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PROFITABILITY, TRANSACTIONAL ALIGNMENT, AND ORGANIZATIONAL MORTALITY IN THE U.S. TRUCKING INDUSTRY

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The winds of creative destruction rarely blow more fiercely than in a newly deregulated environment. Managers simultaneously face a novel focus on operating efficiency and an onslaught of new competitors. What must managers do to enable their firms to survive in such an environment? What factors bear on firms' survival?

This paper presents an analysis of mortality of large motor carriers in the U.S. interstate for-hire trucking industry after deregulation. It examines this phenomenon through a multidisciplinary lens that encompasses organizational ecology, neoclassical economics, and transaction cost economics. The paper posits that carrier mortality is a function of both firm-level and industry-level attributes, which are drawn from both ecological and economic theories. While each of these theories separately informs motor carrier mortality, the inclusion of predictions derived from both disciplines in one model significantly increases explanatory power over either theory evaluated alone. The empirical analysis is among the first to show increased mortality when firms do not adhere to operating policies consistent with transaction cost minimization principles. In sum, managers are well advised to adopt a multidisciplinary approach to strategy to ensure their firms' survival. © 1997 by John Wiley & Sons, Ltd.

INTRODUCTION

Managing in a newly deregulated environment is a crucial strategic problem. In the last 15 years, many domains of economic activity have been deregulated, privatized, or otherwise removed from the relative calm of government protection in the name of increased innovation, customer responsiveness, or national competitiveness. On what should managers focus during these turbulent times to enhance their firms' chances of survival? This study provides some exploratory findings concerning the degree to which managers must consider both organizational and economic issues as they devise strategies to survive the shock of deregulation.

Firm survival and failure have been studied through at least two distinct lenses: economics and organizational theory. The economics lens focuses on market forces that enable more efficient firms to drive out their less efficient competitors (Tirole, 1988). As competition in a market increases, either due to increased supply or reduced demand, the pressure on less efficient firms to exit increases accordingly. Organizational ecologists similarly agree that populations of organizations expand and contract as resources of various kinds become more or less abundant (Hannan and Freeman, 1989). While acknowledging the role of market competition, organizational ecologists typically emphasize the role of socially driven criteria such as political or institutional ties in determining which firms survive and which exit.

While most economists tend to view noneco-

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nomic factors that shape markets as uninteresting, organizational ecologists tend to view efficiency considerations as uninteresting. The fact that each theory focuses on a different set of firm and industry attributes does not indicate that the theories are in conflict; rather, this difference suggests potential complementarity. Indeed, Barron and Hannan (1994) assert that the complementarity between the two theories creates 'the potential for serious engagement between economics and sociology.' While the tendency for each discipline to define the core concerns of the other as irrelevant may be acceptable by researchers working exclusively in one tradition or the other, when the source of interest is normative—as in the case of strategic management—research will benefit by embracing all known, or suspected, factors driving mortality.

This study addresses the above issues by investigating organizational failure in the U.S. interstate for-hire trucking industry. The paper relies on an unusually detailed data base to evaluate empirically several efficiency-based selection criteria within an organizational ecology framework. In particular, we explore the extent to which profitability and transaction cost predictions of organizational alignment extend traditional organization ecology explanations for organizational mortality.

Our study makes two contributions to the understanding of organizations, economics, and strategy. First, this is among the first ecological studies to include economic performance metrics for individual organizations. While prior organization research has shown that firms exhibiting poor economic performance are more likely to go bankrupt than well-performing firms (Hambrick and D'Aveni, 1988), the lack of firm-specific performance measures has generally precluded incorporation of this important factor in population-level analysis. In addition, our incorporation of organizational alignment metrics based on transaction cost predictions enables us to analyze forms of heterogeneity in organizational populations that have been previously ignored. Our study thus extends recent research by organizational ecologists into the effects of regulation and deregulation on existing organizations in a population (e.g., Haveman, 1992; Ranger-Moore, Banaszak-Holl and Hannan, 1991).

Second, virtually all prior research in transaction cost economics has relied on cross-sectional studies to investigate the degree to which transactions are aligned according to transaction cost principles throughout a population (or sample of a population) of firms. While there is by now a large body of such research supporting TCE (Shelanski and Klein, 1995), these cross-sectional studies have rarely directly supported the performance implications of TCE. By incorporating transaction cost measures into an ecological study, we are able to directly examine the effects of transactional alignment on organization survival.

Our empirical analysis finds that efficiency-based and ecologically based selection mechanisms do function as complements. As compared to the baseline case in which ecological variables alone are used to predict mortality, or an alternate baseline that relies solely on economic variables, the joint consideration of economic and ecological measures significantly increases our model's predictive ability. At the same time, the combination of these measures in a single model has virtually no effect on the magnitude and statistical significance of either our ecological or our economic variables. In other words, each theory describes a partial mechanism by which organizations are selected out. If they are to manage the transition to deregulation successfully, managers must be cognizant of both economic and ecological influences on their firms' performance. While our data are in some respects incomplete—as is described in detail below, the data are left-truncated and subject to size bias—and some of our measures necessarily crude, this study provides an empirical foundation for extending and integrating formerly disconnected theories.

THE U.S. FOR-HIRE TRUCKING INDUSTRY[1]

While the U.S. for-hire trucking industry was born at the turn of this century, it remained something of a curiosity until the First World War. Railroads (and incumbent motor carriers),

[1] 'For-hire' trucking refers to motor carriage provided by stand-alone transportation firms. It is distinguished from 'private' trucking, which refers to in-house provision of motor carriage (e.g., Frito-Lay's own trucking fleet). Since 1935, regulations have strictly prohibited private trucking fleets from carrying any freight other than that belonging to their parent firms.

threatened by the dramatic increase in entry during the 1920s, lobbied intensely for regulatory constraints on price and entry (Stigler, 1971; Childs, 1985). As a result, the U.S. for-hire trucking industry was placed under regulatory supervision of the Interstate Commerce Commission (ICC) in 1935. The ICC severely restricted entry of new firms and expansion of existing motor carriers. At the same time, regional price bureaus were established to set route and freight-specific price floors for motor carriage services, thus enabling motor carriers to earn significant rents, a portion of which was extracted by unionized labor (Moore, 1973; Rose, 1987). This arrangement persisted until the Carter administration pushed regulatory reform of the industry through Congress in 1980. The reform process essentially deregulated entry and price, which led to a dramatic increase in entry and severe downward pressure on prices (Robyn, 1984; Corsi *et al.*, 1992).

