RAND Journal of Economics
Vol. 32, No. 2, Summer 2001
pp. 369–386

Contractual form and market thickness in trucking

Thomas N. Hubbard*

A central proposition of the transaction costs literature is that firms will substitute more complicated contractual arrangements for simple spot arrangements when transactions involve relationship-specific investments. I investigate this proposition by testing whether simple spot arrangements are less common when local trucking markets are thin. I find that doubling the thickness of the market increases the likelihood that simple spot arrangements govern transactions by about 30% for long hauls. I find weaker evidence of relationships between local market thickness and contractual form for short hauls—hauls for which quasi-rents are particularly small. Contracts protect quasi-rents over a surprisingly large range, but they play a less important role as quasi-rents decrease.

1. Introduction

■ An important insight of Klein, Crawford, and Alchian (1978) and Williamson (1979, 1985) is that mediating trade with simple spot arrangements can be costly when transactions involve relationship-specific investments. Firms' ability to appropriate the returns from specific investments depends on decisions made by their trading partners, and simple spot arrangements provide no formal incentives to motivate efficient decision making after such investments are made. This insight leads to a central proposition: firms should substitute more complicated contractual arrangements for simple spot arrangements when transactions involve relationship-specific investments.

Early empirical studies found supporting evidence in several procurement contexts, including auto parts (Monteverde and Teece, 1982), aerospace components (Masten, 1984), natural gas (Masten and Crocker, 1985), and coal (Joskow, 1985, 1987). These articles have similar research strategies. The authors collected data on contractual form and measures of asset specificity in contexts where assets are large and sunk over long horizons. For example, in Joskow's work, the relevant assets are coal mines and power plants. The authors show that simple spot arrangements are used less relative to other organizational arrangements (either long-term contracts or vertical integration, depending on the study) when assets are more relationship-specific.

I extend this literature by examining a context where assets are smaller and relationship-specific over shorter horizons. Most transactions involve investments with some degree of relation-

---

* University of Chicago and NBER; thomas.hubbard@gsb.uchicago.edu.

This article was previously part of "Governance in the Deregulated Trucking Industry." I would like to thank Alya Hidayatallah for excellent research assistance and comments, and Judy Chevalier, Michael Crum, Benjamin Klein, Julie Mortimer, Editor Rob Porter, two anonymous referees, various seminar participants, and many individuals at trucking firms and associations for helpful comments. I gratefully acknowledge support from NSF grant no. SES-9975413.

Copyright © 2001, RAND.

ship-specificity, but few involve investments that are as large and relationship-specific as those examined in most of the existing empirical literature.[1] Specificity instead arises for more mundane reasons such as search or transportation costs, or temporal mismatches between supply and demand (Masten, Meehan, and Snyder, 1991). Quasi-rents arise in search (Diamond, 1971) and switching-cost (Klemperer, 1987) models in much the same way as in Klein, Crawford, and Alchian and Williamson, in that agents' actions transform competitive situations to monopolistic or monopsonistic ones.

How large and long lasting must quasi-rents be for firms to address appropriation concerns with formal contracts? When does reputation suffice? When do contracts address appropriation problems associated with specific investments, and when do they exist primarily for other purposes?

I investigate these issues in the context of trucking. Trucking is an interesting context for such an investigation because assets are rarely specific to users over long horizons. Using data from over 30,000 trucks from the Census's 1992 Truck Inventory and Use Survey, I investigate whether the probability that firms mediate trade with simple spot arrangements increases with the thickness of the local trucking market. I find evidence that it does, particularly for long hauls. Doubling the thickness of the market increases the likelihood that simple spot arrangements govern transactions by about 30% for long hauls. There is only weak evidence of such relationships for short hauls. The results suggest that when long-haul markets are thin, firms use formal contracts to address appropriation problems associated with finding backhauls—inbound hauls that complement outbound hauls. There is less evidence that firms use contracts to address appropriation problems associated with trucks' short-run time and space specificity to users. Reputation may mitigate appropriation problems when quasi-rents are small and only appear in the very short run.

My results reinforce and extend the existing literature in several ways. First, the proposition that simple spot arrangements should be used less when transactions involve relationship-specific investments holds well beyond the contexts studied in the early empirical literature. This expands upon Pirrong (1993), who shows that spot contracting is more prevalent for commodities for which shipping markets tend to be thick. My evidence is stronger than Pirrong's, because trucking markets are generally thicker than the thickest ocean shipping markets. Second, the results suggest an empirical limit to this proposition: there is little evidence that differences in the composition of local markets explain differences in contractual form when markets are as thick as those in local trucking. Third, to my knowledge, this article is the first to quantify relationships between market thickness and contractual form.

Several other recent articles have investigated organizational issues in the context of trucking. Baker and Hubbard (2000a), Nickerson and Silverman (1996), and Lafontaine (2000) investigate contractual relationships between firms and drivers. The former does so by testing how the diffusion of monitoring devices—on-board computers—has affected whether drivers own trucks. Baker and Hubbard (2000b) examine how on-board computer diffusion has affected whether shippers use private or for-hire fleets to haul goods. Drawing from Hubbard's (2000) study of on-board computer adoption, we show that information's incentive- and resource-allocation-improving capabilities affect firms' boundaries differently. This article differs from my other work because it investigates the use of different contractual forms rather than firms' boundaries, and because it does not focus on on-board computers.

The rest of the article is organized as follows. Section 2 characterizes the organizational forms used in trucking, describes how appropriable quasi-rents arise, and develops the hypotheses to be tested. Section 3 presents the data, proposes measures of local market conditions, and depicts general relationships between contractual form and these measures. Section 4 contains the estimation results, discusses the hypothesis tests, and investigates alternative hypotheses. Section 5 concludes.

[1] Pirrong (1993) is an exception; see below. See also Palay (1984) for specificity and governance in rail shipping.

© RAND 2001.

2. Organizational form and asset specificity in trucking

■ Shippers and carriers make a series of long-, medium-, and short-run decisions that determine output and the terms of trade.[2] Shippers' long-run decisions include entry into product markets and any large, sunk capital investments such as manufacturing plants. Similarly, carriers' long-run decisions include terminal locations and other infrastructural investments. Shippers and carriers take these as given when making medium-run decisions. For carriers, medium-run decisions include how much to market their services on particular routes, how many trucks to buy, and whether to enter into long-term contractual arrangements with shippers. Carriers base these decisions on demand forecasts and anticipate that short-run production-related decisions will be profit maximizing. Shippers' demand for motor carriage reflects trade patterns with their customers. In many cases, this demand is recurrent and periodic.

Shipping transactions' organizational form is determined in the medium run. When individual firms either ship multiple products or ship products over various distances, they may use different forms for different hauls. Although shippers and carriers seek to maximize profits individually, it is in their mutual interest to choose efficient organizational forms, where efficiency reflects both production and transaction costs.

□ **Organizational forms.** Three organizational forms mediate trade between shippers and carriers: private carriage, contract carriage, and common carriage. Distinctions among these forms follow laws and regulations during the period the industry was heavily regulated (roughly, between 1935 and 1980). Under private carriage, shippers' internal divisions haul goods; under the other forms, shippers procure services from for-hire carriers. Contract and common carriage differ both in the length of the agreement and the specificity to shipper-carrier combinations.

