not having a license to operate (N-firms). To complete the model, entry is taken as occurring only on the fringe--the non-regulated markets--and both entry and exit occur on the fringe without impediment. Together these restrictions result in the zero profit condition $\Sigma_{i\in\Omega N}(P_i\text{-}a_ik)K^*_N\text{-}C(K^*_N)=0$.

The equilibrium system developed here characterizes a case in which firms operating in the non-regulated sectors of the market are marginal firms. Prices adjust to the marginal firms,[6] and the firms operating in both the non-regulated sectors and the regulated sectors may earn profits or returns to authority as a result.

For notational convenience, let D^N represent the vertical summation of demand schedules served by the capacity of both regulated and non-regulated firms, and let D^R represent vertical summation of demand schedules served by only the regulated set of firms. Similarly, let S^N and S^R represent the supply of capacity serving the non-regulated and regulated markets, respectively. With these notational conveniences, Figure 1 represents an illustration of the model. In panels a and c are firm level models, corresponding to market models in panels b and d. Prices in the non-regulated markets (P^N-a^N) and the capacity supplied by non-regulated firms (K^N) are given from the zero profit condition (panel a). The resulting price establishes a "residual" demand confronting the regulated firms defined by D^N-K^NM^N (panel b). The vertical summation of residual demand and the set of regulated demands together with the supply of regulated firms establishes prices in the regulated markets (P^R-a^Rk) (panel c). The equilibrium condition establishes the number of non-regulated firms in the industry.

[6] Nicholson (1958) describes a case where prices adjust to the marginal firms, and Wilson (1987) provides some evidence that prices adjust to these marginal firms.

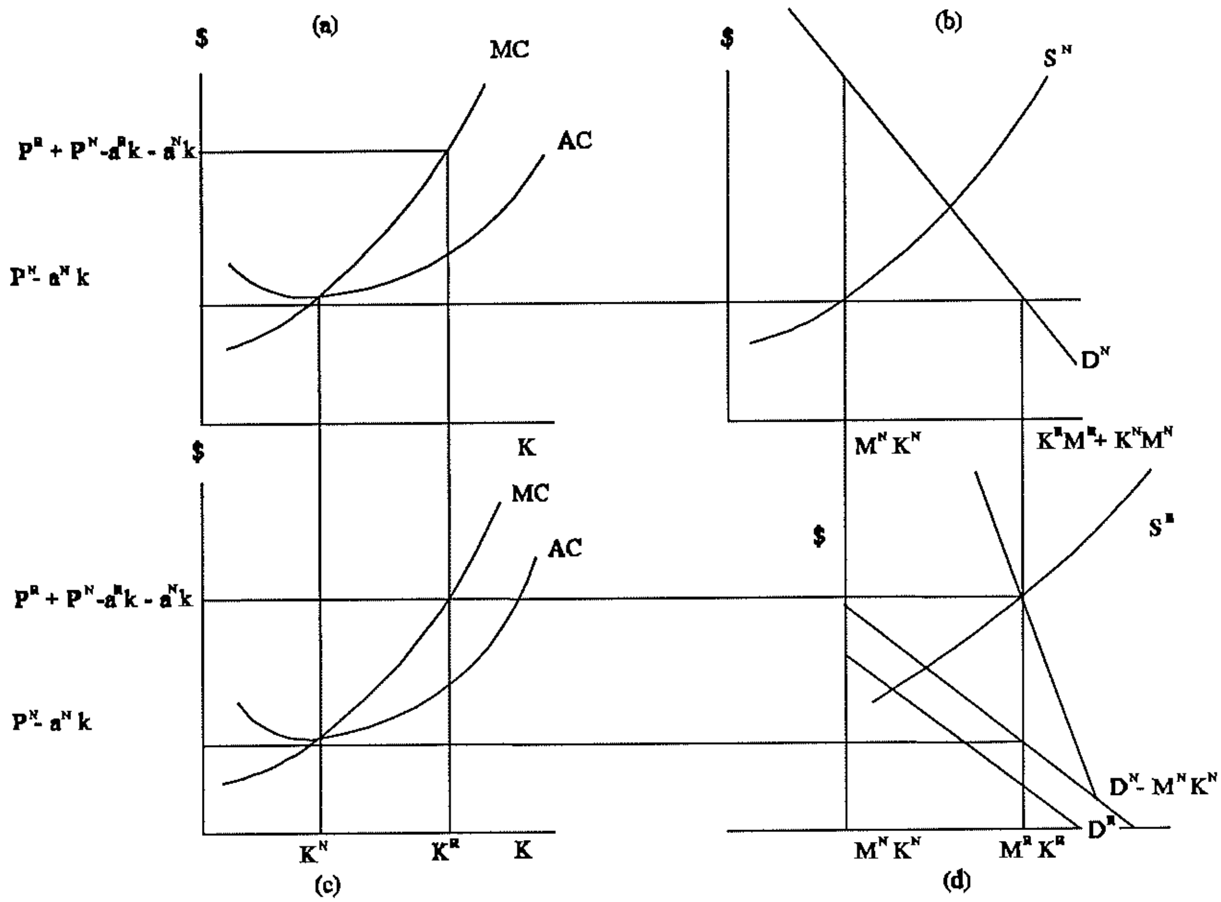


Figure 1 Equilibrium Under Joint Production and Entry Regulation

The primary concern of this paper are spillovers into non-regulated markets from entry regulation. More stringent entry regulation results in fewer firms in the regulated sector. In the short run (M^N fixed), prices in both the non-regulated and regulated sectors rise, profits to the remaining regulated firms increase as do profits to the non-regulated firms. Profits of the latter then induce entry at the margin (the non-regulated markets). Short-run effects of more stringent entry regulation results in higher prices in all markets, while in the long-run price effects are limited only to the regulated markets. Further, more stringent regulation results in capacity not being used that would otherwise be used in the absence of entry regulation, a result that applies both in the short run and in the long run. As the regulatory authority releases markets from regulation, there is greater demand compensating firms for capacity, and as a result, prices in a previous non-regulated market will fall (there is greater demand paying for capacity), and capacity is utilized to a greater degree by the non-regulated firms. At the limit of no regulation, all markets share capacity costs and capacity is fully utilized.