Under ICC supervision, a new entrant (or current carrier seeking to expand the scope of its business) had to file a request for certification to operate. If this request was protested by a carrier currently serving the entrant's proposed market, then the burden fell on the prospective entrant to prove that its proposed service was 'required by the present or future public convenience or necessity.' Existing carriers nearly always protested and, as a U.S. District Court observed in 1967, the ICC never issued a certificate affecting another carrier until the other carrier '[had] been furnished an opportunity either to improve or correct his service to such route or decide whether he wishes to ... furnish the added service sought by the applicant' (United States v. Dixie Highway Express, Inc., 1967). Thus, between 1960 and 1975 the number of ICC regulated carriers remained virtually unchanged, shrinking from 16,276 to 16,005. Although some entry and exit occurred, the population was essentially stable. The period of deregulation has witnessed tremendous increases in both entry and exit of motor carriers, as the once-placid industry has become the site of intense competition. Indeed, by the end of 1991 some 47,890 ICC certified carriers were in operation.

For the purposes of this study, three features of trucking firms are salient. First, for-hire motor carriage is generally divided into two types of carriage. The first, known as less-than-truckload (LTL) carriage, involves the movement of shipments of under 10,000 pounds (United Parcel Service is a familiar example of this type of transport). The second, known as truckload (TL) carriage, involves the movement of shipments of 10,000 pounds or more directly from origin point to destination point. These two types of carriage require significantly different types of investment and organization by participating firms. LTL carriage typically uses a hub-and-spoke system to efficiently consolidate and distribute freight from multiple origin points to a single destination point, and from a single origin point to multiple destinations. This network frequently requires specialized investments in 'breakbulk' facilities—large warehouses with dozens of trailer-sized garage doors and loading ramps to allow rapid unloading, sorting, and reloading of freight onto trucks—to efficiently route freight.[2] While breakbulk facilities can be redeployed for other uses such as manufacturing, the multitude of garage doors and loading ramps have little value outside LTL carriage and thus amount to a degree of industry-specific specialization. Moreover, if only a small number of carriers haul a sufficiently large volume of freight to the environs of a given breakbulk facility, and thus are in a position to fully utilize the facility, it is likely to be highly 'illiquid' (Shleifer and Vishny, 1992). LTL carriage also often involves investment in specialized logistical systems to manage these highly interdependent freight flows (Boyer, 1993). By contrast, the door-to-door nature of TL carriage obviates the need for much of this investment. Thus, LTL carriage tends to require a comparatively greater investment in idiosyncratic or illiquid assets than does TL carriage.[3]

Second, firms can rely on company drivers, for which the carrier owns, leases, or rents vehicles, or on independent owner-operators ('independents') to haul their freight. A large number of firms use a mixture of the two employ-

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[2] While most carriers engaged in LTL carriage rely on breakbulk facilities, not all carriers employ them. Some carriers engaged on LTL carriage, such as USF Holland Motor Express, use larger end-of-line terminals instead of intermediate breakbulk facilities to consolidate freight. Nevertheless, the use of terminal networks is central to LTL carriage. (We thank one of our reviewers for pointing this out.)

[3] An LTL firm's investments in facilities and information systems are idiosyncratic—firm-specific—to the extent that the next-best use of these assets yields markedly less value than their first-best use (Klein, Crawford, and Alchian, 1978).

ment modes. Of the carriers for which information is available in 1989, 40 per cent relied solely on company drivers, 9 per cent relied solely on independents, and 51 per cent employed both company drivers and independents. Nickerson and Silverman (1996) argue that the choice of employment relation for drivers can be explained through the application of transaction cost principles. In particular, three attributes of motor carriage transactions—performance of LTL (rather than TL) carriage, investment in carrier-specific reputation, and carriage of goods requiring idiosyncratic vehicles—lead motor carriers to hire company drivers rather than contract with independents. They find empirical support for their hypotheses through a cross-sectional study of motor carriers in 1989.

Third, many and perhaps most of the thousands of new entrants in the post-deregulation trucking industry are one- or two-vehicle owner-operator 'firms.' These small carriers often contract with, as well as compete with, the larger trucking firms that are the primary focus of this study (Agar, 1986; Boyer, 1993). Thus, the rapid increase in density of new trucking firms following regulatory reform is likely to have complex effects on the population of large carriers. The ICC categorizes motor carriers as Class 1, which have revenues exceeding \$5 million, Class 2, which have revenues exceeding \$1 million, and Class 3, which encompasses all other motor carriers. We refer to Class 1 and 2 firms as 'large carriers' and Class 3 firms as 'small carriers.'

HYPOTHESES

Density dependence

Organizational ecology scholars have paid particular attention to the role of population density in influencing organizations' rates of exit. According to the density-dependence model (Hannan, 1986; Hannan and Freeman, 1989; Hannan and Carroll, 1992), organizational survival rates are affected by two forces—legitimation and competition—each of which is in turn a function of population density. A new organizational form gains 'legitimacy' in the eyes of potential customers and other resource providers as its prevalence increases. Thus, initial increases in a population's density can enhance the ability of its constituent organizations to acquire the resources necessary for survival. However, subsequent increases in population density yield diminishing returns to legitimacy. At the same time, growth in population density means that an increasing number of organizations must compete to acquire needed resources. While this competitive force may be relatively weak for initial increases in density, it grows with population density at an increasing rate. As a result, the relationship between population density and organizational failure rates should be U-shaped, with increases in density first reducing failure due to legitimation effects but eventually increasing failure as these legitimation effects are overtaken by mortality-increasing competition effects. A great deal of empirical research provides support for this curvilinear relationship, although there remains debate over the underlying processes that drive this phenomenon (Zucker, 1989; Hannan and Carroll, 1992).

