Why do firms Make *and* Buy? Efficiency, appropriability, and competition in the trucking industry

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Abstract

Most literature examining firms' "make or buy" decision fails to explore when firms use both governance structures for similar transactions. We examine this phenomenon in the trucking industry where it is common for a carrier to use both employee drivers and outsourcing at the same time. We argue that efficiency, appropriability, and competition concerns lead carriers to organize on a haul-by-haul basis. We empircally examine our theory using a unique data from a small trucking firm in St. Louis, MO, and find broad support for our hypotheses. We also discuss the possibility of alternatives explanations of market power, capacity constraint, agency theory, and property right theory for the use of make and buy. We conclude that these alternative explanations do not explain this phenomenon in the trucking industry. Thus, we conclude that it is the interaction of efficiency, appropriability, and competition concerns that drive the decision to make and buy in the trucking industry. We further postulate that these concerns can manifest in other industries suggesting that our theory has applicability beyond trucking.

Key words • efficiency • appropriability • competition • networks • trucking • integration

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Introduction

The trucking industry has become an empirical hotbed for examining different economic theories of firm boundaries. For instance, firm boundaries have been explored through the lenses of transaction cost economics (Hubbard, 2001; Lafontaine and Masten, 2002; Nickerson and Silverman, 2003; Baker and Hubbard, 2003), agency theory (Baker and Hubbard, 2003 and 2004; Corts, 2000), and property rights (Baker and Hubbard 2003). This research largely focuses on the make v. buy decision for drivers: whether trucking firms use company drivers for hauls or outsource these hauls to owner-operators or other trucking companies. An empirical regularity that remains uncommented on in almost all of this literature is that many trucking firms both use company drivers and outsource hauls to other carriers. Indeed, Nickerson and Silverman (2003) point out that 35% of 353 interstate carriers engage in both modes of organization. Why do firms use both modes of organization? In the case of interstate trucking, why don't carriers *either* own trucks and hire company drivers to operate the trucks *or* outsource all hauls? When a mixture of make and buy is used, what determines the organization of each individual haul?[1]

[1] Masten, Meehan, and Snyder (1991) have suggested that when comparing make v. buy decisions that the comparison should be performed on the same asset for the same transaction. In trucking, firms typically engage to two central acitivites (Nickerson and Silverman 2003). The first activity involves finding hauls that fit various desirable parameters, which is called the origination activity. As we argue in this paper, carriers my have different information sets, which may make make v. buy decisinos incomparable. However, once a haul is discovered and selected, the information provided to the second activity—hauling—is identical whether the information is provide company drivers ("make") or contractors ("buy"). The information is comprised of an origination point, a destination point, and various characteristics about the load. It is this later transaction with identical informaiton sets that we analyze in this paper.

Some have argued that such "tapered integration" (Porter, 1980; Robins, 1989) is adopted to increase a firm's bargaining power. Porter (1980), for instance, asserts that firms engage in tapered integration to acquire knowledge about production costs in order to improve their bargaining position when negotiating with outside suppliers. Bradach (1998) identifies several additional mechanisms for having a mixture of company owned and franchised locations. Mixed ownership enhances product innovation opportunities because ownership versus franchising generates different innovation incentives. He also argues that franchisors may franchise locations that are more distant from company headquarters because of increased monitoring costs. However, the application of these theories to the trucking industry seems misplaced. The cost of trucking is well-known and transparent—fuel costs, vehicle costs (including the purchase of trucks and maintenance costs), and labor costs are all well known. Thus, there is little asymmetric information about the process of turning inputs into outputs and measurement costs vary little with distance. Finally, product innovation opportunities are practically nonexistent in the trucking industry.

In this paper, we argue that trucking firms choose to make *and* buy—use company drivers as well as outsource hauls—for three reasons: efficiency among carriers, concerns over demand-side appropriability, and competition. Central to these reasons is a carrier's investments in what we call "information hubs". We argue that carriers make information investments in a network of cities to identify and develop relationships among shippers (customers who desire to "ship" freight) who will likely demand hauls between city-pairs in the network. Making sunk cost and ongoing investment in information hubs is economically

beneficial. Investments in information hubs increase the likelihood of securing complementary hauls within the network thereby reducing costly deadheading—traveling without a load. Without such investments we assume that deadheading is much more likely, which translates into lower capacity utilization for vehicles and higher operating costs yielding lower carrier profitability.

Investments in information hubs lead to at least some carriers complementing each other. Carriers will find it economically beneficial to outsource those hauls with destinations outside of their existing information hubs to other carriers; carriers whose information hubs include the destination and therefore have an advantage in securing a complementary backhaul. This logic leads to an efficiency rationale—the reduction of deadheading—for originating carriers to outsource hauls (a carrier's "buy" decision). The mixture of make and buy is a result of haul destinations collected from a carrier's investment in collecting demand through its information hubs. In this instance, carriers large and small, while competitors in the classic sense, may complement each other when their information hubs are not perfectly correlated.

Investments in information hubs also lead to a demand-side appropriability problem that generates a competitive instead of complementary effect among carriers. Once an originating carrier invests in information hubs and relationships, other carriers have an incentive to free-ride on these investments. Competitors can free-ride on these investments if the haul is outsourcec to them because they then can interact with the shipper and demonstrate shipping reliability without having to make the up-front relationship investment. Once a competitor

demonstrates reliability to a shipper, any entry barrier that did exist is fully erased and competitors can compete at low cost for the same hauls as the carrier who originally made the investment. Therefore, to prevent potential expropriation caused by outsourcing, the carrier has an incentive to use only company drivers (a firm's "make" decision) to pick up hauls from its information hubs. One exception arises when the carrier allows competitors to pick up hauls from its own break-bulk facility (a wharehouse with many loading docks for droping off, soring, and picking up freight) even when these are located within information hubs. In this case, competitors have no access to shippers and therefore cannot free-ride.

Finally, we argue that originating carriers prefer not to allow competing carriers to deliver hauls into information hubs simply because doing so increases the competition for hauls leaving the hub. Such competition can reduce the likelihood of finding a complementary backhaul, reduce price, or both. We expect that this competitive effect is important although less important than appropriability concerns since the latter involves a sunk investment.

Our paper is connected to but differs from the transaction cost literature on vertical integration (e.g., Williamson, 1985). In particular, our theory does not rely on co-specialized investments or differences in monitoring costs in the hauling transaction to explain make v. buy and therefore identifies a different mechanism for vertical integration compared to Baker and Hubbard (2003), Hubbard (2001), Nickerson and Silverman (2003). While appropriability, a key aspect of our theory, is a relevant concern in the transaction cost literature, such concerns largely focus on the leekage of technological knowledge (e.g., Teece, 1986) and the

employment relation (e.g, Mayer and Nickerson, 2005). Thus, we identify a mechanism the drives the make v. buy decision that is new to the literature on trucking and different from the extant transaction cost literature on vertical integraion.

In sum, we argue that efficiency, appropriability, and competitive concerns combine to explain why trucking firms make *and* buy. We combine these explanations to predict that (1) hauls between information hubs are most likely to be undertaken by company drivers, (2) hauls with the origination-destination pair outside of information hubs are most likely to be outsourced, (3) hauls originating from an information hub and with a destination outside of an information hub are more likely than origin-destination pairs that are hub-to-hub hauls and less likely than origin-destination pairs that are outside of hubs to be assigned to company drivers unless they originate at the carrier's break-bulk facility, and (4) hauls originating from outside an information hub and with an information hub destination are more likely than origin-destination pairs that are hub-to-hub hauls and less likely than origin-destination pairs that are outside of hubs to be assigned to company drivers.

We empirically examine these predictions using an original data set collected from a carrier in St. Louis, Missouri. This data, collected daily over a seven-week period, describes every haul undertaken by the carrier, including information about whether the haul is organized as make or buy, its origin and destination, capacity of our focal firm, revenue per mile, and several other relevant haul characteristics. Coefficient estimates from a Probit analysis provide support for our theory.