Capacity Alternatives and Market Decisions under Entry Regulation

The model generalizes to the case when firms can provide capacity to <u>different</u> sets of markets. Market service requires that returns from providing capacity to one set of markets must equal or exceed the returns from providing capacity to all other sets of markets. In the trucking example, the firm faces a variety of terminal markets (A to B, A to C, etc.). Associated with each market are different levels of return. From the menu of alternatives the trucker chooses to serve a market or markets (depending on the level of capacity $\bar{K}$ available).[7] The particular terminal market served depends on the level of returns in each market which in turn are influenced by entry regulation, demand conditions, and costs.

Let capacity potentially serve J (j=1,2,...,J) mutually exclusive sets of markets with N_j markets served in each set. Also, let Ω_j represent the subset of market in each set j such the $P_{ij}-a_{ij}k \geq 0$. Then the profit maximization problem of the firm is given by:

$$(5) \qquad \max_{K_1,\ldots,K_J} \pi = \Sigma_j \Sigma_i^{\Omega j} (P_{ij}-a_{ij}k)K_{ij} - C(\Sigma K_j) \quad \text{s.t. } \Sigma_j K_j \leq \bar{K}$$

with associated lagrangian and first order conditions then are

[7] The level of capacity available might be considered at a point in time, as the number of trucks available to make a trip. Alternatively, over some time interval the level of capacity might be considered as the number of trips available from the fleet of trucks.

(6) $\mathcal{L} = \Sigma_j \Sigma_i^{\Omega j}(P_{ij}-a_{ij}k)K_{ij} - C(\Sigma_j K_j) + \lambda(\bar{K}-\Sigma_j K_j)$; and

(7) $$\frac{\partial \mathcal{L}}{\partial K_j} = \Sigma_i^{\Omega j}(P_{ij}-a_{ij}k) - C'(\bullet) - \lambda \le 0 \qquad \forall j.$$

By inspection, the firm will choose the set of markets indexed by j by comparing marginal returns across market group alternatives (marginal returns across the J sets of markets). The firm will then choose the set of markets (j) that yields the highest returns. In this model, capacity can refer to the number of trips taken over some time interval, which if $C(\bullet)$ is increasing in K at a decreasing rate and if Ω^* is non-empty yields an interior solution. However, the model is also applicable to a point in time where capacity is fixed. The same hypotheses concerning firm choices can be drawn from the case where a firm with a unit of capacity is choosing how to utilize that capacity (e.g., a trucker choosing its next trip from a menu of alternative trip destinations).

Heterogeneity in regulatory status and access costs may and likely do result in different choices by firms, with the result that regulation may spill into unintended markets through individual firm choices. Consider first the asymmetry in choices made by regulated and non-regulated firms. Let returns associated with market set j be defined by $\pi^*(j)=\Sigma_i^{\Omega j}(P_{ij}-a_{ij}k)\bar{K} - C(\bar{K})$. The particular market chosen (j) by the firm is $\{j\,|\,\pi^*(j)=\text{Max}\{\pi^*(1),\ldots,\pi^*(J)\}\}$. Returns in each market set (m) can be decomposed into regulated (R) and non-regulated (N) market subsets as $\pi^*(m) = \pi^{R*}(m) + \pi^{N*}(m)$ making potential asymmetries in decisions obvious. A regulated firm has access to each subset of the market set, while a non-regulated firm has access only to the market subset (N). It is clear the choice of markets need not be symmetric across regulated and non-regulated firms. In the trucking example, low non-regulated rates to one market may be compensated by high backhaul rates in the backhaul market. However, only the regulated firms serve that market. In contrast, markets without much backhaul potential tend to receive service from non-regulated truckers, as the regulated truckers are bid from the low backhaul market to higher backhaul markets.

Asymmetries in decisions may also emanate from heterogeneity across firms in access costs. If access cost differentials between low (L) and high cost (H) firms are constant across markets ($a_{ij}(L)$-$a_{ij}(H)$=t for all ij) then the market choices are the same for low (L) and high (H) access cost firms. However, if the cost differential changes with the market sets (J) then again the set of markets served varies across firms.

Two central results from these models are that entry regulation results in underutilized capacity and may result in capacity displacement. Each of these effects enter through firms' decisions to access specific markets and to jointly serve subsets of markets. From the above, these decisions may differ across firms because of entry regulation or because of other firm attributes giving rise to different access costs. Delineating the source (regulated or not-regulated) of different market decisions and assessing the significance and magnitude of each source is the purpose of the empirical application described below.

DATA

The data employed have several features that allow an examination of firm decisions under conditions of entry regulation and joint production. These data apply to motor carrier firms that travel in round trips to various terminal markets. On outgoing legs (the fronthaul), firms haul agricultural commodities which are exempt from Interstate Commerce Commission (ICC) entry regulation. On return legs (the backhaul), firms generally haul commodities subject to ICC entry regulation or they travel empty.[8] To access markets subject to entry regulation, firms must have operating authority from the ICC or must "lease" the authority. In the data, only about 39 percent of firms observed have operating authority. Further, as discussed below, the survey and econometric results together with discussions with motor carriers support the contention that the lack of authority restricts access to backhaul markets even though the industry was significantly deregulated in 1980. The data employed here, therefore, apply directly to firm decisions under conditions of joint production and entry regulation allowing a unique and excellent opportunity to examine spillover effects of entry regulation impacts firm decisions.

The firms haul grain from North Dakota to terminal markets including Duluth and Minneapolis, Minnesota, the Pacific Northwest, and local (ND) markets. These data were drawn from a mail survey, consisting of two mailings, follow up telephone calls to non-respondents, and personal and telephone interviews conducted from August of 1987 through October of 1988. In total, there were 108 usable surveys out of 449 estimated possible respondents representing a response rate of about 24 percent.[9] Firms were asked to provide responses to questions comprising revenue, cost, and backhaul information as well as firm characteristics including years in business, size, whether they

---

[8] In rare cases, truckers may be able to access a small set of commodities exempt from ICC jurisdiction on the return leg.