Our population consists of an organizational form that has already existed for more than 40 years at the time our study begins. Theoretically, it is unlikely that carriers will still experience significant legitimation effects in the 1970s and 1980s. Methodologically, Hannan and Carroll (1992: 164–166) have shown that when institutional events (such as deregulation) coincide with the date of left-censoring, sign reversals are likely. Looking at data on the population of U.S. breweries, they show that artifically censoring the data at the end of prohibition produces biases in estimates that reproduce the negative results reported by Delacroix, Swaminathan and Solt (1989) on wineries after the end of Prohibition. This is consistent with the interpretation that failure to observe the population in the years when density is low will produce apparent competition effects only. We therefore expect that the effect of density on our population should be limited to this competition effect, which implies a positive correlation between density and mortality.

Hypothesis 1: The organizational failure rate for motor carriers will increase as density increases.

Mutualism and competition

The density-dependence model has been extended and elaborated in a variety of ways (see Baum, 1995, for a review). Recent studies have hypothesized and uncovered patterns of 'mutualism' among firms, in which the density of one population has a negative effect on another population's failure rate (Brittain and Wholey, 1988). For example, Barnett (1990) finds that the failure rates of telephone systems decreased as the density of technologically complementary systems increased. Similarly, Barnett and Carroll (1987) find evidence of mutualism among telephone systems that covered geographically contiguous areas. Baum and Singh (1994) find mutualism among day care centers that handle nonoverlapping age groups of children.

In the U.S. trucking industry, as noted above, the motor carriers that have entered since regulatory reform have tended to be small firms. The larger established carriers have frequently developed cooperative relations with these firms, in which the new or small carriers contract to haul freight obtained by the large carriers (Boyer, 1993). In this way, large carriers can more effectively exploit their investments in logistics systems or established contacts. This would suggest a mutualistic effect, in which an increase in the number of small carriers should reduce organizational failure of large carriers.[4]

At the same time, there is no institutional or technological barrier to competition between small and large carriers. In the case of telephone companies, geographic or technological delineation enforced a degree of niche partitioning. In the case of day care centers, institutional features associated with regulation prevented direct competition between centers catering to children of different age ranges. In the trucking industry, however, no such delineation is apparent. In the terminology of Baum and Singh (1994), small carriers and large carriers should experience a high degree of niche overlap. Under such circumstances, organizations should compete (Hannan and Freeman, 1989). Indeed, an anthropological study of independents (Agar, 1986) documents examples of small owner-operator-run firms both competing and contracting with large carriers. This would suggest a competitive effect, in which the number of small carriers should increase organizational failure of large carriers.

How will these two effects interact? As with competitive effects that are found within a population, the competitive effect between small and large carriers may be relatively weak for initial increases in the density of small carriers but grows with population density at an increasing rate. As a result, the relationship between population density of the small carriers and organization failure rate of the large carriers should be U-shaped, with increasing density first reducing failure due to mutualism effects but eventually increasing failure as these mutualism effects are overtaken by mortality-increasing competition effects.

Hypothesis 2a: The organizational failure rate for large motor carriers will decrease as small motor carrier density increases.

Hypothesis 2b: The organizational failure rate for large motor carriers will increase as the square of small motor carrier density increases.

Liability of age and liability of newness

Increased organization age has been linked theoretically to lower likelihood of failure, described by Stinchcombe (1965) as the liability of newness. Older firms are thought to be better able to survive because the factors leading to structural inertia also facilitate the provision of reliable and consistent service (Hannan and Freeman, 1984). There is a large body of empirical evidence for this relationship.[5] However, recent research suggests that the liability of newness may be conflated with the liability of smallness; the liability of newness often disappears after controlling for firm size. This has led some scholars to propose a liability of age (Ranger-Moore, 1991; Ingram, 1993; Barron *et al.*, 1994). According to this view, if organizations reflect the environment at the time of their founding, then environmental changes that occur over time should make it

[4] 'Almost all of the apparently new entrants into the industry after deregulation turned out to be owner-operators obtaining authority to carry goods as common carriers. While owner-operators can operate successfully at extremely small scales, they generally act in the role of sub-contractors to private firms doing their own trucking or to for-hire trucking firms with their own network of terminals and electronic data systems to match and route shipments' (Boyer, 1993: 484).

[5] Several economists have also proposed and found a liability of newness (e.g., Evans, 1987), although Klepper (1996) suggests that this may be moderated by time of entry and industry life cycle effects.

difficult for managers to keep their organizations properly aligned. Those ecological studies that have found a liability of age have generally investigated industries undergoing significant change, precisely the circumstance in which structural inertia is likely to be of least value and greatest disadvantage. Given the context of this study, which examines the trucking industry at a time of wrenching environmental shock, we expect that the structural inertia inherent in older firms may prove more a liability than a benefit. We therefore expect that, the older the firm is at the time of deregulation, the more likely it is to fail after deregulation occurs.

Hypothesis 3a: The organizational failure rate for motor carriers will increase as age at time of deregulation increases.

While the environment in which motor carriers operate has been volatile since deregulation, it has not experienced further sea changes akin to deregulation itself. We therefore expect that the number of years a firm has existed since deregulation will reduce its likelihood of failure, as this post-deregulation age represents the accumulation of experiences or resources conducive to operation in the new operating environment.

Hypothesis 3b: The organizational failure rate for motor carriers will decrease as post-deregulation age increases.

The driver employment relation

Transaction cost economics prescribes that organizations should internalize transactions that are characterized by high levels of asset specificity and contract through the market for transactions characterized by generic assets (Williamson, 1985). In a cross-sectional study of employment in the trucking industry, Nickerson and Silverman (1996) investigate whether transaction cost principles explain the varied use of company drivers and owner-operators. They find that, consistent with TCE predictions, motor carriers that engage in LTL carriage (thereby confronting interdependent coordination problems) and/or invest in specific assets (i.e., reputational capital or specialized equipment) tend to hire company drivers rather than owner-operators. The hub-and-spoke nature of LTL carriage makes drivers throughout the network highly interdependent, requiring a degree of coordination for which hierarchy (company driver) offers a lower cost than market (independent owner-operators). TL carriage requires far less coordination, making independents a more feasible contractual form.