While our theory is developed in trucking industry, such efficiency, appropriability and competitive concerns are not unique to the trucking industry. These conditions, we argue, are common to many industries and therefore our theory may have more general applicability beyond the trucking industry. As such, the theory may offer strategic insights into when and how horizontal competitors might benefit from collaboration thereby managing the tension between competition and cooperation.

The paper is organized as follows: our next section provides a model of the driver organizational choice, in which complementarity and appropriation concerns combine to determine the organization modes of a trucking firm. Our third section presents the data, empirical methodology, and the estimation results. Our fourth section discusses our results, evaluates the currency of several alternative explanations, and assesses the generalizability of our theory.

Model

A central source of profit in the trucking industry is the ability to find backhauls—hauls complementary to outgoing hauls that facilitate capacity utilization. This capacity utilization directly impacts profitability because without complementary backhauls trucks are forced to deadhead—travel empty—which accrues costs without corresponding revenue. To observe these costs more precisely and to introduce parameters that we later use in our model, imagine a load of goods is delivered from an origin city A to a destination city B with cost c_1 (costs

associated with the haul) and the truck has to return to the origin city A. If the truck runs empty on the return trip, a cost c_2 (deadhead costs) has to be added to c_1 as part of the cost of delivering the outgoing haul. Typically, c_2 will not be very different from c_1 since the main costs, fuel, labor, and vehicle, are the same but for the additional fuel needed to haul the load. Thus, running deadhead on the return trip almost doubles the cost of a haul with no corresponding doubling of revenue. Of course, carrying a revenue-generating load to city A from city B on the backhaul avoids deadheading. Although our description is based on a city-pair, any combination of backhauls, even if they take the truck to three or four different locations, is beneficial so long as the truck is not deadheading. For this reason, a backhaul is a complement, in terms of profit, to any haul.

Efficiency

Realizing the benefit to securing backhauls, we claim that carriers have an incentive to make investments that increase the likelihood of finding backhauls. The principal investments are searching for shippers with a demand of hauls with origination-destination pairs that match with the carrier's desired traffic pattern and developing and maintaining relationships with these customers to ensure that the carrier (and not some competitor) receives these hauls. Both search and relationship management are costly for the shipper and carrier alike.

Searching for a shipper with a desired traffic pattern can incur costs (Cooper and John 1988, Baker and Hubbard 2003). Developing and maintaining a shipper relationship requires incurring up-front as well as ongoing costs from both the shipper and carrier. Shippers incur an

initial verification cost in which they assess the ability of the carrier to pick up and deliver a haul within its desired specifications. For instance, a shipper may desire specific time-windows for pick-up and delivery or special handling instructions. Although verification is often accomplished by assigning hauls and monitoring performance, assessing a carrier's ability to satisfy these specifications requires additional effort on the part of the shipper. Shippers try to avoid adverse selection by expending effort to investigate carrier reputation. Shippers and carriers also frequently negotiate and sign long-term yet nonexclusive contracts that stipulate the rights and responsibilities of each party; although, these contracts do not specify hauls or prices. Like other types of economic relationships, relationships require maintenance, which may incur additional albeit small ongoing costs.

Hauling demands from any single shipper can be variable. For instance, shippers do not always have fixed traffic patterns to their hauls. As shippers add and drop customers and, more generally, respond to the market for their own products, their origin-destination pairs for each haul may vary and do so at different times. Thus, demand from any particular shipper can and often does vary. With this varying demand, it is in the best interest of the carrier to identify at least a few potential shippers with overlapping traffic patterns so that it can increase the likelihood of finding a backhaul when needed, which is a type of agglomeration economy in terms of demand.

These agglomeration economies give rise to something we refer to as “information hubs”. We define an information hub to be a geographic region—typically a city and its environs—in

which a carrier invests in multiple and proximate shipper relationships to generate information on demand for complementary hauls. Such relationships resonate with recent research that highlights the benefits of interorganizational ties (e.g., Uzzi 1996, 1999). Carriers develop friendshipes with shippers and frequently call them on telephone to maintain their relationships as well as to seek busienss. Shippers also develop expectations about the delievery performance of carriers, which, if positive, can act to strengthen ties between firms. The costs incurred to develop and maintian these relatioships are not trivial. While maintaining these ties located within information hubs may be costly because of the ongoing investment in maintaining shipper relations, it nonetheless offers demand-side benefits: selection of shippers and investments in information hubs increase the likelihood that the carrier will find complementary backhauls. A set of information hubs therefore represents a potential traffic pattern around which a carrier can minimize deadheading.

While our goal is not to offer a general equilibrium model of firm heterogeneity in the trucking industry, we nonetheless believe it is important to comment on the nature of competition we would expect to see in the trucking industry. We do so because we assume that carriers may be heterogeneous in their choice of information hubs. We argued above that the cost to invest in maintaining information hubs is nontrivial but also not prohibitively expensive. In the trucking industry therefore barriers to entry are neither negligible nor so great as to foreclose entry to all but one firm. Positive entry costs imply that we do not anticipate a neoclassical perfectly competitive equilibrium in which all firms are identical and invest in the identical sets of information hubs. Entry barriers are low enough so that we expect that at least some

sets of information hubs may be at least partially replicated by some competitors; but, carriers will find it in their best interest to seek out differentiated positions, which implies at least some heterogeneity in the sets of information hubs firm choose to invest in.

We use this assumption about carrier hetergeneity to argue that at least some carriers can complement one another. We begin by observing that since shippers do not always have fixed traffic patterns to their hauls, a shipper's traffic pattern may correlate more or less with any given carrier's information hubs; yet, it is likely that at least some hauls present origins or destinations outside of the originating carrier's information hubs. When this happens, the shipper may seek out competitive pricing yet prefer to choose a carrier with whom it has an existing relationship because locating and verifying new carriers is costly.

With an origin or destination located outside of the chosen carrier's set of information hubs, the carrier has a choice: it can assign a company driver and truck to pick up and deliver the haul and search on the market for a backhaul or it can outsource the haul to a carrier with an information hub within which is located the haul's origin or destination that is outside of the focal carrier's information hubs. Of course, if a carrier is fortunate to find a backhaul from a destination outside of its hubs or has a truck near the origin outside of its hubs then it can avoid deadheading. Without a backhaul in hand or a truck needing a backhaul, the carrier increases the likelihood of running deadhead compared to those carriers with relevant information hubs. Efficiency will drive the carrier to outsource the haul to another carrier who, on average, has a cost advantage due to its informational advantages in reducing the likelihood of deadheading.

It is this circumstance in which two carriers can complement one another and share in revenue accordingly.

In areas outside of a carrier's information hubs, it often develops relationships with other carriers (including owner-independents). Each carrier possesses its own information hubs, the union of which forms a much broader information network than the originating carrier. With a haul's origin or destination within this meta-information network, the contracted carrier has at least as good of a chance securing a complementary haul as the originating carrier. If the haul's origin or destination is in the meta-network but not in the originating carrier's network, the contracted carrier has a strictly better chance of finding a complementary haul, which ultimately lowers the shipping cost. In the latter case, the originating carrier can achieve greater efficiency by outsourcing the haul.

It is useful to point out that these complementary carriers should not be thought of in terms of a spot market. Carriers develop relationships among themselves. For instance, the company which kindly allowed us to observe its operations and collect data signs relationship agreements with a variety of carriers to form a network of complementary carriers. As with shippers, these agreements do not establish exclusivity or prices, but instead stipulate rights and responsibilities of each party should the carrier outsource to or receive a haul from another carrier. By investing in relationships with other carriers to form a meta-network, the originating carrier enhances the likelihood that either their trucks or the trucks of a contracted carrier will not deadhead. The corresponding surplus generated is shared between the carriers.

In sum, our logic thus far implies that carriers outsource hauls when the origin or destination (or both) is outside of its information hubs and when it does not already have a backhaul.