[9] Two lists of possible grain truckers were obtained from the Upper Great Plains Transportation Institute and from the North Dakota Motor Vehicle Department. The former list included a historical record of truckers that provide grain transportation services. The latter included all truckers licensed to travel in North Dakota. Truckers were asked to return the survey if in fact they do not serve North Dakota grain elevators. Details are provided in Dooley, Bertram, and Wilson (1989).

have operating authority, and destinations of service and level of activity in backhaul markets.[10]

Most of the truckers live in the same community or a community near the grain elevator they service. Virtually without exception, they provide service to those elevators on a regular basis indicating a commitment to round trips. Since grain is exempt from regulation and since most of the freight imported to agricultural areas is subject to regulation, one leg of the round trip is non-regulated and the other leg is likely subject to regulation.

In accessing fronthaul markets, truckers usually use direct search methods (77% of truckers call local elevators for loads), and to a lesser extent, use brokers (21%).[11] In contrast, access to backhauls is more indirect with firms using brokers (51%), trip lease arrangements (40%), or have an in-house broker (16%). It is, however, noteworthy that regulated truckers tend to use the indirect methods of search in backhaul markets to a far greater degree than do non-regulated truckers. Specifically, 64% of regulated and 42% of non-regulated truckers use brokers; 50% of regulated and 33% of non-regulated truckers trip lease; and 33% of regulated and 5% of non-regulated truckers use an in-house broker.

Truckers often choose not to operate in the backhaul markets. The truckers cite the lack of operating authority, the search time required, low rates, and high broker commissions as reasons for inactivity. In the context of the models presented earlier, these reasons represent the notion that either access costs may be too high or prices too low. In addition, the effect of operating authority is constraining with 61 percent of non-

---

[10] The data are fully described in Dooley, Bertram, and Wilson (1988; 1989).

[11] Other methods include the elevator calling the trucker (36%), commission company calls (12%), trucker calls the commission company (25%), broker calls the trucker (9%), and trucker calls the broker (21%).

regulated carriers reporting the lack of authority discouraged them from accessing backhaul markets (the most frequent response). In contrast, only two truckers with authority reported the lack of authority discouraged them from accessing backhaul markets. Thus, despite a widespread belief that partial deregulation of the trucking industry has resulted in open entry, these data suggest that entry restrictions are still constraining and prevalent.

Firm summary statistics (Table 1) indicate that regulated firms are more experienced and larger than are non-regulated ("exempt") truckers. Further, regulated truckers tend to frequent different terminal markets than do non-regulated truckers. Generally, all truckers tend to serve the local and Minneapolis markets. However, exempt truckers specialize to a greater extent in local markets than do regulated truckers. Regulated truckers tend to travel, on a percentage basis, to longer hauled markets. On a trip basis, 36,521 trips were made in the sample. Of these trips, exempt truckers made 20,805 (57%), while regulated truckers made 15,716 (43%) of the trips. Of the trips made by exempt truckers, almost 60 percent were local trips. In comparison, only about 30 percent of trips made by regulated truckers were local. Greater percentages of trips taken to Minneapolis and the Pacific Northwest markets represent the bulk of the differences. In general, Minneapolis is considered a high backhaul market relative to Duluth, while the Pacific Northwest markets are substantially longer-hauled markets and local markets are very short-hauled markets.

In accessing backhaul markets, there are dramatic differences across firm types. On a firm basis (controlling for trips) regulated truckers are considerably more likely to access backhaul markets. On average, regulated truckers are loaded 72 percent of the time on trips taken, while non-regulated carriers are only loaded about 46 percent of the

Table 1 Summary Statistics

Variable[a]	Exempt		Regulated		All	
Years in Business	12.8		14.9		13.7	
Size (# of Tractors)	1.6		3.5		2.4	
Size (Trips)	315		374		338	
Size (Miles Traveled)	129,204		323,672		204,832	
% of Trips to Duluth	14		11		12	
% of Trips to Minneapolis	36		36		36	
% of Trips to PNW	11		31		19	
% of Local (ND)	40		22		32	
Market Trips to:[b]	#	%	#	%	#	%
Duluth	2,169	10	1,227	8	3,396	9
Minneapolis	5,316	26	5,911	38	11,227	31
Pacific Northwest	1,069	5	3,716	24	4,785	13
Local-North Dakota	12,251	59	4,862	30	17,113	47
Total	20,805	100	15,716	100	36,521	100
Proportion of Loaded Return Trips:						
Firm Proportion[c]	%	#	%	#	%	#
Duluth	16	34	38	21	24	55
Minneapolis	60	61	83	38	69	99
Pacific Northwest	95	16	95	23	95	39
Local-North Dakota	11	54	40	20	19	74
All Markets	46	66	72	42	57	108

Table 1 Summary Statistics

Market Proportion[c]	Trips	%	Trips	%	Trips	%
Duluth	259	36	460	64	719	100
Minneapolis	3,367	41	4,918	59	8,285	100
Pacific Northwest	1,061	22	3,664	78	4,725	100
Local-North Dakota	666	27	1,785	73	2,451	100
All Markets	5,353	33	10,827	67	16,180	100

[a] There were 66 non-regulated and 42 regulated truckers included.

[b] The market trip total are sample totals.

[c] The firm proportions are sample averages of the proportion of return trips loaded by firm from each terminal market. The averages are conditioned on the firm traveling to the destination. The number observed for each market is in the column marked #.

time on trips taken. The differences across markets are also quite dramatic except for the longer hauls to the Pacific Northwest markets (Table 1). There are also differences across markets in the likelihood of a backhaul. In traveling to long-haul markets, truckers are uniformly loaded on the return trip (almost without exception). However, in short-haul (local) markets, truckers are loaded only about 19 percent of the time. Of most interest are the differences across markets of approximately the same length of haul. Minneapolis and Duluth are, on average, about 400 miles from the origin of the fronthaul. From Minneapolis, truckers return loaded about 69 percent of the time, while from Duluth truckers return loaded only about 24 percent of the time.

EMPIRICAL MODEL AND PROCEDURES

A trucker provides capacity (a trip) to a terminal market if returns are non-negative and dominate returns from other terminal markets. Further, a trucker will access only those markets in the round trip for which revenues at least compensate access costs (e.g., search, brokerage payments, additional running costs). Let C be the choice set where each element (c) represents fronthaul and backhaul access decisions. Let V_c be the returns associated with a round trip under alternative c.