Bills of lading contain the terms of trade under common carriage. These documents cover individual shipments. They are standard forms that contain the names of the shipper and carrier, the origin and destination, the volume, the type of commodity, and any equipment or handling requirements (such as for refrigerated or fragile goods). Bills of lading indicate the applicable common carriage rate, which covers shipping prices and charges for extra services. Bills of lading have some incentive provisions, but these are rarely specific to the transactional relationship. For example, they contain boilerplate liability provisions, but generally they do not specify delivery windows or penalties for late arrivals.[3]

Interstate Commerce Commission (ICC) regulations covered common carriage rates during the period under study. Between 1983 and 1994, regulations required carriers to file common carriage rates that were nondiscriminatory and required a five-day advance notice for most increases. But these regulations had little practical significance because the ICC had little interest in enforcing them. "Common carriage" became a misnomer: transactions usually took place at negotiated, discriminatory prices that were substantially below filed rates. Furthermore, there was significant uncertainty over whether negotiated discounts off filed common carriage rates were court-enforceable, because it was unclear whether courts would consider filed or negotiated common carriage rates legally binding (Sharp and Novack, 1992). Shipping prices and ancillary charges could be renegotiated in the very short run with little threat of outside enforcement.

Motor carrier contracts contain the terms of trade under contract carriage. These always cover multiple hauls. They can be costly to construct even absent disagreement because they are legal documents that contain provisions specific to carrier-shipper pairs. As a consequence, they usually cover hauls over long periods: six months to two years. Shipping prices are usually stipulated in terms of rate formulas that are based on mileage and sometimes fuel prices. Contracts

[2] Throughout this article, "shippers" refers to firms or divisions demanding transportation services (e.g., manufacturing divisions) and "carriers" refers to those supplying such services. When firms choose to haul their own goods, "shippers" and "carriers" are divisions of the same firm.

[3] For example, the Uniform Straight Bill of Lading states: "Unless arranged or agreed upon, in writing, prior to shipment, carrier is not bound to transport a shipment by a particular schedule or in time for a particular market, but is responsible to transport with reasonable dispatch."

© RAND 2001.

often specify "detention charges" that penalize shippers when they delay trucks and contain take-or-pay provisions that guarantee carriers minimum freight volumes. Many contracts also contain performance incentives in the form of delivery windows and penalties that apply when carriers' trucks are late. Some restrict carriers' ability to use equipment to serve other shippers, thus "dedicating" part of carriers' fleets to individual shippers.[4]

Motor carrier contracts gave firms a way to stipulate incentive provisions and negotiated rates over multiple hauls in a court-enforceable document. While contracts could serve other purposes as well, firms could use them to address concerns about quasi-rent appropriation.

□ **Specific investments.** Two classes of specific investments are relevant. One is that trucks and trailers can be specific to individual shippers in the very short run. The logic is closely related to that described by Pirrong (1993) for ocean shipping. Once a truck arrives at a haul's origin to be loaded, it is costly for the carrier to use that truck to serve another shipper. It must identify an alternative customer and incur time and transportation costs to receive the load. Moreover, it may be costly for the shipper to be served by another carrier, also because of search and time costs. The quasi-rents that arise from this sort of specificity would generally be small, but they might vary systematically with the thickness of local shipping markets. In markets where few local shippers demand service that uses a particular type of trailer, carriers may have to wait longer, travel greater distances, or attach a different trailer to use a truck to serve other shippers.

The other class of specific investments is relevant for long hauls but not short hauls. Long-haul markets differ from short-haul markets because of the importance of lining up backhauls. Shipping markets are decentralized, and shippers and carriers are imperfectly informed about short-run supply and demand on individual routes. Route-specific investments can enable carriers to obtain better matches to their outbound hauls and thereby lower the effective cost of outbound hauls. For example, carriers can utilize capacity at a higher rate when they can identify shippers that frequently ship goods in the opposite direction and coordinate schedules. Evidence from interviews indicates that the investment necessary to line up consistent, complementary backhauls for a series of outbound hauls is commonly on the order of 60 man-hours when the backhaul market is thick, and two to four times as much when it is thin. The quasi-rents associated with route-specific investments thus tend to be significantly larger than those associated with trucks' time and space specificity.

Firms' ability to appropriate the returns from specific investments depends on their trading partner's decisions. These returns are at risk because trading partners may misunderstand the appropriate decision, make mistakes, or attempt to appropriate the returns themselves.

Consider the risk carriers face once they send a truck to a shipper to be loaded. Loading delays threaten carriers' returns, and they can arise for several reasons. One is communication problems between shippers and carriers. Carriers may misunderstand when shippers actually want trucks to arrive. Another is that shippers may make mistakes. For example, they may misschedule loading docks and cargo handlers so that trucks cannot be loaded when they arrive. Neither of these scenarios necessarily requires opportunistic behavior by shippers, but the returns from carriers' specific investments are still at risk. Communication problems or mistakes lower trucks' utilization rates and thus lead quasi-rents to be dissipated. A third reason is the threat of hold-up by shippers: shippers may try to extract quasi-rents from carriers by threatening delays. For example, they may refuse to tender loads until carriers grant them rate concessions.[5] Shippers face similar risks. For example, drivers may refuse to allow their truck to be loaded without concessions.

Carriers face similar risks with respect to route-specific investments. If carriers cannot easily find and serve other shippers with similar demands, part of the value of these investments depends on serving particular shippers. When city-pair markets are thin, quasi-rents are at risk if shippers

[4] Braunschweig, Crum, and Allen (1995) report findings indicating that minimum volume, service quality, and dedicated service provisions are common elements of trucking contracts.

[5] Delays may be threatened in subtle ways; for example, a rate concession may move a truck up in line to be loaded when several trucks are waiting.

© RAND 2001.

and carriers misinterpret or mistakenly breach agreements, or if they actively attempt to extract quasi-rents from each other. One concern that looms large for carriers is that shippers will demand less service or request rate reductions after carriers have arranged a series of complementary backhauls.

As emphasized by Klein, Crawford, and Alchian (1978) and Williamson (1979, 1985), appropriation concerns can lead firms to act in ways that are privately optimal but that reduce the gains from trade. Firms may, for example, underinvest in specific assets or devote resources toward protecting quasi-rents. In trucking, shippers and carriers concerned about appropriating quasi-rents devote resources to creating backup plans: identifying other potential trading partners who could potentially supply or demand service.

□ **Institutional responses to appropriation problems.** Reputational concerns can motivate shippers and carriers to communicate clearly and avoid mistakes and can deter them from appropriating quasi-rents from trading partners. Shippers that tend to delay trucks or renegotiate with carriers may face higher future shipping prices, and carriers that attempt to extract concessions from locked-in shippers may face lower future demand. When reputational incentives work well, motor carrier contracts would not play a role in mitigating appropriation concerns.[6] Using bills of lading to mediate trade would not be costly, even though they provide limited formal protection.

Contracts can play a direct role with respect to appropriation problems when reputation alone fails to give firms sufficient protection. In trucking, contracts could help for three reasons. First, motor carrier contracts contain formal incentive provisions specific to individual shippers and carriers. Such provisions can help motivate efficient decision making after specific investments are in place, for example by discouraging delays. Second, negotiated rates specified in motor carrier contracts are court-enforceable. This can deter attempts to renegotiate rates.[7] Third, motor carrier contracts extend over multiple hauls and hence can include minimum purchase requirements. This can help carriers appropriate the value of route-specific investments.

□ **Empirical tests.** My empirical analysis estimates how the probability that firms use contract rather than common carriage varies with measures of local market thickness, holding constant trucks' physical characteristics. I exploit the fact that the source and magnitude of quasi-rents differ systematically across hauls of different lengths.