Appropriability

Our preceding logic provides an explanation for why the originating carrier may outsource those hauls with origins or destinations outside of its information hubs. The logic is not complete for assessing when it should use company drivers and trucks versus outsourcing for hauls between information hubs especially when information hubs among carriers are perfectly correlated at least for specific origin-destination pairs. For instance, why not originate the haul (i.e., receive a shipper's order) and then outsource it to another carrier? We believe that the carrier's choice derives from its incentive to appropriate returns from investments in shipper relationships.

As discussed above, carriers can complement one another when their information networks join to form a larger network. Yet, it is precisely the possibility of this overlap that can create appropriability and competition concerns. We begin by discussing appropriability concerns. For instance, when the originating carrier outsources a haul to another carrier, the outsourced carrier acquires demand information not only about the shipper but also about the destination of its hauls. Successful delivery of the haul provides at least partial verification information about the capability of the outsourced carrier. Thus, the carrier to whom the haul is outsourced can free-ride on the originating carrier's relationship investments with the shipper and thereby creating additional competition for the shippers demand. Over the long-run, such free-riding

limits returns on relationship investments and creates an incentive to underinvest in information hubs, which diminishes a carrier's competitive advantage.

One way the originating carrier can appropriate returns from its investment is to exclusively use company drivers to pick up hauls that originate within the domain of its information hubs. Employees have a lower propensity to expropriate the carrier's demand information for several reasons. Employees may identify with the firm (Chatman, 1991). Their economic interest may be aligned with the carrier more than contractors especially if employees have preferences for the traffic patterns in which the carrier has invested. Using shipper information to become an independent carrier involves both an equity investment and a substantial amount of risk compared to risk associated with being a company driver. Thus, employees are much less likely to engage in expropriation activities than are contractors (Mayer and Nickerson 2005).

Additionally, the carrier may select workers who are unlikely to start their own business and drivers may self-select to be company drivers because they prefer not to start their own business. These selection issues may systematically reduce the likelihood of expropriation by company drivers compared to outsource. So although company drivers are not immune to expropriation, they are less likely to free ride on the carrier's investments than are carriers to whom hauls are outsourced. Appropriability concerns therefore imply originating carriers will not expose shippers within their information hubs to competing carriers.

Competition

While appropriability concerns represent one dimension of competition, we highlight here another dimension. A haul that is outsourced to a competing carrier with a destination inside of an originating carrier's information hub increases competition for hauls originating within that hub. That is, an originating carrier who outsources a haul with a destination within one of its own information hubs invites other carriers to compete for hauls leaving that hub. While this competition might be diffuse in cities because of the large number of hauls and carriers competing for these hauls, outsourcing a haul nonetheless can lead to lower prices and a lower likelihood of finding efficient backhauls from an information hub. We therefore expect that an originating carrier is less likely to outsource hauls with destinations within their information hubs compared to destinations outside of their information hubs. Yet, because of the diffuse nature of this competitive effect, we expect appropriability concerns to be a much stronger predictor of organizational choice for a particular haul than this competitive effect.

To make clear how the combination of efficiency, appropriability, and competition effects work together to effect the choice of make v. buy, we offer a more formal model of our logic. We assume the dispatcher's goal is to maximize the carrier's long-run profit. His decision for organizing each haul is a bivariate choice y. Let $y = 1$ denote the decision that the dispatcher outsources the haul to another carrier and $y = 0$ be the decision that the dispatcher assigns the haul to an employee driver. For each haul, he compares the profits generated by organizing the haul as make v. buy. Let π^m and π^b denote the profit from a haul delivered by an employee driver (make) and outsourced (buy), respectively. If $\pi^m > \pi^b$, the dispatcher will assign an employee driver to deliver the haul; thus, we will observe $y = 0$. If $\pi^m < \pi^b$, the dispatcher will

outsource the hauls to another carrier; thus, we will observe $y = 1$. Suppose π^m and π^b are determined respectively by

(1) $\pi^m = f(R^m, c_1, c_2, p^m, a^m)$

(2) $\pi^b = f(R^b, c_1, c_2, p^b, a^b)$

where R^m is the revenue that the originating carrier receives from the shipper, p^m is the probability of finding a complementary haul, c_1 is the cost associated with the haul, c_2 is the cost of running deadhead, and a^m is the associated appropriation cost. In equation (1), f is increasing in R and p^m and decreasing in c_1, c_2 and a^m. Equation (2) provides the equivalent equation for outsourcing the haul. Note that we assume that f, c_1, c_2 are the same whether a haul is organized as make or buy and that only the probabilities of finding a complementary haul, the appropriability costs, and Revenue can differ. Also, note that we allocate the cost of deadheading to the focal haul; yet, if a backhaul is secured we treat it as a separate haul with neither revenue nor cost accruing to our focal haul. For simplicity, we assume that f is a linear function, so equations (1) and (2) become:

(3) $\pi^m = R^m - c_1 - (1 - p^m)c_2 - a^m$

(4) $\pi^b = R^b - c_1 - (1 - p^b)c_2 - a^b$

We use this formulation to evaluate five alternative origin-destination pairings. We refer to an origin-destination pair outside of the focal carrier's information hub network as an N-N haul. An origin-destination pair within the hub network is referred to as an H-H haul. An origin within a hub but a destination outside a hub is referred to as an H-N haul while an origin outside of a hub with a destination inside a hub is referred to as an N-H haul. Finally, we refer to an origin that is the originating carrier's break-bulk facility, which is within one of its

information hubs, and a destination outside of the information hub network as an NH-N haul. We establish this special designation because competing carriers that pick up loads at the break-bulk facility are not directly exposed to shippers, which therefore does not raise appropriability concerns. As we proceed with our logic, we will assume that H-N hauls do not include NH-N hauls.

First consider an N-N haul. We assume that revenue does not change by mode of organization. The appropriation problem is absent so that $a^m = a^b = 0$, because the carrier has information investments neither at the origin nor the destination. This conclusion also is true if the origin-destination pair is NH-N. In both pairings, the probability of securing a complementary haul alone will determine whether $\pi^m > \pi^b$ or vice-versa. As argued above, outside the originating carrier's information hubs, complementary carriers have information advantages for securing backhauls; thus, if we assume that the originating carrier is likely to outsource to a carrier with a complementary set of information hubs then $p^b > p^m$, which implies $\pi^b > \pi^m$, and hauls categorized as N-N and NH-N will be outsourced.

Now consider an N-H haul. The competitive effect discussed above suggests that outsourcing a haul with a destination into one of the originating carrier's information hubs creates an externality for other hauls. The externality arises because of the added competition in finding hauls departing from the hub. Although this externality may be diffuse, it nonetheless suggests that on average p^m for other hauls the originating carrier might be seeking from this hub may decline due to the added competition. This competition also could lower the revenue received

from other hauls because a greater number of carriers will be competing. Since appropriability is not a concern, $a^m = a^b = 0$, then $\pi^m > \pi^b$ so long as the outsourced carrier does not offer efficiency advantages with respect to a backhaul to destinations outside of the focal carrier's hub network. If, however, the outsourced carrier does offer such efficiency advantages and these advantages outweigh the competitive effects generated within the information hub then $\pi^b > \pi^m$ and the origination carrier will outsource the aul. We believe that it is reasonable to assume that in a sample of N-H hauls we would find examples of both conditions. We therefore expect a mixture of make and buy and that, on average, the likelihood of outsourcing an N-H haul will be positive but not as great as for N-N hauls.

For an H-N haul, an originating carrier is unlikely to outsource a haul if it originates at a shipper located within its information hubs because the haul poses appropriability concerns. In this case, $a^m = 0$ and $a^b > 0$.[2] Yet, with the destination outside of the originating carrier's information hubs, a complementary carrier may have an advantage in finding a backhaul in which case $p^b \geq p^m$. While we anticipate that in most instances $\pi^m > \pi^b$ because we generally expect the appropriability concerns to be greater than the efficiency benefits from complementary carriers, we cannot rule out that the efficiency advantages may be greater than appropriability concerns for some hauls. Therefore, we anticipate a mixture of make and buy such that the likelihood of outsourcing H-N hauls is positive and greater than outsourcing H-H hauls (which we discuss next) but not as great as outsourcing N-N hauls. The comparison between H-N and N-H hauls for outsourcing is indeterminate from our model.