Returns consist of both deterministic and random components. Let $V_c=\pi_c+\varepsilon_c$ where π_c and ε_c represent the deterministic and random components, respectively. These returns include the cost of providing capacity (a round trip) to market, access costs in the fronthaul market, and access costs in the backhaul market.[12] The cost of providing capacity to a set of markets is taken as a function (log or linear) of distance (D_c) is shared across both legs of the round trip (γD_c). Access costs are as taken a function of observed firm characteristics (X) with parameters that vary across alternatives (β_c).

The random component of returns across markets may arise from several sources. First, there may be unobserved attributes which generate choices. For example, in the data there are five terminal markets and two legs to each terminal market. In formulating the model I assume the trucker is able to choose the particular market yielding the highest returns. However, it is plausible that the trucker provides service on demand as long as the market access condition is satisfied. In such cases it may well be the trucker is not servicing the highest return market. Alternatively, they are serving the

[12] I assume firms (given all else is equal) face the same set of prices. Some limited information on prices was available in the data. No significant differences between fronthaul and backhaul prices per-mile, or between the prices received by regulated and exempt truckers was found.

highest return market, but trips to all locations are not available. While these are plausible, the survey results do suggest that truckers call elevators for loads 80 percent of the time, suggesting they do shop for the "right" load. Second, there may be unobserved elements that generate access and capacity costs that are unrelated to the observed firm attributes and distances. For example, in making a terminal market decision, truckers may try to set up a backhaul before a fronthaul load is accepted. On any particular search, the trucker may get a particularly favorable draw (low search costs) that result in the trip being taken. Alternatively, the trucker may not get a good draw in that market, yet receive a good draw in another market and choose the latter. I assume these errors are independent and identically distributed with the type I extreme-value distribution.[13]

The model estimated is a multinomial choice model with individual (firm) effects. Let δ_c take a value of one if the cth alternative is chosen, and a value of zero otherwise. The probability a particular terminal market

and associated fronthaul-backhaul realization is

$$(8) \qquad Prb(\delta_c=1) = Prb\ \{\pi_c + \varepsilon_c \geq \max_{\substack{k\in C \\ k\neq c}}(\pi_k + \varepsilon_k)\},$$

$$= \frac{e^{\gamma D_c + \beta_c^t X}}{\sum_{k\in C} e^{\gamma D_k + \beta_k^t X}}.$$

Estimation of equation (8) proceeds under maximum likelihood. Observed in the data are the total number of trips taken by the ith firm (T_i), the proportion of trips taken to each terminal market (t_{mi}), and the proportion of backhaul trips from each terminal market

[13] See Madalla (1986), Ben-Akiva and Lerman (1985) for discussion of this distribution.

that are loaded (b_{mi}). There are four possible terminal markets (Duluth, Minneapolis, Pacific Northwest, and locally), and there are two possible outcomes of the trip--the trucker may be loaded on both legs of a round trip to the terminal market or the trucker may be loaded on only the fronthaul. In terms of the conceptual model then there are 8 possible outcomes. The choice set was trimmed to exclude the Pacific Northwest-no backhaul because only a few trips were observed.[14]

The log likelihood function is given by

(9) $\mathfrak{L} = K + \Sigma_{j=1}^{N}\Sigma_{i=1}^{C} T_{ji}\log [P_j(i)],$

where $P_j(i)$ is given by equation (8), K is a sum of constants, j indexes the observation, and i indexes the choice ($i \in C$).

The specific variables employed to explain market choices include distance (representing capacity costs), which varies across terminal markets, and a set of firm attributes which do not vary across markets. Firm attributes include whether a firm has operating authority, size of firm, experience, and location. If firms do not have operating authority, they must search for a commodity that is not subject to regulation, incur brokerage costs, etc. All imply higher returns to carriers with authority. Size of firm has been included in previous papers concerning access to backhaul markets (e.g., Beilock and Kilmer). Larger firms are more likely to have broadly defined authorities and sales and dispatching services to facilitate securing and handling regulated freight.[15] To account for experience, I also include the number of years the trucker has been in business. The

---

[14] Only one trucker reported any activity in this branch of the choice set. That trucker was removed from the data set.

[15] See Beilock and Kilmer (1986) and Taff (1979).

inclusion of this may pick up "familiarity with markets".[16] Finally, I include a set of alternative specific dummy and trucker location dummy variables. The alternative specific dummy variables pick up any omitted variables that vary across choices. The location dummy variables are defined for four regions in North Dakota (the northeast, central east, the southeast and the west). These variables pick up general demand conditions on the fronthaul and the backhaul.

In estimating the conditional logit with individual effects, there is the normal occurrence that individual effects fall out of the model. To uncover these effects, I normalize the individual effects parameters (those that vary across individuals but not across market alternatives) with respect to the most common choice--the North Dakota no-backhaul market. All other coefficients then are relative to this alternative.

EMPIRICAL RESULTS

Initial estimation results based on a linear specification of market set returns (π_c) yielded mixed results.[17] The inclusion of an interaction between size and years removed the mixed results in these early specifications.[18] The final empirical results are provided

---

[16] Beilock and Kilmer used a locational dummy variable to pick up market familiarity, but in these data truckers are almost always located at the origin of the fronthaul. Wilson (1987) used the number of years a firm has been in business to capture the tendency of truckers to get operating authority and to pick up familiarity.

[17] A variety of specifications were examined. These specifications included different explanatory variables, different measurements of explanatory variables, various sub-sets of observations, estimation techniques (Berkson minimum chi-square) etc. The mixed results primarily centered on signs contrary to expectations on the years in business variable.

[18] The interaction likely picks up the influence of unobserved variables that result in lower access costs in backhaul markets (e.g., managerial talent). Lower access costs likely produces larger firms through time. Consistent with this hypothesis is the observation of equally sized firms with differing experience in the sample, where the younger firm has

in Table 2. In terms of overall predictive ability, the correlation between the predicted and observed proportions is quite high (ρ=.73). At a branch level (i.e., for a particular choice), the proportions are more mixed but still quite high ranging from .39 to .73. Finally, all of the coefficient estimates are significant at the five percent level and consistent with *a priori* expectations. Two central empirical observations can be drawn from Table 2. First, participation in specific market set, consisting of a fronthaul and a backhaul, is not random. Rather, participation of firms in markets depends critically on market and firm attributes. Second, entry regulation has significant effects on market choices. In all markets, ICC authority has a positive and significant influence on the probability that a firm is on a backhaul branch, and a negative and significant influence on the probability that a firm is on a no-backhaul branch of the choice set. The result, as demonstrated below, is consistent with the notion that entry regulation results in underutilized capacity.