I first test whether firms become more likely to use contract than common carriage as market thickness decreases for short hauls. If so, this suggests that firms use formal contracts to mitigate appropriation problems arising from tractor-trailers' time and space specificity. If not, this implies either that appropriation problems do not exist, that they do not vary with market thickness, or that they are mitigated in ways that do not involve formal contracts—for example, reputation suffices.

I conduct similar tests for longer hauls. Finding that contract carriage use increases as market thickness decreases for long but not short hauls is evidence that firms use contracts to address appropriation problems associated with route-specific knowledge but not trucks' time and space specificity. Contracts do address appropriation concerns, but only those in which assets are specific beyond the very short run. Finding no such relationship for either short or long hauls suggests that contracts play little or no role with respect to either of the appropriation issues described above. More generally, such a result would suggest that contracts are not commonly used to mitigate appropriation problems unless specific investments are large and long lasting.

I do not attempt to empirically distinguish among explanations of why firms are concerned about their ability to appropriate the returns from specific investments. The interpretation emphasized in the existing literature is that firms are concerned that their trading partners may attempt to hold them up, thereby extracting quasi-rents directly. But contracts can also help hold

[6] Trucking contracts are not public and hence do not help reputations work better by allowing market participants to verify breaches.

[7] Pezold (1998, p. 1) echoes this: "Properly drawn transportation contracts afford shippers the best protection against. . . rate disputes. . . [and] unexpected accessorial charges."

© RAND 2001.

firms accountable for mistakes that cause quasi-rents to be dissipated. These interpretations are difficult to distinguish because their contractual implications are very similar. When mistakes would dissipate quasi-rents, parties can appropriate quasi-rents by threatening to make mistakes. It would be difficult to infer, even with detailed information about contractual provisions, whether appropriation concerns are due to hold-up or other, closely related matters.[8]

3. Data

■ The data are from the 1992 Truck Inventory and Use Survey (TIUS). The TIUS is a mail-out survey taken by the Bureau of the Census as part of the Census of Transportation. The Census sends survey forms to a random sample of truck owners. The survey asks questions about trucks' characteristics: for example, their type (e.g., pickup, truck-tractor), make, model, and after-market equipment. It also asks questions about how trucks are used. The answers indicate how far trucks operated from their base, the class of trailer to which they were commonly attached, and the product class they generally hauled. The survey also asks whether trucks were part of private or for-hire fleets. If trucks were for-hire, it asks whether they operated primarily under common or contract carriage. I use only observations of truck-tractors—the front halves of tractor-trailer combinations—and exclude truck-tractors that were used primarily for personal transportation, rented out by the day, used to haul waste, or not used to haul goods.[9] I also exclude the small fraction of trucks used mainly for "exempt" carriage: interstate hauls to which ICC regulation traditionally did not apply. The data do not indicate contractual form for such trucks. The sample includes 32,015 trucks, of which 30,740 have nonmissing values for all of the variables used in the analysis.[10]

Table 1 shows basic patterns in organizational form during 1992.[11] Overall, 55% of trucks are used for private carriage. Slightly over half of the rest haul under common carriage agreements.

TABLE 1 Contractual Form by Trailer Type, 1992

	Common (%)	Contract (%)	Private (%)	*N*
All	24.3	21.1	54.6	32,015
Auto trailers	38.9	50.6	10.5	257
Basic van	36.5	24.7	38.8	9,856
Specialized vans	24.3	18.5	57.3	1,252
Tank trucks	24.3	20.6	55.2	3,224
Refrigerated van	20.1	28.9	51.1	3,920
Platform	19.9	22.9	57.2	5,200
Dump trailer	15.9	14.9	69.2	2,670
Specialized trailers	7.7	6.7	85.5	5,636

[8] This is a general problem in empirical literature. One *may* be able to distinguish among these interpretations with data on behavior before and after contracts are instituted. For example, if delays are out-of-equilibrium events under the "hold-up" but not the "mistakes" interpretation, showing that contracts lead to fewer delays is evidence against the former.

[9] The latter excludes trucks that are used to transport trailers that have cranes or large winches permanently attached.

[10] Most missing values are for trucks' base state. Also, the survey oversamples trucks registered in less-populous states. All the analysis in this article uses the weights provided by the Census to adjust for oversampling. See Bureau of the Census (1995) and Hubbard (2000) for more details on the data.

[11] Because observations are of trucks rather than hauls and the calculations do not adjust for differences in intensity of use, the shares in Table 1 indicate capacity shares rather than output shares.

© RAND 2001.

The table reports shares according to the type of trailer to which trucks are normally attached. "Specialized vans" includes insulated nonrefrigerated vans, drop frame (side-loading) vans, and open-top vans. "Specialized trailers" includes all trailer types not otherwise classified; grain bodies, livestock trailers, and logging trailers are the most common in this category. There is a general correspondence between contractual form and trailers' specificity to uses. Common carriage is more prevalent when trucks are attached to basic vans than most other trailers.

Relationships between the common carriage share and trailers' physical characteristics may reflect firms' response to specificity-related appropriation problems. But they also may reflect differences in shipping volumes. Contract carriage is less advantageous relative to common carriage when shippers ship small volumes because of the fixed cost of constructing contracts. Specialized trailers such as grain bodies or logging trailers tend to haul goods for which shipping volumes are high. This is why I base the empirical tests below on relationships between market thickness and contractual form, conditional on trailers' physical characteristics. These tests compare, for example, contractual form for hauls using logging trailers in regions where there are few local users versus many (for instance, Kansas versus Oregon). An assumption maintained throughout is that the volume individual shippers ship does not systematically differ with local market conditions. This may not strictly hold, but if high-volume shippers tend to be located in thick local markets, shipping volumes' effect on the probability that firms use contracts would work against appropriation problems' effect. The former would lead to more contract carriage in thicker markets. Finding that the opposite is true suggests the interpretation that appropriation problems affect contractual form.[12]

Table 1 also indicates that trucks attached to specialized trailers tend to operate under private carriage. Finding that shippers use private fleets more when local markets are thin may reflect that vertical integration is a response to concerns about quasi-rent appropriation—as posited by Klein, Crawford, and Alchian (1978) and Williamson (1979, 1985)—or that asset ownership reflects an attempt to elicit noncontractible investments (Grossman and Hart, 1986). However, it may also reflect that specialization is limited by the size of the market. Private fleets are, by definition, managed by firms that are not trucking specialists. Trucking specialists have a comparative advantage over nontrucking specialists in achieving scale economies if they can aggregate demands of different shippers at lower cost.[13] This advantage may be smaller when local markets are thin. If so, one would expect to see more private carriage in thinner markets even absent concerns about quasi-rent appropriation. This alternative interpretation does not arise when examining whether firms use common or contract carriage because the decision is between contractual forms that do not involve integration. The main economic inferences in this article are based on the margin between common and contract carriage rather than the margin between contract and private carriage for this reason.[14]

□ **Trailer type, local market conditions, and contractual form.** I now introduce the local market conditions variables. One is "trailer density," defined as:

$$TD_{jk} = \frac{\textit{number of state } k \textit{ trucks with trailer } j \textit{ as their principal trailer}}{\textit{developed area of state } k}. \qquad (1)$$

I calculate the numerator from the individual observations in the TIUS and the sampling weights provided by the Census. A truck's state corresponds to where it is based, not where it is registered

[12] The bias works in the wrong direction if, for example, plant size is systematically higher in thin local markets than in thick ones.