[2] a^m is not necessarily zero because employees could expropriate shipper information. We normalize a^m and assess the impact of the relative increase in appropriation costs due to outsourcing.

Finally, consider a haul with an origin-destination pair H-H. In this case, $a^m = 0$ and $a^b > 0$. As argued above, the originating carrier's probability of finding a backhaul is at least as great as a carrier to whom a haul is outsourced; therefore, $p^m \geq p^b$. Moreover, the competitive effect discussed above suggests that outsourcing a haul with a destination into one of the originating carrier's information hubs creates an externality for other hauls that, on average, lowers the likelihood of finding backhauls. Combining this competitive effect with the appropriability concern implies $\pi^m > \pi^b$. The dispatcher is least likely to outsource H-H hauls compared to the other types of hauls discussed above.

Our logic suggests that in combination, efficiency, appropriability, and competitive concerns yield the following predictions:

H1: A haul is most likely to be outsourced when the origin and destination are external to the originating carrier's network of information hubs (N-N) or when the origin is the originating carrier's own break bulk facility and the destination is not within an information hub (NH-N).

H2: A haul is less likely than N-N and more likely than H-H to be outsourced when the origin is outside the originating carrier's network of information hubs but the destination is within a hub (N-H).

H3: A haul is less likely than N-N and more likely than H-H to be outsourced when the destination is outside the originating carrier's network of information hubs but the origin is within a hub (H-N).

H4: A haul is least likely to be outsourced when the origin and destination are both within the carrier’s network of information hubs (H-H).

Data Description and Empirical Methodology

The dataset that we use to test our prediction comes from a small-sized trucking company based in St. Louis. The carrier positions itself as providing basic truck load and less-than-truckload (LTL) hauling services. It self-reports that it has invested in three principal information hubs: St. Louis, Kansas City and Chicago. It refers to the routes among these three cities as its primary "traffic lanes". It maintains a break-bulk facility in St. Louis and maintains an employee in Chicago to collect and consolidate less than truck load shipments from different shippers. Nonetheless, the majority of hauls are truckload. The carrier uses both company drivers and outsourcing to pick-up and deliver hauls.

The haul and its mode of organization is our unit of analysis. Over a 7-week window from February 22nd, to April 16th, 1999, we observed 29 complete days of data with 472 hauls in total, delivered either by company drivers or other carriers, among which 376 hauls were delivered by 27 company drivers and 86 hauls were outsourced. For every haul, we observed organization of the haul along with detailed information on the origin-destination pair, the date of the haul, haul revenue, haul weight, the shipper, the recipient, and the driver or the carrier to whom the haul is outsourced. We also observed detailed haul characteristics such as whether the haul is LTL; involves hazardous freight; is delivery-time sensitive; whether the haul requires multiple drops; whether a penalty-provision for late delivery is charged to the carrier and, if so, the size of penalty; and how many hauls are dispatched in each day. This unique dataset gives us very detailed haul-level information which enables us to implement our empirical model for a single firm.

Figures 1 and 2 provide a visual inspection of the origin-destination pairs in our data. Figure 1 presents a map showing all the origin-destination pairs for hauls organized by company drivers during the observation window. Thicker lines represent multiple hauls between the same origin-destination pairs. The figure provides visual confirmation of our focal carrier's assertion that its primary information hubs and corresponding traffic lanes arise among St. Louis, Chicago, and Kansas City. That said, the figure also clearly shows that the carrier undertakes hauls across much of the Midwest.

Figure 2 presents an equivalent geographic map showing all the origin-destination pairs for hauls outsourced to other carriers. Visual inspection indicates that few outsourced hauls traveled between our focal carrier's principal information hubs. We also note that many of the outsourced hauls were to destinations quite distant from our focal carrier's principal traffic lanes. That said, substantial overlap of routes remains. Outsourced haul destinations do overlap with company driver destinations in Arkansas, Indiana, Illinois, Kansas, Louisiana, Mississippi, Missouri, Ohio, and Tennessee.

These two figures provide some visual confirmation to our predictions in the theory section: outsourced hauls largely started from the focal firm's warehouse in St. Louis or outside the network of information hubs with destinations outside the network of the firm's information hubs while hauls delivered by company drivers largely concentrated on the traffic lanes between pair cities in the network of the firm's information hubs. Yet, alternative explanations remain. For example, an LTL haul is less likely to be outsourced since it demands more

coordination efforts and also are more lucrative; a hazardous haul may be less likely to be outsourced since it may requires special training on the drivers. Considerations like these (and more below) cannot be evaluated by inspection of Figures 1 and 2. Therefore, a more rigorous and quantitative analysis is necessary.

Variables

Table I summarizes the variables, their definition and the corresponding predicted signs where applicable. The dependent variable, *Outsource*, is a dummy variable that takes value 1 if a haul is outsourced and takes value 0 if it is delivered by a company driver.

Origin Hub measures the distance in miles of a haul's origin to the nearest information hubs. *St. Louis Origin Hub* measures the distance in miles of a haul's origin to the focal firm's warehouse in St. Louis. Similarly, *Destination Hub*, measures the distance in miles of a haul's destination to the nearest information hub. From these three continuous variables, we construct the main explanatory dummy variables that allow us to test our four hypotheses in Section II.

Dummy variable *H-H* is equal to 1 if both *Origin Hub* and *Destination Hub* are less than 15 miles[3], i.e. if the haul originated and destined within 15 miles from the center of one of the

[3] We chose the 15 mile radius in part because it seemed a reasonable approximation for locus of economic activity within the information hubs studied. We also evaluated different radi ranging from 5 miles to 25 miles with increments of 1 mile. A radius 15 miles yielded the highest pseudo-R^2. Our results do not change substantively by selecting another radius with this range.

information hub cities. *NH-N* is equal to 1 if a haul originated from the St. Louis warehouse with a destination outside the 15 radius of any of the hub cities; *NH-N* equals to 0 otherwise. *N-H* is equal to 1 if the haul originated outside the 15 radius of any of the hub cities with a destination inside the 15 mile radius of any of the hubs; *N-H* is equal to 0 otherwise. *H-N* is equal to 1 if the haul originated within 15 miles of any of the hub cities with a destination outside the 15 mile radius of any of the hub cities (but excludes those hauls identified as *NH-N*). Finally, *N-N* is equal to 1 if the haul originated outside the 15 mile radius of any of the hub cities with a destination outside the 15 mile radius of any of the hubs; *N-N* is equal to 0 otherwise. These 5 dummy variables indicate the origin-destination situation of a haul, which are necessary for testing the hypotheses.

N-N is our omitted category. Thus, according to hypothesis H1, the coefficient for *NH-N* should not be statistically different from zero. Hypothesis H2 predicts that the coefficient for *N-H* is negative. Hypothesis H3 also predicts that the coefficient for *H-N* is negative. Hypothesis H4 not only predicts that the coefficient for *H-H* is negative but also that is more negative than the coefficients for *NH-N*, *N-H*, and *H-N*.

Our remaining variables are controls. *Revenue per Mile* is the amount of revenue that the focal carrier received from the shipper divided by the total mileage of the trip, which is directly related to the profitability of a haul. Because higher *Revenue per Mile* is positively associated with higher profitability it may be in the carrier's best interest to use company drivers to retain these hauls. Alternatively, the carrier might instead outsource the hauls keeping excess profits.

Therefore, we offer no prediction for this control variable.

LTL is a dummy variable indicating whether a haul is "less-than-truckload", which is a standard term used in the trucking industry. *LTL* is relevant because LTL hauls demand more inter-haul coordination since carriers bundle multiple loads in to a single hauls, which is more lucrative and highly sought-after. Prior research suggests that carriers utilize company drivers for LTL hauls (see Nickerson and Silverman 2003).