Distance, a proxy for capacity costs, is the sole market attribute observed. As expected, when distance (capacity costs) increase firms are less likely to serve the market, and the effect varies across markets. Overall, the average effect of an increase of 100 miles on the likelihood of being on a particular branch (e.g., Duluth/BH) is -4.2 percentage points, ranging from -8 percentage points for ND/No-BH to -1 percentage points in the MPLS/No-BH.

Firm attributes consist of years, size, and whether the firm has operating authority from the ICC. Years and size are determinants of access costs. Most of these variables have positive and significant coefficients suggesting that more experienced and larger firms are more likely to serve backhaul markets rather than the ND/No-BH market pair.

---

greater participation in the backhaul markets.

Table 2 Coefficient Estimates

Variable	Market	Access	Estimate[a]	Standard Error
Distance	All	All	-0.0049	0.0000
Constant	Duluth	BH	-6.3841	0.3820
	Duluth	No-BH	-2.4183	0.1520
	MPLS	BH	-1.3209	0.0763
	MPLS	No-BH	-1.5904	0.0946
	PNW	BH	1.2373	0.1529
	ND	BH	-3.7999	0.1012
ICC	Duluth	BH	1.1686	0.0868
	Duluth	No-BH	-0.5368	0.0591
	MPLS	BH	0.7950	0.0357
	MPLS	No-BH	-0.2188	0.0510
	PNW	BH	0.8652	0.0531
	ND	BH	1.8733	0.0554
Years	Duluth	BH	0.0813	0.0054
	Duluth	No-BH	-0.0084	0.0040
	MPLS	BH	0.0346	0.0030
	MPLS	No-BH	0.0212	0.0043
	PNW	BH	0.0576	0.0054
	ND	BH	0.0470	0.0045
Size	Duluth	BH	0.7001	0.0388
	Duluth	No-BH	0.3666	0.0285
	MPLS	BH	0.8162	0.0196
	MPLS	No-BH	0.7797	0.0245
	PNW	BH	1.2079	0.0238
	ND	BH	0.6992	0.0283
Size * Year	Duluth	BH	-0.0217	0.0016
	Duluth	No-BH	-0.0033	0.0011
	MPLS	BH	-0.0190	0.0008

Table 2 Coefficient Estimates

Variable	Market	Access	Estimate[a]	Standard Error
	MPLS	No-BH	-0.0182	0.0012
	PNW	BH	-0.0320	0.0012
	ND	BH	-0.0219	0.0013
Summary Statistics				
Chi-Square	(K=57) = 51,583			
Corr (p, $\hat{p}$) = .73				
Mean Trips = 338				
Mean p = .14				
Duluth-BH	Corr (p, $\hat{p}$) = .41			
Duluth-No BH	Corr (p, $\hat{p}$) = .64			
MPLS-BH	Corr (p, $\hat{p}$) = .54			
MPLS-No BH	Corr (p, $\hat{p}$) = .49			
PNW-BH	Corr (p, $\hat{p}$) = .72			
ND-BH	Corr (p, $\hat{p}$) = .39			
ND-No BH	Corr (p, $\hat{p}$) = .72			

[a] All coefficients are significant at the 5 percent level. Only some of the regional dummy variables were not significant at the 5 percent level.

Further, inspection of the results suggest that these coefficients vary substantially acrossmarket pair branches. The marginal effects again vary across markets. For market i, the marginal effect of a firm specific variable is $P_i\{(1-P_i)\beta_i-\Sigma_k P_k\beta_k)\}$. For years, the average marginal effect ranges from -0.5 percentage points in the ND/No-BH branch to 0.22 percentage points in the PNW/BH and MPLS/BH branches. While the average effects are somewhat small, they are positive for all but the Duluth/No-BH and the

ND/No-BH branches. Thus, younger firms are more likely to serve either local or medium distance markets without much potential for backhaul loads. In contrast, more experienced firms tend to serve either interstate or local markets with profitable backhaul prospects. For size of firm, the effects are more dramatic. The average marginal effect of size ranges from -12.3 percentage points in the ND/No-BH branch to 5.2 percentage points in the MPLS/BH branch. Again, in the ND/No-BH and Duluth/No-BH branches the effects the average marginal effects are negative. Again, in the backhaul branches or the longer-hauled markets, the effects are positive. Thus, smaller firms tend to serve local and/or medium distant markets without much potential for profitable backhaul loads, while larger firms tend to serve markets with more potential for profitable backhaul loads and, in particular, the MPLS/BH market pair.

EVALUATION OF REGULATORY SPILLOVERS

The spillover effects of entry regulation on capacity utilization and on market choices of firms are of primary interest. The coefficients on the ICC dummy variables suggest that firms with ICC authority are more likely to serve BH branches in the choice set than to serve the ND/No-BH branch. Further, the coefficients are different across market pairs suggesting the influence of entry regulation varies across markets.

To assess the magnitude of the effects of entry regulation into market choices, I use a counterfactual approach. Branch probabilities were calculated first under the assumption that the *observed* firm has ICC operating authority and second under the assumption that the *observed* firm did not have ICC operating authority. These probabilities were calculated at the *observed* values for size, experience, distance, and regional dummies for the firm isolating the direct effects of entry regulation.

The results are given in Table 3. Three main differences result. First, the branch probabilities are quite different across exempt and regulated dimensions suggesting that entry regulation affects market choices. Specifically, firms *equal in all respects* except regulatory status differ in market choices. The differences are in the direction expected--exempt firms tend to serve local markets and no-backhaul branches--regulated firms tend to serve backhaul branches and interstate markets. Second, entry regulation directly influences capacity utilization. The conditional backhaul probabilities all indicate greater access to backhaul markets to firms with ICC operating authority. Further, there are very dramatic differences across markets. Finally, not only does entry regulation result in underutilized capacity, it also displaces capacity. Firms with access to regulated backhaul markets are more likely to go to markets with considerable regulated backhaul traffic (MPLS) and less likely to go to markets without much potential of profitable backhaul market access (Duluth).