[13] See Keeler (1989) for scale economies in trucking. One explanation for specialists' competitive advantage relies on "coordination economies" similar to those in Bagwell and Ramey (1994). Shippers uncertain about which carriers serve which routes economize by calling for-hire carriers first.

[14] Baker and Hubbard (2000b) provide evidence that shippers' make-or-buy decisions reflect both appropriation issues identified by Grossman and Hart (1986) and the measurement cost and job design issues highlighted in Holmström and Milgrom (1994).

© RAND 2001.

or the headquarters of the firm that owns it. I compute the denominator from data summarized in the 1998 Statistical Abstract of the United States (Bureau of the Census, 1998) from the Department of Agriculture's National Resources Inventory. "Developed area" includes urban and built-up areas of 10 acres or more and is measured in square miles.[15] Trailer density captures both the composition and density of a state's fleet—i.e., state trailer and truck capacity normalized by a measure of geographic area. Because capacity measures reflect aggregate demand, trailer density and other measures of local market conditions have demand- as well as supply-side interpretations. The composition of the fleet reflects the composition of shipping demand. Likewise, fleet density reflects the density of shippers.

One can break trailer density down into components that reflect composition and density:

$$TD_{jk} = \frac{trailers_{jk}}{area_k} = \frac{trailers_{jk}}{trucks_k}\frac{trucks_k}{area_k} = TS_{jk}TA_k. \tag{2}$$

TS_{jk} is "trailer share": the fraction of state k's fleet that is principally attached to trailer type j. TA_k is trucks/area for state k. In log form, $\ln(TD_{jk}) = \ln(TS_{jk}) + \ln(TA_k)$. Including $\ln(TD)$ in a model is identical to including both $\ln(TS)$ and $\ln(TA)$ and restricting their coefficients to be the same. Differences in these coefficients imply that the composition and general density of the market (as measured) affect contractual form differently.

Below I show how these measures capture cross-state and cross-trailer differences in market thickness, but they have two shortcomings worth mentioning here. First, they do not capture differences in local geographic markets within states. Thus, the only regional differences are cross-state differences. The second is related to agglomeration. Normalizing by developed area rather than geographic area accounts for the fact that in some states, most of the economic activity is concentrated in one or two small areas. But one smaller issue remains. Holding constant the fraction of geographic area that is developed, states where the developed area is dispersed (such as Iowa) look thick relative to those where it is agglomerated (such as Nevada).[16] This may distort estimates of the $\ln(TD)$ and $\ln(TA)$ coefficients. One can check this by comparing the estimates that include $\ln(TS)$ and $\ln(TA)$, and $\ln(TS)$ and state fixed effects. If replacing $\ln(TA)$ with state fixed effects affects the coefficient on $\ln(TS)$, this suggests that measurement error may be biasing estimates in specifications that include either $\ln(TD)$ or $\ln(TA)$. One would therefore place more weight on results from the fixed-effect specifications.

Another issue is that these proxies reflect where trucks are based, not necessarily where they haul. Long-haul shipping markets are origin-destination pairs. Ideally, measures of market thickness should be based on the density of individual shipping lanes, not characteristics of one of the endpoints. The proxies work well for long hauls if the density of shipping lanes emanating from a state is highly correlated with characteristics of its trucking fleet. There is reason to believe that this is true. For example, one would expect the density of long-haul shipping lanes in states with large trucking fleets relative to their area to be high (higher in shipping lanes involving New Jersey than those involving New Mexico) and to be related to fleets' composition (higher for hauls using logging trailers in Oregon than in Kansas).

TA is highest in states where economic activity is most concentrated in large cities. It ranges from over ten trucks/square mile in Illinois, California, and Utah to just under 2.5 trucks/square mile in New Mexico and North Dakota. Raw contractual form shares vary across states with *TA*. The average common carriage share across the top five states in *TA* is 29.2%; the average share across the bottom five states is 18.4%. Simple spot arrangements are more prevalent in states with dense markets.

[15] Only about 4.7% of land in the United States is developed. This ranges from over 30% in New Jersey to less than 1% in Wyoming, Nevada, and Alaska. Alaska and Hawaii are excluded from the analysis.

[16] Compare two states that are identical except that in one, all activity is within a single city, but in the other, it is evenly divided into two geographically separated cities. Although there would be more alternative local users for a given piece of equipment in the first state, *TD* and *TA* would be the same.

© RAND 2001.

TABLE 2 Trailer Shares by Home Base State of Truck, 1992

Trailer Type	Mean Share (%)	Standard Deviation (%)	Maximum Share (%)	Top 3 States	Minimum Share (%)	Bottom 3 States	Top Product	Product Concentration
Basic van	29.2	12.2	54.4	TN, NJ, WI	6.7	WY, ID, NM	Processed food	.087
Refigerated van	11.4	5.2	28.9	UT, NE, MT	3.5	NM, RI, HI	Processed food	.568
Platform	15.4	4.1	26.9	HI, CA, MT	8.8	NJ, WI, MA	Lumber	.107
Dump trailer	8.3	5.9	27.0	NV, HI, WV	2.2	ME, VT, GA	Building materials	.449
Auto trailer	.7	.5	2.6	MI, NY, FL	.1	IA, WY, WA	Trans. equipment	1.000
Tank trucks								
Tank truck/liquid	7.5	2.9	15.0	LA, VT, WY	3.3	SD, OR, WI	Petroleum	.308
Tank truck/dry	1.7	.7	3.9	MT, MD, NV	.5	RI, MI, HI	Building materials	.319
Specialized vans								
Insulated van	1.2	2.1	15.1	UT, MN, ME	.1	NH, VT, MD	Processed food	.387
Drop frame van	2.5	1.2	6.0	MS, CT, CO	.3	VT, HI, IA	Household goods	.256
Open van	1.3	1.3	5.6	OR, ID, ME	.2	NV, NE, DE	Logs	.249
Specialized trailers (selected)								
Grain body	4.5	5.5	23.7	ND, SD, NE	.2	ME, CT, WV	Farm products	.637
Livestock trailer	1.7	2.1	9.3	UT, WY, ID	.1	RI, MA, IL	Livestock	.937
Logging trailer	3.1	3.5	12.1	OR, SC, ME	1.1	RI, NY, KS	Logs	.854

Table 2 summarizes patterns in *TS*. Taking a simple average across states, the mean share of basic vans is 29.2%. The mean share is lower for hauls using more specialized equipment, particularly for those grouped in "specialized vans" and "specialized trailers." *TS* varies considerably across states for each trailer type, especially for the most prevalent trailer types. For example, basic vans' share ranges from 6.7% in Wyoming to 54.4% in Tennessee. *TS* reflects cross-sectional differences in what is shipped from each state. For example, states in which the share of the "specialized trailers" is highest are regions from which shipments of autos, grain, livestock, and logs tend to originate. The right two columns show the class of products most commonly shipped on each trailer type, and a Herfindahl-like measure of trailers' specificity to product classes. I construct the latter by classifying trucks by trailer type, then calculating the fraction that are used primarily to transport each product class in the data. Call this fraction s_{ij}, where i indexes the trailer type and j indexes the product class.[17] The concentration measure is $H_i = \sum_{j=1}^{J} s_{ij}^2$, where J is the number of product classes. This rough measure confirms the intuition that basic vans and platforms are least specific to product classes, and that auto trailers and "specialized trailers" are the most specific.