Hazardous is a dummy variable indicating whether the haul is hazardous or not. Hazardous freight usually requires more caution during loading/driving along with a certain level of driver training; these requirements suggest the use of company drivers who can be given low powered incentives appropriate for these requirements. The predicted sign of the coefficient is negative.

Delivery Sensitivity is a dummy variable indicating whether the delivery of a haul is time-sensitive or not. Extent theory predicts the sign of this coefficient to be negative because such hauls need added scheduling and delivery effort and tend to have negative effect on the trucking company's reputation if the delivery does not meet the time requirement (Nickerson and Silverman 2003).

Multi-Drop is a dummy variable indicating whether a haul has more than one drop-off location. Such hauls, similar to the LTL hauls, require more coordination and scheduling effort thus are

less likely to be outsourced. The difference between *Multi-Drop* hauls and *LTL* hauls that the former comes from the same shipper while the latter comes from multiple shippers. The predicted sign of this coefficient is negative.

Penalty Provision is a dummy variable indicating whether there is penalty provision in the delivery contract. This variable indicates a risk factor in the delivery service. The carrier might employ a company driver if the carrier offers superior delivery time performance. Alternatively, the carrier may want to pass on the risk to the other carriers. We leave whether the coefficient is expected to be positive or negative as an empirical question.

Capacity Unfilled measures how much of the carrier's trucks were left unfilled each day. We expect that unfilled capacity will positively affect the likelihood of using company drivers. Unfortunately, our data didn't provide us with the carrier's capacity per se. So, we used the number of drivers in the observational period as a proxy for the capacity of the firm. This proxy may overestimate the capacity of the firm since drivers may drop or join the firm during the observational window. We will return to this point in the discussion session.

Table 2 reports summary statistics and correlations for our variables. About 18% of the hauls in the sample were outsourced. The average distance between origin and the nearest information hub is 69 miles with a standard deviation of 95 miles, while the average distance between destination and the nearest information hub is 160 miles with a standard deviation of 151 miles. The maximum is 1070 miles. Approximately 9% of the hauls originated and

terminated within 15 miles of one of the hubs (*H-H*). About 11% of the hauls originated from St. Louis, which we presume originated at the carrier's break-bulk facility[4], and terminated at least 15 miles outside any of the hubs (*NH-N*). About 25% of the hauls originated within 15 miles of any information hub (but except for those originating from St. Louis warehouse) and terminated at least 15 miles outside any hub (*H-N*). About 5% of the hauls originated outside a radius of 15 miles of a hub and destined within a 15 miles radius of one of the hubs (*N-H*). About 49% of the hauls originated and terminated at least 15 miles outside any of the hubs (*N-N*). *Revenue per M*ile averaged $1.2 per mile with a standard deviation of 0.46. *LTL* hauls accounts for 12% of the sample. *Hazardous* hauls accounts for 2% of the sample. Approximately half the hauls are delivery-time sensitive. About 19% of the hauls have multiple drop-off locations and 10% of the hauls have penalty provisions in the delivery contract. Using the number of drivers in the observational period as a proxy for capacity, there is unfilled capacity every day during the sample period.

Empirical Methodology

We analyze our data with a Probit model because our dependent variable is bivariate. The Probit model takes the form of:

$$y_i^* = \beta X_i + u_i$$

$$y_i = 1 \text{ if } y_i^* > 0, \text{ 0 otherwise.}$$

[4] Unfortunately, we were unable to identify whether the haul originated at the carriers break-bulk facility or from elsewhere in St. Louis city. With the inability to precisely distinguish origination, our estimated coefficient may be biased downward since the collection of NH-N hauls will likely include both hauls originating with shippers in St. Louis city as well as hauls originating at the break bulk facility.

where y = 1 if a haul is delivered by another carrier and 0 if a haul is delivered by a company driver.

X is a vector of variables which includes *H-H*, *NH-N*, *N-H*, *H-N, Revenue per Mile, LTL, Hazardous*, *Delivery Sensitivity*, *Multi- Drop*, *Penalty Provision*, and *Capacity Unfilled*. *N-N* is our omitted variable so all the estimated coefficients are relative to that of NN. We assume that the error term u_i follows an i.i.d normal distribution.

Results

Table 3 reports the estimated coefficients of the explanatory variables in our Probit model. Note that we develop signed predictions for all variables except *Revenue per Mile*, which implies one-tailed t-tests are appropriate for examining the statistical significance of our data. We first estimated Model A with only the control variables as the explanatory variables. The coefficients for *LTL*, *Delivery Sensitivity*, and *Multi-Drop* all are negative and highly significant ($p<0.01$) as predicted. The carrier is more likely to use company drivers when these conditions are present. Similarly, the coefficient for *Capacity Unfilled* also is negative and significant ($p<0.05$), which implies that the carrier is more likely to use company drivers when spare capacity is available. The coefficient for *Revenue per Mile* is positive and weekly significant using one tailed-test. As mentioned above, a two-tailed test is appropriate for this coefficient since we have no clear prediction for sign. With this latter test, the coefficient is not statistically significant.

We then estimated Model B, which includes *H-H, NH-N, H-N and N-H*. The estimated coefficients of the same control variables in both models mostly have the same sign and are of the same order of magnitude. However, the Psuedo-R^2 from Model B is 0.22 while that of Model A is only 0.12. Also our χ^2 statistic increased to 196.5 from 143. 05, which is statically significal. This change in Psuedo-R^2 along with our χ^2 statistic indicate a significant improvement in the fitness of the model, i.e., the explanatory variables *H-H, NH-N, H-N and N-H* do explain a significant amount of the variation in the dependent variable.

We begin by assessing the coefficient estimates for our control variables. Coefficient magnitudes and levels of statistical significance are the same except for two variables. The coefficient for *Revenue per Mile* is now positive and significant (using one-tale as well as a two-tail test). Our carrier is more likely to outsource hauls that yield a high revenue per mile. The coefficient for *Multi-Drop* remains negative and significant although at a lower level ($p<0.05$) of statistical significance. We now assess the coefficient estimates for our hypothesis variables.

Variable H-H is negative and significant ($p < 0.05$), indicating a significant decrease in the likelihood of outsourcing of haul compared to when the origin-destination pair is *N-N*. This conforms to the predications of part of hypothesis H1 and hypothesis H4: hauls with external (internal) origin-destination pair are more (less) likely to be outsourced. The negative and significant coefficient for *NH-N* causes us to reject that portion of Hypothesis 1 that predicts the likelihood of outsourcing to be no different than for *N-N*. The estimated coefficient of

variable *H-N* is negative and significant ($p < 0.05$). This result supports Hypothesis 3 which predicts that hauls originating from information hubs and terminating outside any information hubs are less likely to be outsourced compared to *N-N* hauls. The coefficient for *N-H* is negative and weakly significant ($p < 0.10$), which indicates that hauls originating outside of an information hub but terminating within up are more likely than *N-N* hauls to be outsourced. This estimate is consistent with Hypothesis 2

Note that magnitude of the estimated coefficient of variable *H-H* is larger than that of *NH-N*, *N-H*, and *H-N*, which is what we predict. Chi-square tests indicate that the estimated coefficient of *H-H* is significantly different from the estimated coefficients of *NH-N*, *H-N* and *N-H*. The coefficients for *NH-N*, *H-N* and *N-H* are not significantly different from one another.

Table III also reports the marginal effects of the explanatory variables in Model B. We computed the marginal effect of our main explanatory variable *H-H*, *NH-N*, *H-N*, and *N-H* while holding *Revenue per Mile* and *Capacity Unfilled* fixed at their mean level and all other binary dummy variables at 0. The last column of Table III implies that the main explanatory variables are economically significant. If a haul has an *H-H* origin-destination pair, the likelihood of its being outsourced is 14% lower than a haul with internal origin-destination pair. Similarly, a haul with an *NH-N* origin-destination pair is 12% less likely to be outsourced; a haul with an *H-N* origin-destination pair is 15% less likely to be outsourced; and a haul with an *N-H* origin-destination pair is 10% less likely to be outsourced. These results imply an economic significant impact of efficiency, appropriation, and competition concerns in the

dispatcher's outsourcing decision. Note that marginal effect of *H-H* is bigger than that of *N-H* and *H-N* as we predicted.