To assess the effects of firm attributes and spillovers across the range of data (rather than simply mean values), probability schedules were plotted against continuous variables (Figures 2, 3, and 4). In all Figures, the probability schedules were evaluated at mean values of the continuous variables and a weighted average of the probabilities for each region was used (weighted by the number of trips from each region).

The probability of a backhaul represents capacity utilization. Both the marginal probability of a backhaul (the probability of being on one of the four backhaul branches) and the conditional probability of a backhaul (conditional on the terminal market choice), are given in Figures 2 and 3, respectively. In all cases, regulated firms tend to access backhaul markets more often than non-regulated firms. There are also dramatic

Table 3 Summary of Empirical Results

Branch Probabilities

Market	Access	Observed	Exempt	Regulated
Duluth	BH	0.02	0.01	0.03
Duluth	No-BH	0.07	0.10	0.05
MPLS	BH	0.23	0.19	0.28
MPLS	No-BH	0.08	0.11	0.06
PNW	BH	0.13	0.12	0.14
ND	BH	0.07	0.03	0.13
ND	No-BH	0.40	0.44	0.32

Conditional Backhaul Probabilities

Market	Observed	Exempt	Regulated
Duluth	.22	.09	.67
MPLS	.74	.63	.82
PNW	NA	NA	NA
Local-ND	.15	.07	.29

Terminal Market Probabilities

Market	Observed	Exempt	Regulated
Duluth	.09	.11	.08
MPLS	.31	.29	.34
PNW	.13	.12	.14
Local-ND	.47	.47	.45

differences between firms owing to experience and size, and the probability schedules do differ significantly across markets. In Figure 2, the marginal probability of a backhaul is quite different for regulated firms than for non-regulated firms across the experience dimension, and appear to be more closely related across the size dimension. The conditional probability schedules suggest that in all backhaul markets, regulated firms tend to be loaded more often on backhaul, than non-regulated firms. Further, there are dramatic differences in the conditional schedules across markets. Namely, Duluth and local terminal markets, as expected, tend to be low backhaul markets relative to Minneapolis. In general, these results suggest quite significant differences in capacity utilization across markets by regulated and non-regulated dimensions, by the level of backhaul traffic, and by firm attributes.

Marginal "terminal market" probabilities are used to summarize the second type of entry regulation spillover. Provided in Figure 4 are these marginal probability schedules (the probability of going to Duluth, Minneapolis, etc.). These results suggest generally there are dramatic differences across both regulatory status and firm attributes in the terminal market choices. Specifically, in all cases non-regulated firms tend to serve the local markets at least when firm attributes suggest they are high access cost firms. However, as firms become more experienced or larger (lower access costs) they tend to tradeoff the local markets for high backhaul markets, in particular Minneapolis.

Figure II.--Marginal Backhaul Probability Schedules.

a. Experience b. Size

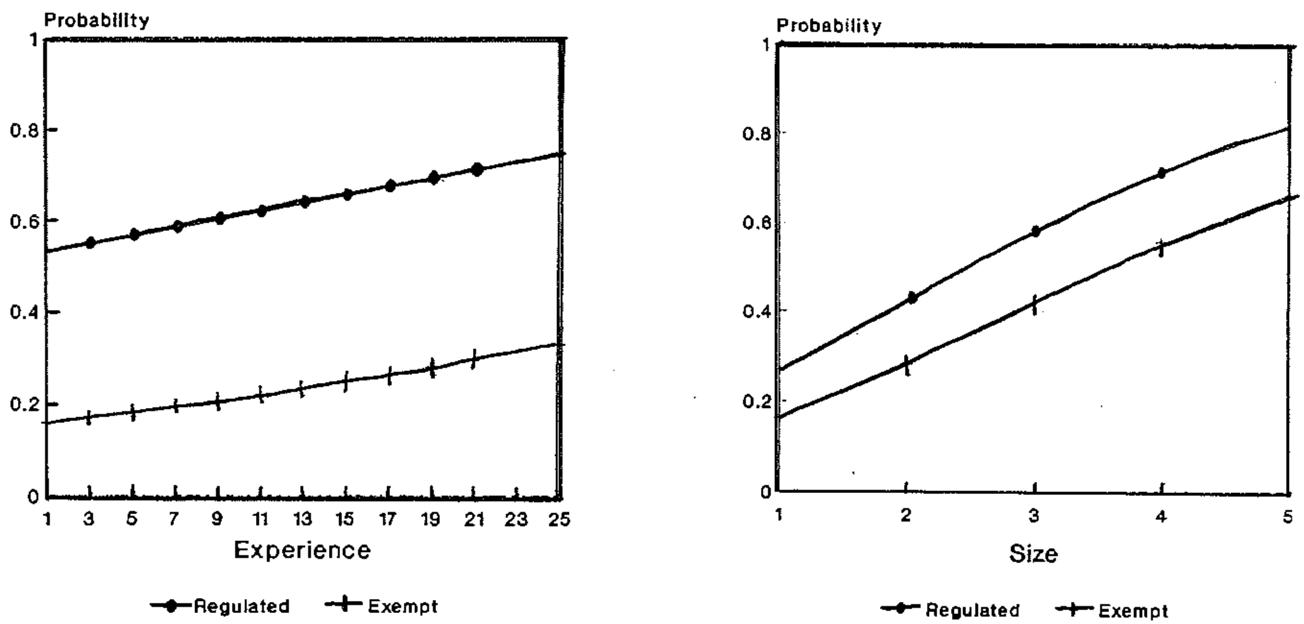


Figure III.--Conditional Backhaul Probability Schedules.