A motor carrier that invests in a reputation for quality service (e.g., on-time delivery) may suffer reputation devaluation if freight arrives late or damaged. Whereas monitoring difficulties and misaligned incentives may lead independents to take actions which devalue the carrier's reputation, company drivers face muted incentives and are thus less likely to take actions that devalue a carrier's reputation. Thus company drivers are more likely to be employed the more a carrier invests in its reputation. Finally, vehicle power train configurations vary widely to match specific haul characteristics. Given uncertainty about the availability of return hauls, vehicles whose configurations are tailored to suit unusual haul characteristics can face contractual hazards associated with small numbers and temporal specificity (Masten, Meehan, and Snyder, 1991; Pirrong, 1993). As a result, independents typically purchase only the most redeployable configurations, leaving carriers to employ company drivers for hauls involving specialized vehicles.

Nickerson and Silverman (1996) add to what is by now a large body of empirical work supporting the importance of transaction cost principles in the make or buy decision (Shelanski and Klein, 1995). These studies generally show through cross-sectional analysis that a given transaction is aligned 'properly'. However, there are virtually no empirical studies that directly investigate whether adherence to transaction cost principles is associated with enhanced performance, measured either by profits or by survival.[6]

Yet TCE does predict that proper alignment of transactions will confer performance benefits. While the processes by which selection or adaptation occur are not precisely spelled out, TCE predicts that those organizations that adhere to its principles will outperform, and eventually outsurvive, poorly aligned competitors (Williamson,

[6] The only studies that have directly explored performance implications of TCE are several that test whether M form organization produces greater profitability for diversified firms than other forms of organization (Armour and Teece, 1978; Teece, 1981; Steer and Cable, 1978; Hill and Pickering, 1986).

1985, 1988). If it is true that transaction cost-economizing alignment enhances survivability, then (*ceteris paribus*) those large carriers conforming to transaction cost prescriptions should face a lower rate of organizational failure than those that do not.

Hypothesis 4: Carriers that properly align their use of company drivers and independents with their operational characteristics and specific investments so as to minimize transaction costs will have lower mortality rates than those that do not.

Leverage and specific assets

Since Modigliani and Miller (1958), traditional finance theory has argued that absent tax, signaling, and agency considerations, the value of a firm should be unaffected by its capital structure (Ross, 1977; Jensen and Meckling, 1976). Under equilibrium conditions, a firm's survival chances presumably should be highly correlated with its market value. Hence, an implication of this literature is that a firm's survival chances should not be affected by the extent to which it finances its operations with debt rather than equity (Zingales, 1994), except where increased debt will increase the expected costs of bankruptcy.

Recent research has identified specific conditions under which a firm is likely to face a limit on the amount of debt it can issue (known as 'debt capacity'). Finance scholars have argued that a firm has a limited debt capacity because of conflicting incentives for stockholders and bondholders (Jensen and Meckling, 1976; Myers, 1977). A firm that is near its debt capacity faces the threat of poor performance or mortality because it may not be able to issue additional debt to take advantage of profitable opportunities that arise (Myers, 1977) and because it may be vulnerable to predation by better-financed competitors (Bolton and Scharfstein, 1990). Some of this research identifies characteristics that lead different types of firms to have different debt capacities. However, except perhaps for Long and Malitz (1985), this research has ignored the idea that different types of assets should be financed by different types of instruments—that debt capacity may be affected by the nature of a firm's assets.

TCE proposes that the link between a firm's reliance on debt and its ownership of highly specialized assets will play a significant role in firm value and survival. In particular, a firm that invests heavily in highly specific assets that are not easily redeployed should rely primarily on equity, while a firm that owns generic, easily redeployable assets should rely more heavily on debt (Williamson, 1988). This is because the value to the bondholder of a claim on a firm's assets decreases as those assets become more idiosyncratic. As a result, the cost of debt financing and the benefits of closer supervision both increase with increased asset specificity. Put in financial terminology, a firm with highly specific assets will have a lower debt capacity than a similar firm with generic assets. Balakrishnan and Fox (1993) provide an initial test of the transaction cost hypothesis on a cross-sectional sample of U.S. manufacturing firms. They find that proxies for firm-specific assets, such as R&D expenditure, are more important than financial effects in explaining cross-sectional variance in leverage (although there are alternative explanations for the R&D–leverage relationship, e.g., Hall, 1990).[7]

As was argued above, LTL carriage requires investment in assets that are more idiosyncratic than those required for TL carriage. According to TCE, this should translate into a lower debt capacity ceiling for LTL carriers than for TL carriers. Specifically, in response to disturbances, the survival chances for carriers that engage in LTL carriage will be more severely penalized for incurring debt than firms engaging in TL carriage.

Hypothesis 5: The effect of leverage on motor carrier failure will be stronger the greater the share of a carrier's hauls is LTL carriage as compared to TL carriage.

Profitability

Organization theorists have noted that variance in economic performance is likely to generate differ-

[7] Williamson's contention has been largely ignored by finance scholars. An exception is Shleifer and Vishny (1992), which expands the asset-specificity argument to embrace the concept of 'asset illiquidity'. They argue that most assets are specialized, at least to some degree, and that liquidation values of assets are influenced by the set of potential buyers, most importantly buyers within the same industry. Moreover, 'when a firm in financial distress needs to sell assets its industry peers are likely to be experiencing problems themselves' adding to asset illiquidity (Shleifer and Vishny, 1992: 1343).

ent probabilities of organization action. In their examination of a sample of large U.S. corporations that declared bankruptcy between 1972 and 1982 and a matched pair of surviving firms, Hambrick and D'Aveni (1988) find that economic performance as measured by return on assets had a stronger and more consistent impact on failure than any of their nonperformance constructs. Haveman (1992, 1993) finds that economic performance has a significant effect on an organization's likelihood of undertaking change—in particular, on diversification within the banking industry. She also compares models predicting performance with those predicting mortality. Relatedly, Mitchell (1991) compares models predicting market share (a proxy for economic performance) with those predicting mortality, finding that new entrants in the medical imaging industry face a trade-off between rapid increases in market share and the likelihood of mortality. Nevertheless, to the best of our knowledge, the only organizational ecology study that actually includes a performance measure in a model predicting mortality is Barnett and Carroll (1987). They include market share in an analysis of telephone company mortality and find its effect to be negative (however, market share was not included in models that estimated density-dependent selection). Given the immense difficulty of obtaining performance measures for each organization in a population, most ecological research has either ignored performance or analyzed size, which can be interpreted as a performance metric. Implicit in the ecological literature is the assumption that the organization and population variables typically included in their models capture the effects of economic performance, thus rendering direct measures of economic performance unnecessary.