Table 3 also shows that some of the control variable are economically significant. For instance, the marginal effects of the bivariate variables *LTL*, *Delivery Sensitivity*, and *Multi-Drop* are negative and imply that a hauls is less likely to be outsourced by 12%, 12%, and 11%, respectively, when these haul attributes are present. The marginal effects of the variables *Hazardous* and *Penalty Provision* are not significant, indicating that hazardous hauls or hauls with penalty provision do not influence the dispatcher's decision to use an employee driver or to outsource. The marginal effect of the continuous control variable *Revenue per Mile* is 10%, indicating that small increases in revenue per mile above the mean level have a substantial impact on the make or buy decision, increasing the likelihood of outsourcing the haul.. The marginal effect of *Capacity Unfilled* is negative 1% at its mean level, indicating that if there is one more company truck idling, a haul would be 1% less likely to be outsourced. Although this effect is statistically significant, economic significance is lacking.

Discussion

Our theory predicted that trucking firms use company drivers as well as outsource hauls for reasons of efficiency, appropriability concerns, and competition. A central feature in our theory was the notion of a network of "information hubs" in which carriers invest to identify and develop relationships among shippers who will likely demand hauls between city-pairs in the network. The fact that some carriers invest in correlated but different networks creates the

opportunity for efficiency gains by outsourcing those hauls for which other carriers have an informational advantage in generating backhauls. Demand-side appropriability concerns create an incentive for the originating carrier to internalize hauls originating from shippers within their information hubs. Competition provides an incentive, albeit a weaker one than for appropriability, to retain hauls with information hubs as destinations.

Our empirical results provide broad support for our theory. We found statistically significant evidence that originating carriers are most likely to "make" those hauls with origin-destination pairs within the network of information hubs and most likely to "buy" those hauls with origin-destination pairs outside of the network. Hauls with only one leg haul either originating or terminating in a hub were more likely to be outsourced than hub-to-hub hauls but less likely to be outsourced than outside of hub-to-outside-of-hub hauls. The one empirical discrepancy between our theory and empirical results arose because the coefficient for *NH-N* is negative and significant. One reason for this significance is that we were unable to distinguish in our data if a haul from St. Louis originated from the carrier's break-bulk facility or from a shipper's location. If both types of hauls existed, then we should expect the coefficient to be negative and significant reflecting that some hauls were *H-N* instead of *NH-N*. Yet, another explanation is possible. For competitive reasons similar to the one we described above, the carrier may not want to encourage competing carriers terminating hauls in St. Louis because it can increase the competition for hauls originating in the city. The magnitude of the *NH-H* coefficient is not statistically different from the coefficients for *N-H* and *H-N*, which is consistent with this latter explanation.

While our empirical analysis provides support for our theory, several alternative explanations are possible. Porter might argue that tapered integration may derive from a desire to accumulate bargaining power in the trucking industry. We argue that bargaining power offers an unlikely explanation for the use of make and buy in the trucking industry. For instance, if the purpose of making *and* buying is to accumulate bargaining power then the hauls delivered by company drivers should be the same or at least similar to those outsourced, because only then could the firm infer from its own operation the costs incurred by the outside carrier. Our data does not support this conclusion. As shown by our regression results, outsourced hauls are significantly different from the hauls delivered by company drivers in several aspects: outsourced hauls had higher revenue per mile; they are unlikely to be LTL, or time sensitive, or have multi-drops. More fundamentally, we wouldn't expect bargaining to lead to different rates of outsourcing based on the location of origin-destination pairs.

Another alternative explanation is that the originating carrier outsources because of a capacity constraint. For instance, the carrier may outsource when facing an unexpected surge in demand. In other words, outsourcing is a means to deal with uncertainty in demand. We considered this possibility and found it to be consistent with the data. Table 3 displays that the coefficient for variable *Capacity Unfilled* is significant, i.e. given a fixed capacity of the focal firm, whether there is idle capacity or not does affect the firm's dispatching decision. Yet this explanation does not have sufficient currency to explain all decisions. Indeed, our hypothesis variables remain significant controlling for unfilled capacity.

Examining the data, we found that the majority of days during our sample period had unfilled capacity yet the firm outsourced, even when we use different measures of capacity. Of course, measuring capacity can be difficult in the trucking industry since equipment can be rented; therefore, we focused our attention on the number of company drivers available to the carrier. During our observation window the carrier employed 27 drivers. Due to the possibility of hires and fires, this proxy may overestimate capacity so we also investigated alternative measures of capacity. The maximum number of drivers utilized on any given day was 23. Figure 4 examines these two measures of capacity and compares these to the number of hauls driven by drivers—"make"—as well as those outsourced—"buy"—during the observation window. Note that the number of hauls driven by company drivers is substantially below the carrier's driver capacity even on those days when the number of outsourced hauls is large. This observation might indicate that all drivers were not available everyday, which suggests that the maximum number of company drivers utilized on any given day might be a better measure of driver capacity. Yet, even with this measure of capacity, we find that the carrier outsources hauls even when the number of hauls per day is substantially below the capacity. For instance, day 28 had a total of 11 hauls, three of which were outsourced. We conclude that a short-run capacity constraint is not driving the decision to outsource.

Agency theory provides yet another alternative explanation. Trucks have long been deemed the prototypical user-owned asset by agency theorists because it is relatively easy to measure individual drivers' performance while at the same time it is relatively difficult to measure

maintenance efforts (see Alchian and Demsetz, 1972; Milgrom and Roberts, 1992). Nickerson and Silverman (2003) argued that externalities and vehicle idiosyncrasy help to explain why the prediction of the agency theory does not conform to what we observe in trucking. Yet, it seems that their argument is incomplete. Our data set does not involve the externality reported by Nickerson and Silverman (2003) and all the trucks are standard. In this case, classic agency theory would predict outsourcing of hauls presumably to owner-independents. Our data does not conform to this prediction; therefore, we conclude that classic agency theory does not explain the pattern we observe in the data.

Similar to agency theory, property rights theory predicts that the driver should own trucks since drivers have more influence on the variation of profitability (Grossman and Hart, 1986). Property right theory does not explain why some trucking firms' decision to make and buy. Moreover, this theory does not predict that a trucking firm should discriminate between employee drivers and outsourcing on a haul-by-haul basis. Therefore, we conclude that property rights theory does not explain the empirical phenomenon identified in our data set.

Another possible explanation is that drivers have experience with specific customers or with a specific region and that it is this experience that accounts for the pattern of make v. buy. However, we think this explanation is unlikely. In our Probit analysis we cluster on the customer identifcation, which accounts for the extent to which diriver experience is matched with a specific customer. Thus, our results account for customer-related driver experience. Of course, driver experience also may be with respect to a particular geographic region. We

unfortunately do not have information on drivers for the outsourced hauls and therefore can not directly account for the possibility of that regional experience determines haul assignment. Nonetheless, this explanation is doubtful because most trucking firms at the time of our study have software, which is inexpensive, that provides precise maps to drivers of how to get from point A to point B. In fact, we used the software the firm owned to locate origin and destinations and to calculate traveling distances from one point to another. The software accounts for speed limits, road construction, and other issues that may impact driving time in determining the optimal route. Moreover, discussions with management gave no suggestion that a key factor in haul assignment decisions was driver knowledge of a region.

Finally, our dataset only spanned a seven week window because collecting this data was costly requiring a researcher on site four hours a day. Thus, we can not exclude the effect of seasonality in the empirical results. The pattern we observed from the data might change substantially if we had longer observational period. Yet, interviews with company personnel suggest that the pattern of outsourcing was not unusual compared to other times of the year.