Table 3 shows private and common carriage shares, by trailer type. The left column of each panel reports shares calculated across the entire sample. The right column reports shares calculated across only the three states for which trailer shares are highest for each trailer type. Comparing the two columns in the left panel, common carriage has a higher average share for the "top three states" than the sample mean for all trailer types except platforms. This suggests that contractual form, given outside procurement, is influenced by the composition of the local fleet. In the right panel, private carriage has a much smaller than average share for the "top three states" than the

[17] "Product classes" are those in Hubbard (2000). They are broadly defined, e.g., "processed food," "building materials," "transportation equipment."

© RAND 2001.

TABLE 3 **Contractual Form Proportions by Trailer, 1992. All States, Top 3 States**

	Common Carriage (%)		Private Carriage (%)	
Trailer Type	All States	Top 3 States	All States	Top 3 States
Basic van	36.5	54.2	38.8	23.2
Refrigerated van	20.1	40.8	51.1	24.7
Platform	19.9	18.9	57.2	63.8
Dump trailer	15.9	17.6	69.2	63.4
Specialized vans				
Insulated van	31.2	76.3	46.7	10.6
Drop frame van	29.8	30.3	55.5	66.3
Open van	9.4	25.9	70.7	50.7
Specialized trailers (selected)				
Auto trailer	38.9	56.6	10.5	9.0
Grain body	11.9	12.8	80.1	80.5
Livestock trailer	16.1	17.6	75. 3	78.3
Pole/logging trailer	6.2	8.1	83.1	71.7
Tank trucks				
Tank truck/liquid	24.7	28.4	55.9	45.7
Tank truck/dry	22.5	36.0	52.6	35.1

Note: "Top 3 States" are the states in which trucks using the specified trailer make up the largest fraction of the state's fleet.

sample mean for all of the vans and tank trucks except drop frame vans. The private carriage share varies with market composition for hauls using these trailers. Similar differences do not appear for the specialized trailers.

Cross-tabulations portray relationships between contractual form and local market conditions. The next section explores these relationships further. I first test the hypotheses outlined in the previous section. I then investigate whether relationships between local market conditions and contractual form arise for reasons having to do with the selection of trucking rather than other shipping modes. Finally, I test whether these relationships are strongest in states with the thinnest backhaul markets.

4. Specification and results

■ I estimate a model of organizational form. Let y represent an index of hauls' propensity toward long-term arrangements, where $y = X\beta + \varepsilon$. Factors that increase y push hauls from common to contract and from contract to private carriage. In the base specification, X includes a vector of dummy variables indicating the trailer type to which the truck was generally attached, a "mixed cargo" dummy that equals one if the truck generally carried cargo from multiple product classes and zero otherwise, and $\ln(TD)$.[18] The mixed cargo dummy is an indicator for trucks used for "less-than-truckload" hauls. These hauls are generally governed by short-term arrangements due to lower shipping volumes and efficiencies of consolidation. The error term includes unobserved shipper characteristics (such as shipping volume) and unobserved

[18] None of the basic results change when I include trailer density rather than its log. I use the log form to exploit the decomposition: $\ln(TD) = \ln(TS) + \ln(TA)$.

© RAND 2001.

local market characteristics. Let θ_1 be the threshold at which the production-plus-transaction cost of mediating trade using common and contract carriage agreements is equal; firms choose common carriage if and only if $y < \theta_1$. Let θ_2 be the analogous threshold at the margin between contract and private carriage; firms choose private carriage if and only if $y > \theta_2$. I specify $\theta_1 = -X\beta_1$, $\theta_2 = -X\beta_2$, and normalize $\beta = 0$. This allows X to affect the common/contract and the contract/private margin differently. Positive estimates of β_1 identify variables that are correlated with greater use of contract rather than common carriage. Assuming that ε has a logistic distribution produces an ordered logit specification, where

$$\begin{aligned} P(common) &= \frac{e^{-X\beta_1}}{1+e^{-X\beta_1}} \\ P(private) &= \frac{1}{1+e^{-X\beta_2}} \\ P(common) &= 1 - P(common) - P(private). \end{aligned} \tag{3}$$

This specification includes two important restrictions. One is that unobserved factors ε that push hauls from common to contract carriage also push them toward private carriage. I have examined this restriction by estimating multinomial probit versions of the model. The multinomial probit allows unobserved factors that push hauls from common to contract carriage to be correlated with those that push them toward private carriage, but it does not restrict the correlation to one. I found that in some of the specifications, the maximum is not defined: the likelihood function increases as the correlation parameter becomes arbitrarily close to one. When the model has an interior maximum, the estimated correlation parameter is large and positive (usually on the order of .8) and the sign, significance, and marginal effects implied by the coefficients on the local market conditions proxies are very similar to those in the ordered logits reported below.[19] I report the ordered logit results because the likelihood functions always have well-defined maxima, and there is little evidence that the implied restriction on the effect of unobserved factors is affecting the results.

The other restriction—implied by the ordering—is that hauls are never at the margin between common and private carriage. This ordering is strongly suggested by a reading of the trade press, which generally depicts contract carriage as the relevant alternative to private carriage. One reason for this is that many shippers use private fleets when they want trucks to be available on short notice. Contract carriage is the for-hire substitute in such cases because motor carrier contracts can include performance incentives or control-right provisions that support timely service.[20]

□ **Results.** Table 4 summarizes results from the base specifications. The three panels use samples of trucks that primarily operate within 50 miles, between 50 and 200 miles, and over 200 miles from their base. The coefficients of interest are those on ln(TD), particularly those explaining the margin between common and contract carriage.

The main result is that common carriage is used more when trailer density is high, especially for longer hauls. The coefficient on ln(TD) at the common/contract margin is negative and significant for each of the distance categories. The short-haul coefficient suggests that tractor-trailers' specificity in the very short run affects contractual form. The fact that the medium- and long-haul coefficients are larger suggests that specificity arising from route-specific knowledge affects contractual form. These results indicate that contracts are used to address quasi-rent appropriation problems well beyond circumstances where investments are large and relationship-specific over long horizons.

[19] The fact that unobserved factors that tend to shift hauls from common to contract carriage also shift them toward private carriage is unsurprising; Tables 4 and 6 will indicate that this is true for nearly all of the *observed* factors.

[20] I have explored the implications of ordering by reestimating the specifications below after switching the order of private and contract carriage. The results at the common/private margin in these auxiliary specifications are very similar to those at the common/contract margin reported here.

© RAND 2001.