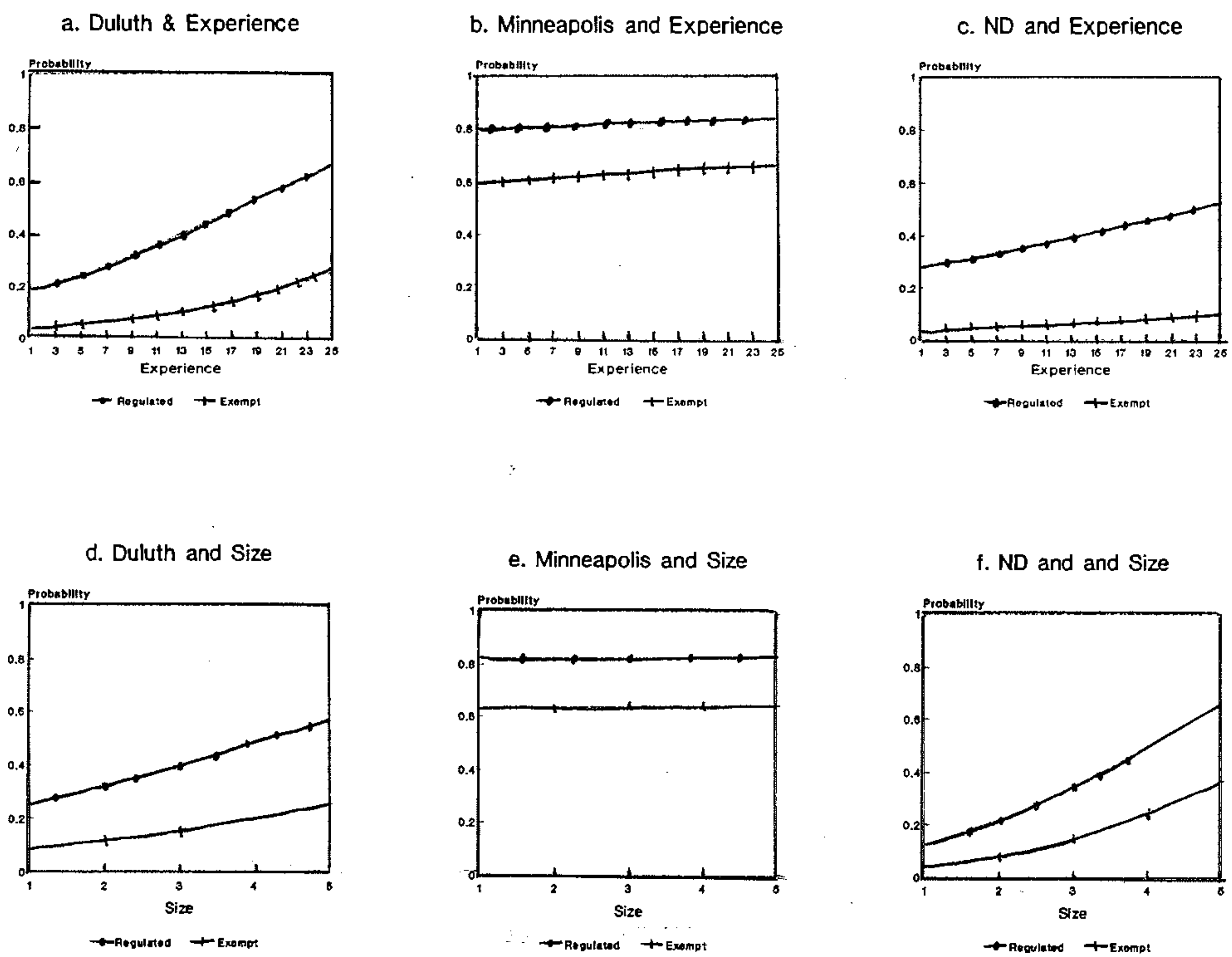
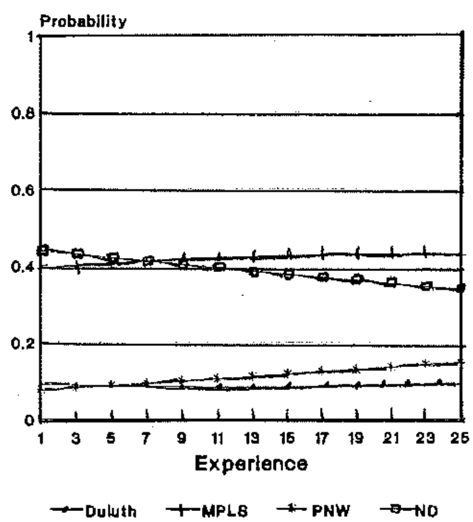
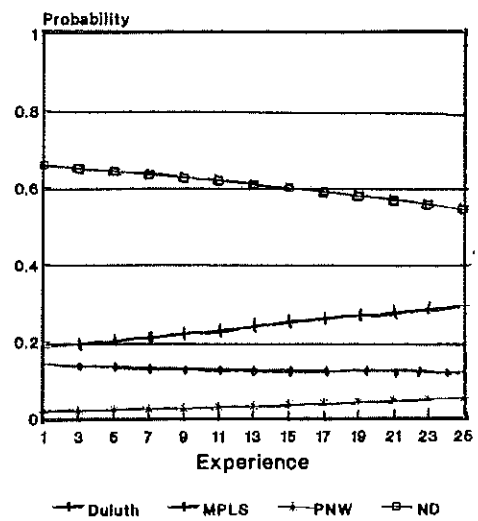


Figure IV.--Terminal Market Probability Schedules.