In contrast, while economic theory is admittedly opaque about the process by which firms are selected out of a population, economists have no doubt as to the fundamental mechanism that drives selection. The lack of (expected) profits is the sole reason that a firm exits a market. In neoclassical economics, a firm is conceived as a production function—a mechanism to produce a particular set of goods. If the firm cannot produce goods at a cost sufficiently below the market price such that it earns its risk-adjusted rate of return, then it will cease production. The implication of economic theory, then, is that profitability is the primary driver of organizational mortality.

Hypothesis 6: The organizational failure rate for motor carriers will increase as profitability decreases.

DATA AND SPECIFICATION OF THE MODEL

Data

Thanks to the reporting demands placed on motor carriers by the ICC, the data available for an important segment of the trucking industry are unusually detailed. The ICC has required large motor carriers—private and public—to file detailed annual reports (called Form Ms) since at least 1944. The Form M provides a comprehensive income statement, balance sheet, and description of operations and organizational structure. This study used the Form Ms to compile life history information on all large motor carriers that operated in the United States at any time between 1977 and 1989. In addition to conventional life history information, our data base includes measures of organizational profitability. Our data base also allows us to generate measures of the degree to which these motor carriers align transactions—notably their financing and the truck driver employment relation—according to the prescriptions of transaction cost economics. We do not cover the pre-1977 period for two reasons, one conceptual and one methodological. Conceptually, the pre-1977 period, characterized by rigid price and entry regulation, describes an environment in which both founding and failure were severely and artificially curtailed. While a study of organization mortality in such an environment might be fruitful, it falls outside our present concerns. Methodologically, the pre-1977 data are not available electronically, and some of the most interesting information is not available through the presently available paper records.

At the start of 1977, 2669 carriers existed in the ICC's large carrier population. By the end of 1989, entry and exit led to a population of 1588 large carriers. During the 1977–89 period, the number of Class 3 (small) carriers rose from 16,606 in 1977 to 42,700 in 1989, reflecting the end of regulatory restrictions on entry. Figure 1 shows the rate of founding and failure for large

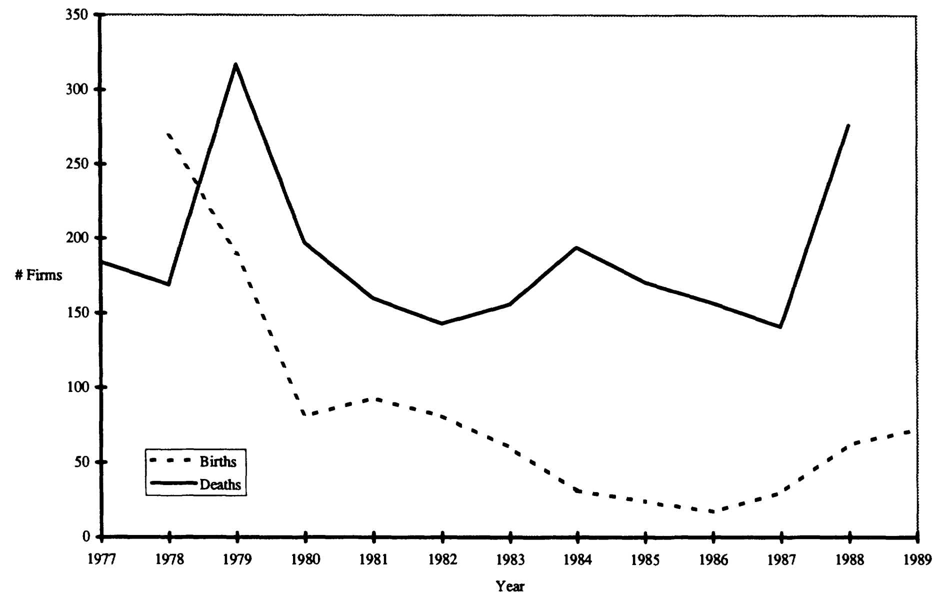

Figure 1. Births and deaths among large motor carriers, 1977–89

carriers and Figure 2 shows the annual density for small and large carriers.

Limitations of the data

As mentioned in the introduction, the data used in this study have several limitations that constrain our ability to interpret empirical results. Below we describe in detail three significant limitations, addressing their implications and describing our methods for minimizing their effect.

Left-censoring

Although we know the dates of founding for most of the carriers that existed before 1977, we