TABLE 4 Ordered Logits. Dependent Variable: Contractual Form

	Short Haul Only		Medium Haul Only		Long Haul Only	
Margin	Common/ Contract	Contract/ Private	Common/ Contract	Contract/ Private	Common/ Contract	Contract/ Private
C_1	**−1.472**		**−1.880**		**−1.403**	
	(.083)		**(.071)**		**(.050)**	
C_2		**−.635**		**−.922**		**−.131**
		(.070)		**(.059)**		**(.047)**
Refrigerated van	**.809**	**1.236**	**1.468**	**1.057**	.025	**−.200**
	(.244)	**(.208)**	**(.188)**	**(.113)**	(.067)	**(.066)**
Platform	**1.172**	**1.136**	**.157**	**.240**	**−.220**	**−.470**
	(.149)	**(.113)**	**(.092)**	**(.074)**	**(.064)**	**(.064)**
Specialized trailer	**1.446**	**1.744**	.019	**.346**	−.131	**.340**
	(.172)	**(.140)**	(.130)	**(.105)**	(.137)	**(.123)**
Tank truck	−.120	−.084	**−.968**	**−.638**	**−.679**	**−.759**
	(.161)	(.134)	**(.115)**	**(.097)**	**(.099)**	**(.100)**
Specialized van	**.751**	.082	**−.732**	**−.627**	**−.856**	**−.463**
	(.334)	(.233)	**(.196)**	**(.162)**	**(.136)**	**(.139)**
Dump trailer	**.488**	**.677**	**−.618**	**−.657**	**−.978**	**−.935**
	(.140)	**(.114)**	**(.117)**	**(.097)**	**(.160)**	**(.165)**
Auto trailer	.350	**−1.252**	**−2.191**	**−3.574**	**−1.708**	**−3.350**
	(.911)	**(.508)**	**(.231)**	**(.311)**	**(.173)**	**(.261)**
Mixed cargo	**−2.739**	**−2.832**	**−2.097**	**−2.143**	**−1.409**	**−1.342**
	(.108)	**(.128)**	**(.100)**	**(.119)**	**(.075)**	**(.102)**
0–50 miles	—	—				
50–100 miles			—	—		
100–200 miles			**−.346**	**−.437**		
			(.055)	**(.046)**		
200–500 miles					—	—
>500 miles					**−.647**	**−.952**
					(.041)	**(.040)**
ln(Trailer Density)	**−.243**	**−.209**	**−.389**	**−.332**	**−.405**	**−.421**
	(.060)	**(.049)**	**(.043)**	**(.036)**	**(.035)**	**(.036)**
$-\log L$	4,430		8,172		13,512	
N	7,653		10,387		12,600	

Note: Bold indicates rejection of H_0: $b = 0$ using a two-tailed t-test of size .05. The omitted trailer type is "basic van." Standard errors are in parentheses.

Table 5 reports probability derivatives for ln(TD). These indicate predicted changes in contractual form from doubling trailer density, which corresponds roughly to moving from the 25th to the 50th, or the 50th to the 75th, percentile values. Holding all explanatory variables at their sample means, an interquartile change in trailer density increases the common carriage share for long hauls by 8.6 percentage points, or 28.1%. It increases the common carriage share for

© RAND 2001.

TABLE 5 **Trailer Density Probability Derivatives**

	Common	Contract	Private
Short-haul trucks			
Predicted shares	.115	.101	.784
Probability derivative	.025	.011	−.035
Derivative/share	21.5%	10.6%	−4.5%
Medium-haul trucks			
Predicted shares	.161	.188	.652
Probability derivative	.052	.023	−.075
Derivative/share	32.6%	12.2%	−11.6%
Long-haul trucks			
Predicted shares	.306	.360	.334
Probability derivative	.086	.008	−.094
Derivative/share	28.1%	2.1%	−28.0%

Note: All calculations use estimates from Table 4. Probability derivatives and predicted shares are calculated at mean values.

medium hauls by 5.2 percentage points, or 32.6%, and for short hauls by 2.5 percentage points, or 21.5%. Together, the results suggest that the empirical relationships between market thickness and contractual form are economically important as well as statistically significant.

Other patterns in Table 4 may reflect problems associated with quasi-rent appropriation, but they have other interpretations as well. In particular, the ln(*TD*) coefficients on the contract/private margin are all negative and significant, and they are higher in absolute value for longer hauls. Shippers haul their own goods more when local markets are thin. This may indicate the same phenomena as at the common/contract margin, but it may also reflect that for-hire carriers cannot achieve scale economies in thin markets ("specialization is limited by the size of the market").

Table 6 contains results from more detailed specifications that further explore relationships between local market conditions and contractual form. These specifications indicate that the factors that identify the results in Table 4 for short hauls are different from those that do so for long hauls. The results in Table 6 provide weaker evidence that relationships between trailer density and the common/contract margin for short hauls are due to contracting problems.

The results in the top panel are from specifications that allow relationships between trailer density and contractual form to differ across trailer types. Whereas the coefficients on ln(*TD*) in Table 4 exploit differences across trailer types and geographic regions, the coefficients on the interactions exploit only geographic differences. I report only the interaction coefficients here; the specification includes the same control variables as above. Considering the common/contract margin for short hauls, only three of the interaction coefficients are negative and statistically significant. In contrast, almost all of the interactions are negative and statistically significant for medium and long hauls. Relationships between trailer density and spot contracting persist across a wide range of trailers for medium and long hauls, but not for short hauls.[21]

The middle panel breaks ln(*TD*) into components that reflect differences in the composition and size of local markets: ln(*TS*) and ln(*TA*). The coefficient on ln(*TA*) is negative and statistically significant for each distance category; the coefficient on ln(*TS*) is negative and significant for

[21] I also test the null that the interaction coefficients at each margin are equal, and I reject the null in each case using an F-test of size .05. Relationships between trailer density and organizational form thus differ across trailer types.

© RAND 2001.

TABLE 6 Ordered Logits—Selected Coefficients. Dependent Variable: Contractual Form

	Short Haul Only		Medium Haul Only		Long Haul Only	
Margin	Common/ Contract	Contract/ Private	Common/ Contract	Contract/ Private	Common/ Contract	Contract/ Private
Panel A						
ln(TD) ∗ Ref. van	**−1.196**	**−.922**	−.408	**−.749**	**−.366**	**−.500**
	(.470)	**(.450)**	(.378)	**(.207)**	**(.090)**	**(.090)**
ln(TD) ∗ Basic van	.109	−.083	**−.297**	**−.563**	**−.516**	**−.682**
	(.108)	(.106)	**(.093)**	**(.085)**	**(.064)**	**(.066)**
ln(TD) ∗ Platform	**−.518**	−.296	**−.554**	**−.446**	**−.214**	−.156
	(.223)	(.155)	**(.128)**	**(.099)**	**(.105)**	(.104)
ln(TD) ∗ Specialized trailer	.025	−.044	**−.339**	**−.224**	−.223	**−.192**
	(.134)	(.112)	**(.087)**	**(.068)**	(.120)	**(.097)**
ln(TD) ∗ Tank truck	−.174	**−.278**	−.141	−.024	.080	−.102
	(.132)	**(.110)**	(.085)	(.075)	(.091)	(.090)
ln(TD) ∗ Specialized van	−.188	−.151	**−.540**	−.267	**−.758**	**−.442**
	(.323)	(.213)	**(.179)**	(.142)	**(.097)**	**(.103)**
ln(TD) ∗ Dump trailer	**−.981**	**−.488**	**−.784**	**−.640**	**−.936**	−.319
	(.130)	**(.112)**	**(.140)**	**(.117)**	**(.264)**	(.256)
ln(TD) ∗ Auto trailer	—	—	**−.995**	−.828	**−.687**	**−1.616**
			(.328)	(.516)	**(.227)**	**(.348)**
P-value for F-test of equality of estimates	.000	.046	.001	.000	.000	.000
−log$L$	4,384		8,140		13,464	
Panel B						
ln(trailer share)	−.100	−.002	**−.367**	**−.168**	**−.531**	**−.456**
	(.077)	(.063)	**(.053)**	**(.043)**	**(.046)**	**(.046)**
ln(trucks/area)	**−.446**	**−.539**	**−.400**	**−.664**	**−.201**	**−.376**
	(.096)	**(.096)**	**(.096)**	**(.061)**	**(.058)**	**(.057)**
P-value for F-test of equality of estimates	.006	.000	.710	.000	.000	.272
−log$L$	4,417		8,134		13,502	
Panel C						
ln(trailer share)	.002	.102	**−.367**	**−.159**	**−.365**	**−.330**
	(.080)	(.065)	**(.054)**	**(.044)**	**(.048)**	**(.047)**
−log$L$	4,309		8,016		13,282	

Notes: All specifications include constants, a mixed cargo dummy, trailer dummies, and distance from home dummies, not reported here. N = 10,387 and 12,600 for medium and long-haul specifications, respectively. N = 7,640 for the first short-haul specifications; observations of auto trailers are dropped because the ln(TD) ∗ Auto parameters are not identified. N = 7,653 for the other short-haul specifications. In the bottom panel, I include state fixed effects and constrain the parameters associated with them to be equal across the two margins.