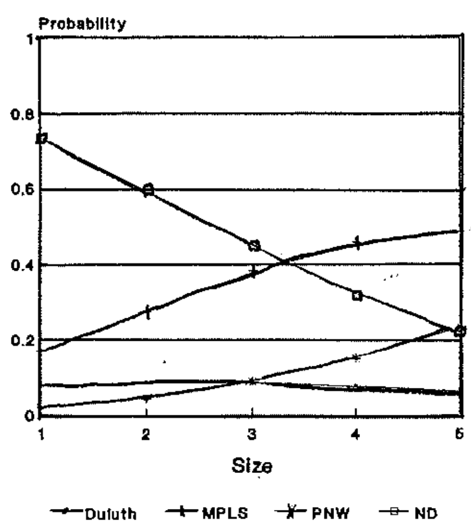
a. Regulated Truckers and Experience



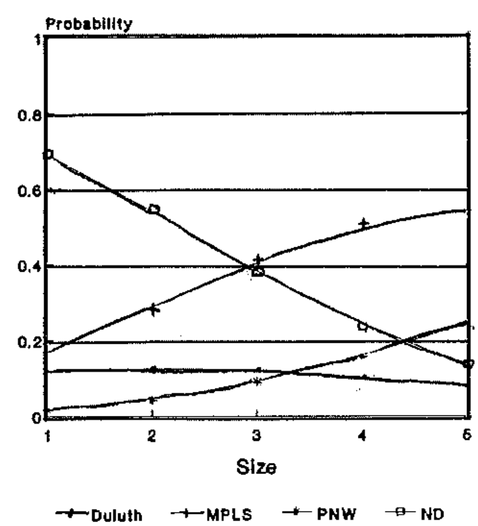
b. Exempt Truckers and Experience



c. Regulated Truckers and Size



d. Exempt Truckers and Size



CONCLUDING COMMENTS

This paper develops and provides estimates of a model of firm behavior under conditions of joint production and entry regulation. Theoretically, spillovers of entry regulation are potentially important, both for non-regulated markets and for firm decisions to serve markets. Empirical estimates of the model for truck markets, where firms typically haul exempt from regulation commodities on one leg of a round trip and search for various (generally regulated) commodities on the other leg of a round trip, indicate that entry regulation significantly influences capacity utilization and market choices of firms. Generally, young and inexperienced firms without ICC operating authority tend to access local markets and markets without much potential for return movements. Large and experienced firms with ICC operating authority tend to access markets with more potential for backhaul traffic and are much more successful in accessing markets on the backhaul. These results suggest that the effects of entry regulation in truck markets still impacts truck markets despite partial deregulation in 1980 and that those effects may impact not only the intended markets but may also spillover into unintended markets.

REFERENCES

Basememann, R. C., A. F. Daughety, and F. S. Inaba, "Complementarity in Production and Empty Backhaul in Transportation," Transportation Center, Northwestern University Working Paper 601-15-77, 1977.

Baseman, Kenneth C., "Open Entry and Cross-Subsidization in Regulated Markets," in *Studies in Public Regulation*, ed. Gary Fromm, (Cambridge, Mass: MIT Press, 1981), pp. 329-360.

Baumol, William J., John C. Panzer, and Robert D. Willig, *Contestable Markets and the Theory of Industry Structure* (New York: Harcourt Brace Jovanovich, Inc., 1982).

Beilock, Richard and Richard L. Kilmer, "The Determinants of Full-Empty Truck Movements," *American Journal of Agricultural Economics*, Vol. 68, (February, 1986), No. 1, pp. 67-76.

Beilock, Richard and James Freeman, "Into the Fold: Post-Reform Involvement of Produce Haulers in Regulated Carriage," paper presented at the 1990 Transportation Research Board meetings.

Ben-Akiva, Moshe and Steven R. Lerman, *Discrete Choice Analysis* (Cambridge: The MIT Press, 1985).

Berry, Steven, "Estimation of a Model of Entry in the Airline Industry," Yale University Working Paper.

Dooley, Frank J., Leslie M. Bertram, and Wesley W. Wilson, "Operating Costs and Characteristics of North Dakota Grain Trucking Firms," UGPTI Report No. 67, Upper Great Plains Transportation Institute, North Dakota State University, Fargo, 1988.

Dooley, Frank J., Leslie M. Bertram, and Wesley W. Wilson, "Backhaul Opportunities for North Dakota Grain Truckers," UGPTI Report No. 69, Upper Great Plains Transportation Institute, North Dakota State University, Fargo, 1989.

Felton, John Richard, "Impact of ICC Rate Regulation upon Truck Back Hauls," *Journal of Transport Economics and Policy*, Vol. 15, (September, 1981), No. 3, pp. 253-267.

Freas, Howard, "Rate Regulation Today," *I.C.C. Practitioner's Journal*, Vol. 33, (June, 1966), No.9, pp. 777-782.

Inaba, Fred S. and Nancy E. Wallace, "Spatial Price Competition and the Demand for Freight Transportation," *Review of Economics and Statistics*, Vol. 71 (November, 1989), No. 4, pp. 615-625.

Kahn, Alfred E., *The Economics of Regulation* (New York: John Wiley & Sons, Inc., 1970).

Lane, Sara J., "Entry and Industry Evolution: The ATM Manufacturer's Market," School of Management Working Paper Series, Boston University, December 1989.

Mabley, R. and W. Strack, "Deregulation-A Green Light for Trucking Efficiency," *Regulation* Vol. 56, (July/August, 1982), pp. 36-42.

Madalla, G. S., *Limited-Dependent and Qualitative Variables in Econometrics* (New York: Cambridge University Press, 1983).

Miklius, W. and D. B. DeLoach, "A Further Case for Unregulated Truck Transportation," *Journal of Farm Economics*, Vol. 47, (1965) No., pp. 933-947.

Mohring, Herbert, *Transportation Economics* (Cambridge: Ballinger Publishing Company, 1976).

Moore, Thomas Gale, "Rail and Trucking Deregulation," in *Regulatory Reform: What Actually Happened* eds. L. W. Weiss and M. W. Klass (Boston: Little Brown, 1986).

Nicholson, Howard W., "Motor Carrier Costs and Minimum Rate Regulation," *Quarterly Journal of Economics*, Vol. 72, (February, 1958), No. 1, pp. 139-152.

Pederson, Larry E., R. C. Mittelhammer, and Kenneth L. Casavant, "Factors Affecting Interstate Backhauling of Exempt Agricultural Commodities by Regulated Motor Carriers: A First Look," *Transportation Journal*, Vol. 18, (Summer, 1979), No. 4, pp. 46-52.

Shapiro, Daniel and R. S. Khemani, "The Determinants of Entry and Exit Reconsidered," *The International Journal Of Industrial Organization*, Vol. 5, No. 1, pp. 15-26.

Taff, Charles A., "A Study of Truck Brokers of Agricultural Commodities Exempt from Economic Regulation," *Transportation Journal*, Vol(, 1979) No. 3, pp. 5-15.

Tschirhart, John, "Partial Regulation of Natural Monopoly," in *The Political Economy of Governmental Regulation*, ed. Jason F. Shogren (Kluwer Academic Publishers: Boston, 1989), pp. 55-81.

Wilson, Wesley W., "Transport Markets and Firm Behavior," *Journal of the Transportation Research Forum*, Vol. 28, (1987), No. 1, pp. 325-333.

Winston, Clifford, "The Demand for Freight Transportation Models and Applications," *Transportation Research*, Vol. 17, (November, 1983), pp. 419-427.

Winston, Clifford, "Conceptual Developments in the Economics of Transportation: An Interpretive Survey," *Journal of Economic Literature*, Vol. 23, (March, 1985), No. 1, pp. 57-94.