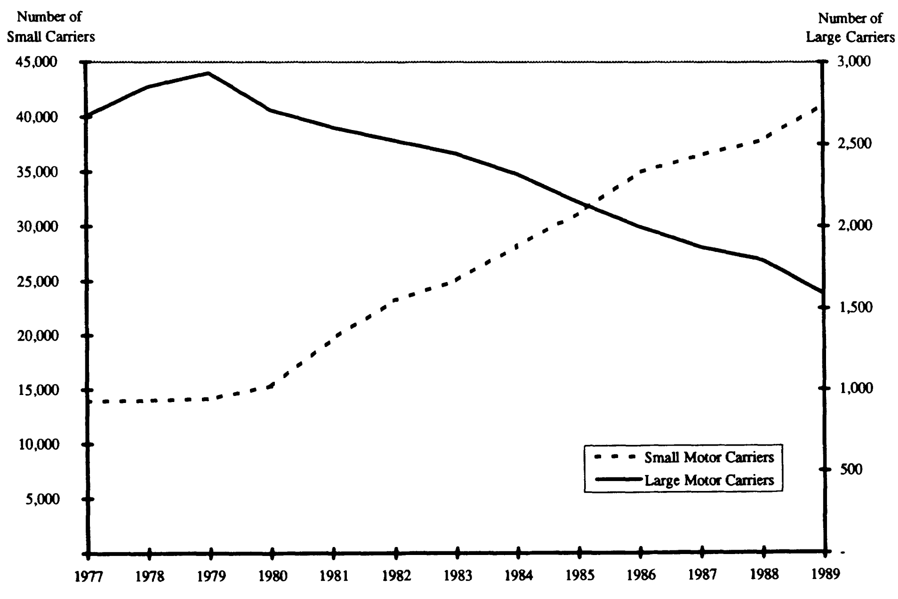

Figure 2. Interstate motor carrier population

lack detailed information on the history of the motor carrier population before that date, and thus our data are "truncated" on the left. The lack of population-wide information for prior years nevertheless has implications for our study. Such data introduce a sample-selection bias—the survival rates of motor carriers already existing in 1977 may appear to be different from those of later-founded carriers because not all the carriers 'at risk' of failure prior to 1977 are known. Below, we get a sense of the degree to which organizational failure rates among left-censored observations differ from those that are not left-censored by running models on constrained samples of the population. However, we cannot dismiss the contention that such sample selection bias may mislead us. The left-censoring also precludes our testing the effects of density at founding.

Size bias

Since 1980, the ICC has only required interstate carriers with annual revenues of $1 million or more (defined above as 'large' carriers) to file comprehensive Form Ms. Since a truck that is run at average productivity typically generated revenue of between $100,000 and $130,000 per year in the mid-1980s, a motor carrier must have 8–10 trucks before it will file a Form M. This represents a deficiency of our current data base, in that we lack firm histories for carriers with revenue below the $1 million floor. Fortunately, the ICC Annual Report to Congress provides information on the total motor carrier population (regardless of firm revenue). We are thus able to add population density to our data, partially ameliorating the problem of our $1 million cut-off, although we cannot derive life histories for each small carrier. As a result, we can examine the effect of small carrier density on failure rates of large carriers, but we are unable to directly investigate organizational mortality of small carriers.

What are the implications of this omission of small carriers? Given this omission, we cannot generalize our results to the small carrier population. However, we find no reason *ex ante* to expect that inclusion of small carriers would yield different results in our models. The omission of small carriers can be partially evaluated by re-estimating our models below with various revenue floors to get an indication of the severity of the size-bias problem. Such sensitivity analyses are discussed below.

Exit measurement

In addition to the omission of small firms, the size bias in our data adds two wrinkles to our measurement of mortality, First, until 1980 the ICC classified large (Class 1 and 2) motor carriers as those with revenues exceeding $500,000 rather than $1 million. This change in disclosure requirements threatens to bias our results by artificially creating a spike in exits in 1980 unless we impose a minimum sales level for the 1977–79 period. Following Zingales (1994), who tried several levels between $0.5 million and $1.5 million to determine an appropriate cut-off, we set the sales floor for 1977–79 at $1 million.

Second, it is possible that firms that exit our data base do not fail, but rather continue to exist with revenues slightly below the $1 million revenue floor. To reduce this problem, we categorize as failed only those carriers that disappear from the ICC's Form M population and never return (through 1989). We also artificially introduced a floor $1.2 million and found that of the 591 firms that exited by permanently dropping below the floor, only 10 of the firms did not also drop below the $1 million threshold.[8]

A more serious concern about our measurement of exit is our apparent inability to differentiate between exit by business dissolution and exit by acquisition/merger. Prior research has demonstrated that different processes operate on dissolution than on divestiture/acquisition (Mitchell, 1994). But as Boyer (1993) notes, merger activity has been low in the post-deregulation for-hire trucking industry—firms have generally eschewed mergers in favor of purchasing the assets of bankrupt carriers. This is due to 'the problem of unfunded pension liabilities that followed the

[8] We also checked the Yellow Pages listings for three cities—San Francisco, St. Louis, and Denver—for firms that exited our data base in 1985. None of the exiting firms with HQs in those cities showed up in the Yellow Pages for 1994. In contrast, most of the trucking firms headquartered in those cities that remained in our sample through 1989 did appear in the 1994 Yellow Pages. While an ideal check would be to examine the Yellow Pages for each year after 1985 to get a sense for the speed with which these exiting firms ceased operations, this check provides crude evidence that firms that fall below the $1 million threshold do not persist for long.

writing down of the value of certificates after deregulation: a live trucking firm often has a negative net worth while a bankrupt carrier has positive scrap value' (Boyer, 1993: 485). Furthermore, in those acquisitions that have taken place, the acquirer has often maintained an arm's length relationship with its acquisition (at least in a legal sense), especially when the acquirer is unionized and the acquiree is nonunionized. In these cases, the acquired company continues to report to the ICC as a separate entity, and remains in our data sample as a continuing firm.[9] To check the prevalence of exit through merger, we searched through one year's worth of *Traffic World*, a weekly trade journal, for announcements of failures, mergers or acquisitions. Failures outnumbered acquisitions by more than two to one (19 vs. 8). We then checked our data base to determine whether the acquired firms stopped filing Form Ms. All but one of the "failed" firms disappeared from our sample; all but one of the acquired firms continued to file their own Form Ms. In sum, 18 of the 19 exits from our data base that we checked were failures. Therefore, we assume that large carriers that exit our sample do so due to failure rather than merger.

Variables

Table 1 lists and defines the variables used in our study. It also provides the predicted sign of the coefficient for each independent variable, along with the hypothesis that generates this prediction (where applicable). We have grouped our variables by the theoretical source that has inspired their inclusion but stress that no group of scholars *owns* a variable. It is merely a matter of convenience to group them this way. Below we briefly discuss the construction of those variables that are novel or otherwise not transparent. We also briefly discuss the control variables.