While these alternative explanations do not appear to hold, the efficiency, appropriability, and competition concerns that combine to create our theory are not individually new. For instance, others have noted that firms in the trucking industry compete with one another but also can complement one another (Silverman et al., 1997). More generally, appropriability concerns, as highlighted in the introduction, are not new. The value of our theory stems from the combination of all three concerns. Together, these concerns combine to generate an admittedly

nuanced theory about which transactions are outsourced and which are internally organized. Also, our focus on appropriability is on the demand-side—relationships that provide demand—rather than on the supply-side such as intellectual property on which most research on appropriability focuses.

Although our theory is developed in trucking industry, it nonetheless begs the question to what extent do such efficiency, appropriability, and competitive concerns apply more generally to other industries? We maintain that these concerns are not unique to the trucking industry. Many industries display conditions in which tasks are in essence outsourced to potential competitors and for which competitors can complement each other. For instance, other transportation segments like airlines display similar circumstances where competitors sometimes cooperate in hauling passengers. Ingram and Roberts (2000) identified such horizontal competition and cooperation in the Sidney, Australia, international hotel market. IT project outsourcing is often organized both internally as well as with contractors (Nickerson and Mayer, 2005). Demand-side appropriability from investments in customer relationships is a key concern for considering this organizational choice; however, this hazard is not fully considered in the literature. Investment banking activities in which firms often collaborate in syndicates but also compete for lead underwriting displays similar parallels with respect to complementing and competing. Here again, we maintain that appropriating returns in investments in customer relationships is an important consideration. While the application of our theory to these and other contexts must be worked out for the specific context, the parallels appear strong enough to suggest that these conditions may be common to many industries. Our

theory thus may have applicability beyond the trucking industry.

If this applicability is born out in other industries then our theory offers several prescriptions for managers. Our theory is consistent with the notion found in the network literature (e.g., Brown and Butler, 1995; Ingram and Roberts, 2000) that competitors can benefit by cooperating in horizontal networks. For instance, large generalist firms might benefit by outsourcing certain tasks to specialists or groups of small firms might work together as a network to compete against large firms. That said, our theory draws attention not only to the cooperative effects but also the demand-side appropriability hazards that can arise with cooperation. Such network modes of cooperation can only arise if firms can appropriate returns from investments in customer relationships. Cooperation among firms where appropriability concerns are present and can not be mitigated is unlikely to occur. One obvious response is to seek out ways to increase appropriability perhaps through contracts and intellectual property. For instance, firms might sign long-term contracts such as those found between large hub-and-spoke airlines and regional airlines. These legal means notwithstanding, other avenues are available. Large airlines choose to control information systems, selling, and customer interactions so that, in part, regional carriers could not easily take customers with them should the exit the contractual agreement. Our theory points to improving appropriability by using employees to interact with customers and in doing so increase the appropriability of relationship investments.

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Table 1: Variables Definitions and Predicted Signs

Variables	Variable Description	Predicted Sign
Outsource	=1if a haul is outsourced, else 0.	Dep. var
H-H	=1 if both the origin and destination of a haul are in the hubs, else 0.	-
NH-H	=1 if origin of a haul is in St. Louis and destination is not in the hubs, else 0.	-
H-N	=1 if origin of a haul is in either Chicago or Kansas City and destination not in the hub.	-
N-H	=1 if origin is not in the hub but destination is in the hub, else 0.	-
N-N	=1 if origin is not in the hub but destination is in the hub, else 0.	
Revenue per Mile	revenue received from shipper divided by delivery mileage	-/+
LTL	dummy variable indicating whether a haul is LTL	-
Hazardous	dummy variable indicating whether a haul is hazardous	-
Delivery Sensitivity	dummy variable indicating whether a haul is delivery time sensitive	-
Multi-Drop	dummy variable indicating whether a haul has multi-drops	-
Penalty Provision	dummy variable indicating whether a haul has penalty provisions	-

Note: in/not in the hub in this table are defined as "within/outside a radius of 15 miles of any of the hubs"

Table 2: Summary Statistic and Correlations

	Variable	Mean	Std.Dev	Min	Max	4	5	6	7	8	9	10	11	12	13	14	15
1	*Outsource*	0.18	0.39	0	1												
2	*Origin Hub*	69.09	94.51	0	477.03												
3	*Destination Hub*	160.46	150.97	2.54	1069.97												
4	*H-H*	0.09	0.29	0	1	1											
5	*NH-N*	0.11	0.31	0	1	-0.11	1										
6	*H-N*	0.25	0.43	0	1	-0.18	-0.20	1									
7	*N-H*	0.05	0.22	1	1	-0.07	-0.08	-0.13	1								
8	*N-N*	0.49	0.50	0	1	-0.32	-0.36	-0.58	-0.23	1							
9	*Revenue per Mile*	1.26	0.46	0.28	4.25	-0.10	0.26	-0.15	0.01	0.01	1						
10	*LTL*	0.12	0.32	0	1	0.25	0.02	0.03	-0.05	-0.16	-0.04	1					
11	*Hazardous*	0.02	0.15	0	1	0.24	-0.01	-0.02	-0.03	-0.1	0.01	0.08	1				
12	*Delivery Sensitivity*	0.52	0.50	0	1	0.02	0.15	-0.11	0.05	-0.04	-0.07	0.02	0.04	1			
13	*Multi-Drop*	0.19	0.39	0	1	0.00	-0.10	0.29	-0.01	-0.18	-0.14	-0.06	-0.07	-0.05	1		
14	*Penalty Provision*	0.10	0.30	0	1	-0.11	-0.05	-0.15	0.04	0.2	0.24	-0.05	-0.01	-0.15	0.03	1	
15	*Capacity Unfilled*	10.71	3.63	3	18.00	-0.05	0.04	-0.15	0.04	0.12	0.15	-0.09	-0.01	-0.05	-0.32	0.11	1

Table 3: Probit Estimations

Variables	*Model 1*		*Model 2*		*Marginal Effects*
H-H			-1.50	*	-0.14
			(0.70)		(0.07)
NH-N			-0.97	*	-0.12
			(.51)		(0.07)
H-N			-1.04	*	-0.15
			(.57)		(0.10)
N-H			-0.85	†	-0.10
			(0.56)		(0.07)
Revenue per Mile	0.41	†	0.55	**	0.10
	(0.26)		(0.20)		(0.04)
LTL	-1.11	**	-1.07	**	-0.12
	(0.24)		(0.35)		(0.04)
Hazardous	-0.59		-0.05		-0.01
	(0.60)		(0.48)		(0.09)
Delivery Sensitivity	-0.58	**	-0.61	**	-0.12
	(0.15)		(0.14)		(0.05)
Multi-Drop	-0.99	**	-0.78	*	-0.11
	(0.33)		(0.34)		(0.05)
Penalty Provision	0.12		-0.47	†	-0.07
	(0.30)		(0.36)		(0.068)
Capacity Unfilled	-0.04	*	-0.06	**	-0.01
	(0.02)		(0.02)		(0.00)
Constant	-0.51		-0.11		
	(0.64)		(0.62)		
Psuedo R^2	0.12		0.22		
χ^2	143.05	**	196.50	**	
No. of Observations	472		472		