Bold indicates rejection of H_0: $b = 0$ using a two-tailed t-test of size .05. Standard errors are in parentheses.

long and medium hauls. These specifications indicate that market composition and size drive relationships between ln(TD) and contractual form at the common/contract margin for medium and long hauls. Moving from a .05 share to a .10 share increases the probability that long hauls are mediated by common carriage arrangements from .20 to .26, or 32%. However, there is only weak evidence that market composition and contractual form are related for short hauls.

© RAND 2001.

I also report p-values for two-tailed t-tests of the null that the coefficients on ln(TS) and ln(TA) are equal. Looking at the common/contract margin test results, I reject this null for short and long hauls. The evidence suggests that market size affects this margin more than composition for short hauls, but that the opposite is true for long hauls. I fail to reject this null for medium hauls; there is no evidence that market size and composition affect this margin differently for these hauls.

The bottom of Table 6 reports estimates from specifications that replace ln(TA) with fixed effects for each state. These specifications are unrestricted versions of those in Table 4 and in the middle panel of Table 6. For each distance category, one can easily reject the null that the parameters on the 49 fixed effects are equal, using a likelihood ratio test of size .05. I report the coefficients on ln(TS).[22] The relationship between ln(TS) and contractual form remains strong for long and medium hauls. Moving from a .05 share to a .10 share increases the probability that medium and long hauls are mediated by common carriage agreements by 20–25%. I do not find a relationship between ln(TS) and contractual form for short hauls. The statistically significant coefficients reported in Table 4 for these hauls reflect only relationships between contractual form and the general density of states' trucking fleets.

I have also estimated each of these models including a full set of dummy variables that indicate the class of product primarily hauled by the truck. In all, there are thirteen product categories; examples are "processed food," "paper products," and "building materials." In all cases, the point estimates and standard errors on the local market conditions coefficients are almost exactly the same as those reported in Tables 4 and 6. The estimates' similarity lends support to the interpretation that the coefficients in Tables 4 and 6 reflect relationships between local market thickness and contractual form, not the effect of omitted factors related to the products that trucks haul. For example, it is unlikely that the estimates reflect regional differences in the products shipped on particular trailer types.

□ **Intermodal selection issues.** An alternative interpretation of the results above is that they reflect shippers' choice of shipping mode. Rail can be a close substitute for trucks for long-distance shipping, particularly for goods that are shipped in bulk such as coal, minerals, grain, lumber, and metals. Suppose rail is characterized by large scale economies, and cross-price elasticities between truck and rail are high. Then, looking across local markets, rail's share may be negatively correlated with trailer share. For example, one might observe high rail shares and low dump trailer shares in regions where mining is important. Despite the fact that the shipping market is thick for products hauled by dump trailers, dump trailers' share of long hauls would be small because the market is large enough to allow scale economies to be achieved in rail. If rail is a closer substitute to common carriage than to contract or private carriage, selection would create relationships between trailer share and contractual form similar to those in Table 6.

I investigate this in two ways. First, I examine whether trailer share is low where production of products typically hauled by the trailer is high. From Table 2, dump trailers' share is very high in Nevada and West Virginia: states that produce the most metallic ores and coal, respectively. It is also high in other major mining states such as Arizona and Kentucky. Similar patterns appear for specialized trailers' shares: grain bodies' share is highest in the major grain-producing states, for example. Trailer share is high, not low, in regions where production of products that are hauled by these trailers is high.

Second, I explore whether trailer share for particular products is low in regions where rail share is high. Using data from the Census's 1993 Commodity Flow Survey, I compute the share of lumber and primary metals that are shipped by rail from each state. These two commodities are almost exclusively hauled on platform trailers when they are hauled by trucks. I test for relationships between rail share and trailer share by regressing state-level rail shares of lumber and primary metals on state-level platform trailer share. I find no evidence of a negative correlation

[22] The coefficients on ln(TS) here are the same as those one would obtain if one instead includes ln(TD) and the state dummies. To see this, note that ln(TS) = ln(*trailers*) − ln(*trucks*), ln(TD) = ln(*trailers*) − ln(*developed area*), and that both trucks and developed area are computed at the state level.

© RAND 2001.

between the rail share of either product and platform share. I find some evidence of a positive correlation.[23]

Combined, these results do not suggest that shipping mode selection is driving the results in the previous subsection. If anything, the results show that selection would work against finding positive relationships between common carriage and trailer density.

□ **Outbound/inbound ratios.** I next explore the hypothesis that relationships between local market thickness and contractual form are due to specific investments that are backhaul related. Under this hypothesis, one would expect such relationships to be strongest when backhaul markets are thin, because the investments required to identify and serve backhaul customers would tend to be larger.

I test whether the relationship between common carriage use and trailer density differs across states along with the ratio of interstate outbound and inbound truck shipments. Backhaul markets tend to be thinner, the higher the outbound/inbound ratio. Using data from the 1993 Commodity Flow Survey, I calculate the volume of outbound and inbound interstate truck shipments for each state. The ratio between these quantities varies considerably, ranging from about .5 for Nevada, Delaware, and Massachusetts to about 2.0 for Wyoming, Maine, and Montana. Finding that the relationship between common carriage use and trailer density is strongest when trucks are based in states where the outbound/inbound ratio is high is consistent with the hypothesis that decreases in the use of common carriage are due to concerns about appropriating the returns from backhaul-related route-specific investments.

The results in Table 7 support this hypothesis.[24] In the top panel, the interaction between ln(*trailer share*) and ln(*outbound/inbound*) is negative and significant for both medium and long hauls. Combined with the coefficient on ln(*trailer share*), one can compute the value of outbound/inbound such that the marginal effect of ln(*trailer share*) on contractual form is equal to zero. This value is .49 for medium hauls and .13 for long hauls; both of these are lower than the minimum in the sample. From the bottom panel, these results do not change qualitatively when I replace ln(*TA*) and ln(*outbound/inbound*) with state fixed effects. The outbound/inbound ratio such that the marginal effect of ln(*trailer share*) on contractual form equals zero is .44 and .26 for medium and long hauls, respectively. There is only a weak relationship between trailer density and common carriage use states where the ratio of outbound to inbound shipments is very low. This relationship becomes stronger as this ratio increases, and it is very strong in states where this ratio is high. This is exactly what one would expect if appropriation problems are backhaul related.