AgeAtD

Hypothesis 3a hypothesizes a liability of age due to the marked environmental changes associated with deregulation. AgeAtD is an age clock that freezes in 1980, the year of deregulation. For the years 1981 through 1989, AgeAtD retains its value from 1980. The clock is set to 0 for carriers that were not born before 1980. This clock thus captures the effects of age at deregulation on a carrier's survival chances. Hypothesis 3a predicts that AgeAtD will be positive.[10]

AgePostD/Inc and AgePostD/Ent

Hypothesis 3b hypothesizes a liability of newness for the post-deregulation years. AgePostD/Inc and AgePostD/Ent are age clocks for firms existing in 1980 and for firms that are born after 1980, respectively. Each begins with the first year of a carrier's existence after 1980. This clock thus captures the effects of age (or experience) in the deregulated environment on a carrier's survival chances. Hypothesis 3b predicts that AgePostD/Inc and AgePostD/Ent will be negative. Separate clocks are constructed for incumbents and for entrants to test for different effects of age on the two types of firms.

Leverage

The extent to which firms rely on debt to finance their assets can be measured in several ways, including debt/equity, debt/assets, or, in the trucking industry, debt/total miles driven (or some other measure of scale of operation). Prior literature on the trucking industry has largely relied on debt divided by equity as the primary measure of motor carrier leverage (e.g., Corsi and Scheraga, 1989). Accordingly, we employ debt and equity to construct the leverage variable, although in the form debt/(debt + equity) so that Leverage ranges from zero to one.

Profitability

Firms' economic performance can also be measured in various ways. In an ideal world, Tobin's Q would be the most appropriate measure for our study, since it most directly measures expected profitability. The vast majority of firms in our sample are private, which precludes calculation of Tobin's Q values for them. We instead rely on measures of current profitability—return on

[9] A case in point is Viking Transportation, a California-based carrier that was acquired by Consolidated Freightways in the 1980s. Viking has continued to report its activities as a standalone firm to the ICC.

[10] We are grateful to one of our reviewers for suggesting this type of clock construction.

Table 1. Definition, derivation, and predictions for independent variables

Variable	Construction	Source	Prediction	Hypothesis
Organizational ecology variables				
Large Density	No. of large motor carriers (revenue ≥ $1 million) operating in the U.S.A. at end of year *t*	Form M	+	H1
Large Density^2	Square of Large Density/1000	Form M	?	
Small Density	No. of small motor carriers (sales < $1 million) operating in the U.S.A. at end of year *t*/1000	ICC Annual Report	–	H2a
Small Density^2	Square of Small Density/1000000	ICC Annual Report	+	H2b
AgeAtD	For 1977–79, age of carrier *i*; for 1981–89, age of carrier *i* in 1980 (0 if carrier born after 1980)	ICC documents	+	H3a
AgePostD/Inc and AgePostD/Ent	No. of years carrier *i* has had interstate motor carriage operating certification post-1980 in year *t*	ICC documents	–	H3b
Transaction cost economics variables				
Misalign	Residual between motor carrier *i*'s actual level of driver integration and that predicted by Tobit estimation, for year $t-1$	Form M; Nickerson and Silverman (1996)	+	H4
Leverage*LTL	Product of Leverage and LTL	Form M	+	H5
Neoclassical economics variables				
ROS	Net Income/Revenue for carrier *i* for year $t-1$	Form M	–	H6
ROA	Net Income/Assets for carrier *i* for year $t-1$	Form M	–	H6
Control variables				
LnRev	Natural log of revenue for carrier *i* for year $t-1$	Form M	–	
Births	No. of carriers entering the large motor carrier data set for year $t-1$/1000	Form M		
Deaths	No. of carriers exiting the large motor carrier data set for year $t-1$/1000	Form M		
Leverage	Debt/Equity for motor carrier *i* at end of year $t-1$	Form M	+	
LTL	Proportion of carrier *i*'s revenue in year $t-1$ derived from LTL freight carriage	Form M	?	
GDP	% change in U.S. GDP between $t-1$ and *t* (measured at year-end)	Survey of Current Business	–	
Future GDP	% change in U.S. GDP between *t* and $t+1$ (measured at year-end)	Survey of Current Business	–	
Dereg	1 for years 1980–89, 0 for 1977–79		+	
Left-Censor	1 if carrier *i* existed before 1977, 0 otherwise	Form M; ICC documents	?	

sales (ROS) and return on assets (ROA)—as second-best proxies for our theoretical construct.

Misalign

As described above, Nickerson and Silverman (1996) found that the extent to which a motor carrier relies on company drivers rather than owner-operators is largely dependent on transaction cost attributes of the carrier. Their analysis employed a two-sided Tobit model that estimated the degree of a carrier's reliance on company drivers (measured as miles driven by company drivers/all miles driven) as a function of: (1) the proportion of revenue received from LTL carriage; (2) several haul characteristics including the average length of haul and average weight of haul; and (3) the carrier's advertising intensity; and a series of control variables. The Misalign variable for this study was constructed by reestimating their model for each year in our sample, excluding the advertising variable because only a small subset of firms reported such expenditures, and calculating the absolute value of the residual for each firm observation. Thus, Misalign will range between 0, which occurs when the proportion of a firm's total miles driven by company drivers conforms perfectly to the proportion predicted by Nickerson and Silverman's model, and 1, which occurs when a firm's reliance on company drivers is diametrically opposite that predicted by transaction cost predictors.

Control variables

As Table 1 shows, several control variables are included in the model. One of the most consistent results of ecological and economic studies of exit is that firm size enhances survival chances (Hannan and Carroll, 1992; Evans, 1987; Dunne, Roberts, and Samuelson, 1988), except perhaps in declining industries (Lieberman, 1990).[11] We include LnRev to control for this effect, and expect it to negatively influence a carrier's mortality. Ecological research suggests that prior foundings and failures can influence organizational mortality. We include Births and Deaths in year $t-1$ to control for these effects. The trucking industry's fortunes largely mirror the business cycle. We include the change in GDP in year t to capture this macroeconomic effect. We also include Future GDP—the change in GDP for $t+1$—to capture the effect of economic expectations on motor carrier survival. These variables are both expected to have negative effects on carrier mortality. We also include a categorical variable, Dereg, to control for greater likelihood of mortality after deregulation in 1980. Finally, we include LTL and Leverage as control variables because we wish to include their interaction to test Hypothesis 5. We have no *ex ante* prediction for the sign of LTL. We expect Leverage to have a positive effect on carrier mortality, because leverage has been associated with failure in prior research on organizational mortality in general (Hambrick and D'Aveni, 1988) and on motor carriers in particular (Corsi and Scheraga, 1989). We reiterate that it is not the effect of leverage *per se* that interests us, but rather the interaction of a carrier's leverage and its reliance on specific assets, as measured by the degree to which it performs LTL carriage.