** p< 0.01, * p<0.05, † p<0.10, one-tailed tests.

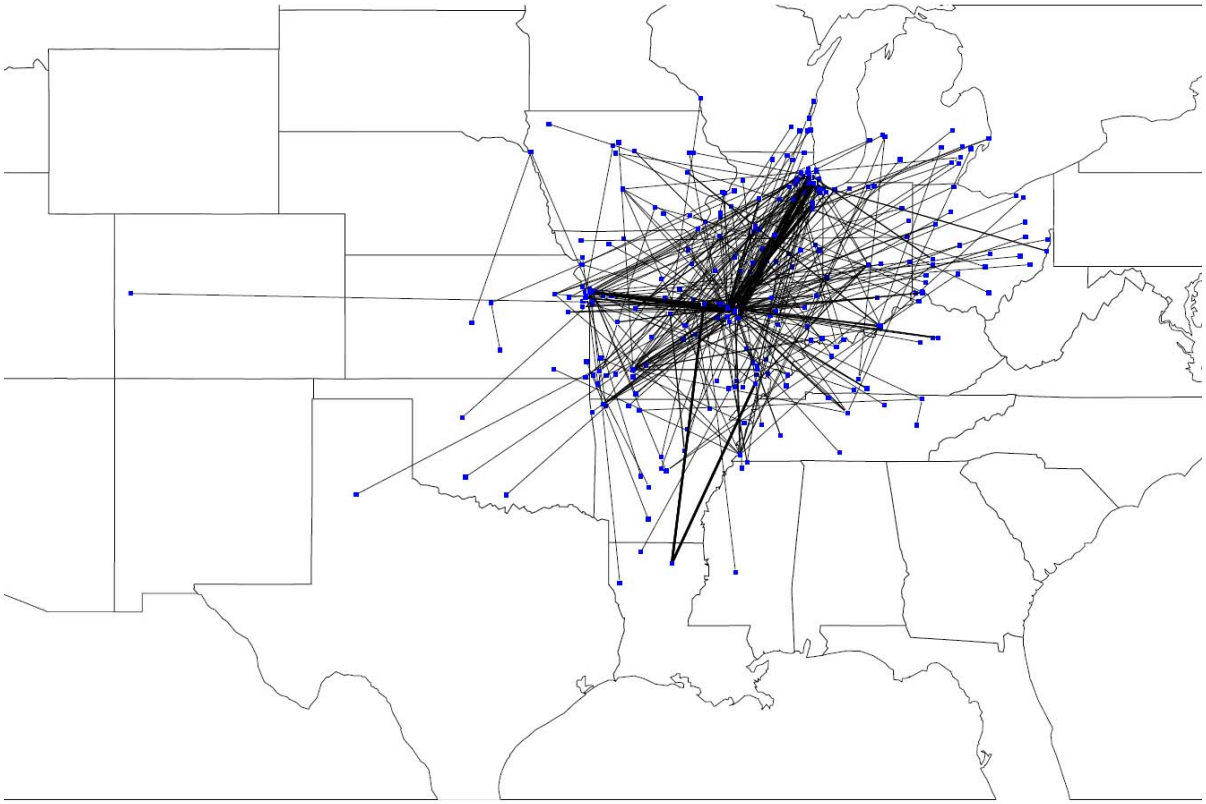

Figure 1: Origin-destination pairs for hauls organized by company drivers

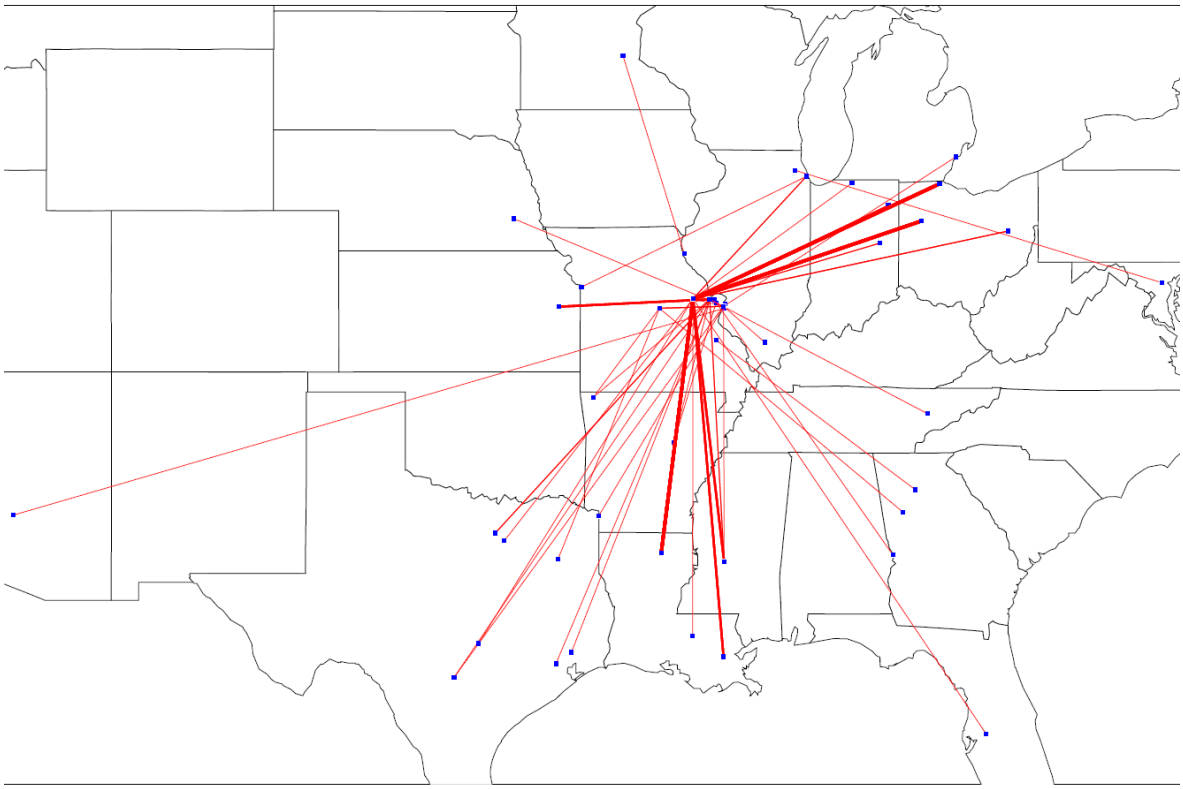

Figure 2: Origin-destination pairs for outsourced hauls

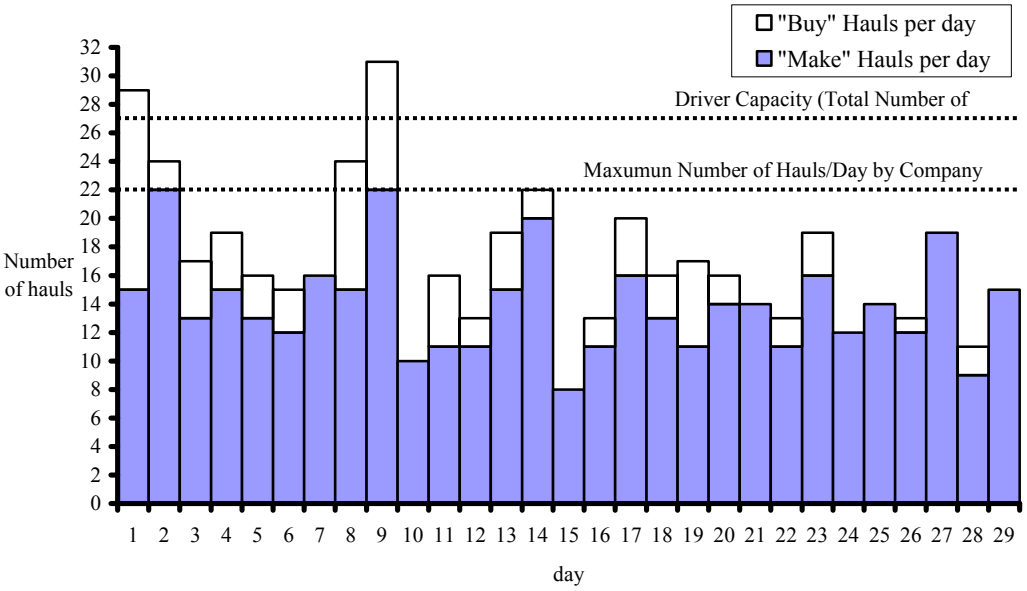

Figure 3: Proportion of Total Company Drivers Utilized Each Day