5. Conclusion

■ This article provides evidence on the roles of contracts and reputation in mitigating concerns about quasi-rent appropriation. There is some evidence that contracts are used more as local markets become thin for short hauls, but this evidence is weak. This suggests that reputation plays an important role in mitigating appropriation problems when investments are small and are relationship-specific only over short horizons. However, there are strong relationships between contractual form and market thickness for long hauls: contracts are used more relative to simple spot arrangements for long hauls when local markets are thin, especially in states with thin backhaul markets. This empirical fact suggests that in trucking, contracts address appropriation concerns associated with route-specific investments. More generally, this result indicates that quasi-rents need not be very large for firms to begin to address appropriation problems with formal contracts.

Contracts have many roles. Klein, Crawford, and Alchian (1978) and Williamson (1979, 1985) argue that contracts guide the allocation of quasi-rents that appear once firms make

---

[23] Further details and estimates are available in an earlier version of this article (Hubbard, 1999).

[24] The specification is analogous to those on previous tables; for brevity I omit all coefficients with respect to the private/contract margin.

© RAND 2001.

TABLE 7 Ordered Logits—Selected Coefficients. Dependent Variable: Contractual Form

Margin	Short-Haul Trucks Common/ Contract	Medium-Haul Trucks Common/ Contract	Long-Haul Trucks Common/ Contract
Panel A			
ln(trailer share)	−.066	**−.345**	**−.506**
	(.079)	**(.053)**	**(.047)**
ln(trucks/area)	**−.594**	**−.301**	−.097
	(.111)	**(.079)**	(.062)
ln(outbound/inbound)	**18.180**	3.849	3.043
	(3.307)	(2.444)	(1.996)
ln(*TS*) ∗ ln(out/in)	−.065	**−.477**	**−.244**
	(.168)	**(.110)**	**(.092)**
ln(*TA*) ∗ ln(out/in)	**−2.131**	**−.613**	**−.451**
	(.381)	**(.281)**	**(.229)**
$-\log L$	4,392	8,155	13,454
N	7,653	10,387	12,600
Panel B			
ln(trailer share)	.006	**−.362**	**−.355**
	(.081)	**(.053)**	**(.049)**
ln(*TS*) ∗ ln(out/in)	−.280	**−.436**	**−.265**
	(.144)	**(.097)**	**(.084)**
$-\log L$	4,292	7,996	13,253
N	7,653	10,387	12,600

Note: In the bottom panel, 49 state fixed effects are included.
Bold indicates rejection of H_0: $b = 0$ using a two-tailed t-test of size .05. Standard errors are in parentheses.

relationship-specific investments. Early empirical work provided evidence that contracts play this role when investments are large and relationship-specific over long horizons. My results suggest that contracts play a smaller role in mitigating appropriation problems as quasi-rents decline, but this role matters over a large range.

References

BAGWELL, K. AND RAMEY, G. "Coordination, Economies, Advertising, and Search Behavior in Retail Markets." *American Economic Review*, Vol. 84 (1994), pp. 498–517.

BAKER, G.P. AND HUBBARD, T.N. "Contractibility and Asset Ownership: On-Board Computers and Governance in U.S. Trucking." Working Paper no. W7634, National Bureau of Economic Research, 2000a.

——— AND ———. "Make Versus Buy in Trucking: Asset Ownership, Job Design, and Information." Mimeo, University of Chicago, 2000b.

BRAUNSCHWEIG, C.D., CRUM, M.R., AND ALLEN, B.J. "Evolution of Motor Carrier Contracting" *Transportation Quarterly*, Vol. 49 (1995), pp. 99–115.

BUREAU OF THE CENSUS. *Truck Inventory and Use Survey: 1992*. Washington, D.C.: G.P.O., 1995.

———. *Statistical Abstract of the United States: 1998*. Washington, D.C.: G.P.O., 1998.

DIAMOND, P.A. "A Model of Price Adjustment." *Journal of Economic Theory*, Vol. 3 (1971), pp. 156–168.

GROSSMAN, S.J. AND HART, O.D. "The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration." *Journal of Political Economy*, Vol. 94 (1986), pp. 691–719.

HOLMSTRÖM, B. AND MILGROM, P. "The Firm as an Incentive System." *American Economic Review*, Vol. 84 (1994), pp. 972–991.

© RAND 2001.

HUBBARD, T.N. "How Wide Is the Scope of Hold-Up-Based Theories? Contractual Form and Market Thickness in Trucking." Working Paper no. W7347, National Bureau of Economic Research, 1999.

———. "The Demand for Monitoring Technologies: The Case of Trucking." *Quarterly Journal of Economics*, Vol. 115 (2000), pp. 533–560.

JOSKOW, P.L. "Vertical Integration and Long-Term Contracts: The Case of Coal-Burning Electric Generation Plants." *Journal of Law, Economics and Organization*, Vol. 1 (1985), pp. 33–80.

———. "Contract Duration and Relationship-Specific Investments: Evidence from Coal Markets." *American Economic Review*, Vol. 77 (1987), pp. 168–185.

KEELER, T.E. "Deregulation and Scale Economies in the U.S. Trucking Industry: An Econometric Extension of the Survivor Principle." *Journal of Law and Economics*, Vol. 32 (1989), pp. 229–253.

KLEIN, B., CRAWFORD, R.G., AND ALCHIAN, A.A. "Vertical Integration, Appropriable Rents, and the Competitive Contracting Process." *Journal of Law and Economics*, Vol. 21 (1978), pp. 297–326.

KLEMPERER, P. "The Competitiveness of Markets with Switching Costs." *RAND Journal of Economics*, Vol. 18 (1987), pp. 137–150.

LAFONTAINE, F. "Incentive Contracting in Practice: A Detailed Look at Owner Operator Leases in the US Truckload Trucking Industry." Mimeo, University of Michigan, 2000.

MASTEN, S.E. "The Organization of Production: Evidence from the Aerospace Industry." *Journal of Law and Economics*, Vol. 27 (1984), pp. 403–417.

——— AND CROCKER, K.J. "Efficient Adaptation in Long-Term Contracts: Take-or-Pay Provisions for Natural Gas." *American Economic Review*, Vol. 75 (1985), pp. 1083–1093.

———, MEEHAN, J.W., AND SNYDER, E.A. "The Costs of Organization." *Journal of Law, Economics and Organization*, Vol. 7 (1991), pp. 1–25.

MONTEVERDE, K. AND TEECE, D.J. "Supplier Switching Costs and Vertical Integration in the Automobile Industry." *Bell Journal of Economics*, Vol. 13 (1982), pp. 206–213.

NICKERSON, J.A. AND SILVERMAN, B.S. "Determinants of the Employment Relation in For-Hire Trucking." Mimeo, Washington University, 1996.

PALAY, T.M. "Comparative Institutional Economics: The Governance of Rail Freight Contracting." *Journal of Legal Studies*, Vol. 13 (1984), pp. 265–287.

PEZOLD, G.C. *Contracts of Carriage and Bills of Lading.* Huntington, N.Y.: Transportation Consumer Protection Council, 1998.

PIRRONG, S.C. "Contracting Practices in Bulk Shipping Markets: A Transactions Cost Explanation." *Journal of Law and Economics*, Vol. 36 (1993), pp. 937–976.

SHARP, J.M. AND NOVACK, R.A. "Motor Carrier Deregulation and the Filed Rate Doctrine: Catalysts for Conflict." *Transportation Journal*, Vol. 32 (1992), pp. 46–53.

WILLIAMSON, O.E. "Transaction-Cost Economics: The Governance of Contractual Relations." *Journal of Law and Economics*, Vol. 22 (1979), pp. 233–261.

———. *The Economic Institutions of Capitalism.* New York: Free Press, 1985.

© RAND 2001.