Specification of the model

This study uses both exponential hazard rate event-history estimation (performed in STATA) and logistic regression analysis (in SAS) to examine the effects of the above variables on the probability of exit of large motor carriers. The specifications offered nearly identical results. Below we report only the event-history results, specified as:

$$h(t) = e^{\{\beta \mathbf{X}\}}$$

where $\mathbf{X}$ = a vector composed of the independent variables that appear in Table 1.

Table 2 provides descriptive statistics and correlations for our variables.

RESULTS

Table 3 presents the estimates of four different failure rate models for large carriers. Model 1 presents a baseline that consists of only the popu-

[11] Further, numerous studies of the trucking industry since deregulation have found that the size of a motor carrier is positively related to its economic performance (Corsi and Scheraga, 1989; Smith, Corsi, and Grimm, 1993; Corsi *et al.*, 1992), due possibly to scale economies, customer preferences for one-stop shopping for national motor carriage, or the ability to better balance traffic flows.

Table 2. Means, standard deviations, and correlation matrix for variables

	Exit	LnRev	AgeAtD	AgePost D/Inc	AgePost D/Ent	Large Density	Large Density^2	Small Density	Small Density^2	Births	Deaths	Left Censor	ROS	ROA	Levrge	Levrge * LTL	Mis-Align	GDP	Future GDP	LTL
Mean	0.075	15.878	19.206	2.918	0.168	2382	5837	24.826	705	0.309	0.173	0.821	0.027	0.054	0.560	0.191	0.407	2.829	2.583	0.347
S.D.	0.264	1.353	13.651	3.045	0.990	405	1856	9.436	496	0.736	0.74	0.383	0.082	0.395	0.257	0.242	0.360	2.161	2.099	0.376
Exit	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
LnRev	–0.065	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
AgeAtD	0.036	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
AgePostD/Inc	0.010	–	–0.021	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
AgePostD/Ent	–0.006	0.191	–0.239	–0.163	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Large Density	–0.005	–0.148	0.129	–0.894	–0.234	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Large Density^2	–0.008	–0.148	0.128	–0.892	–0.225	0.997	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Small Density	0.005	0.160	–0.126	0.907	0.221	–0.980	–0.981	–	–	–	–	–	–	–	–	–	–	–	–	–
Small Density^2	0.002	0.156	–0.128	0.904	0.237	–0.988	–0.980	0.991	–	–	–	–	–	–	–	–	–	–	–	–
Births	–0.013	–0.062	0.048	–0.344	–0.062	0.414	0.440	–0.405	–0.366	–	–	–	–	–	–	–	–	–	–	–
Deaths	–0.041	0.088	0.003	0.128	0.067	–0.145	–0.122	0.173	0.187	0.092	–	–	–	–	–	–	–	–	–	–
Left Censor	–0.007	0.090	0.287	–0.096	–0.224	0.191	0.194	–0.188	–0.185	0.136	0.007	–	–	–	–	–	–	–	–	–
ROS	–0.089	0.045	–0.005	0.016	–0.028	0.009	0.011	0.006	0.005	0.039	0.095	–0.013	–	–	–	–	–	–	–	–
ROA	–0.057	0.036	–0.029	0.009	–0.007	0.001	0.002	0.007	0.007	0.022	0.042	–0.024	0.394	–	–	–	–	–	–	–
Levrge	0.100	0.024	–0.078	–0.108	0.047	0.075	0.074	–0.083	–0.081	0.006	–0.040	–0.039	–0.333	–0.194	–	–	–	–	–	–
Levrge*LTL	0.182	0.136	0.157	–0.100	–0.025	0.108	0.107	–0.108	–0.108	0.048	–0.017	0.154	–0.144	–0.088	0.317	–	–	–	–	–
MisAlign	0.031	0.180	0.098	0.093	–0.036	–0.068	–0.081	0.093	0.069	–0.063	–0.072	0.097	–0.040	–0.012	–0.023	0.460	–	–	–	–
GDP	0.026	–0.008	–0.038	0.160	0.031	–0.123	–0.123	0.118	0.130	0.244	–0.457	–0.020	–0.031	–0.007	–0.008	–0.011	0.025	–	–	–
Future GDP	0.013	–0.032	–0.033	0.122	–0.022	–0.123	–0.160	0.117	0.077	–0.056	0.496	–0.054	–0.076	–0.039	–0.000	–0.024	0.154	0.229	–	–
LTL	0.037	0.178	0.222	–0.078	–0.052	0.103	0.102	–0.098	–0.099	0.006	0.006	0.189	–0.020	–0.018	–0.037	0.848	0.556	–0.020	–0.33	–

$\rho > 0.021 = p < 0.05$; $\rho > 0.029 = p < 0.01$

Table 3. Exponential regression models of large motor carrier failure

	(1)	(2)	(3)	(4)
Large Density	0.049***	0.050***		0.052***
	(0.005)	(0.007)		(0.007)
Large Density^2	−0.008***	−0.008***		−0.009***
	(0.001)	(0.001)		(0.001)
Small Density	−1.239***	−1.231***		−1.229***
	(0.122)	(0.179)		(0.178)
Small Density^2	0.028***	0.029***		0.029***
	(0.003)	(0.004)		(0.004)
AgeAtD	0.007***	0.014***		0.014***
	(0.002)	(0.003)		(0.003)
AgePostD/Inc	0.606***	0.486*		0.545**
	(0.231)	(0.307)		(0.322)
AgePostD/Ent	0.686***	0.567**		0.609**
	(0.242)	(0.322)		(0.339)
Leverage*LTL			0.678**	0.702**
			(0.383)	(0.386)
Misalign			0.164	0.135
			(0.132)	(0.134)
ROS			−1.383***	−1.342***
			(0.402)	(0.427)
ROA			−0.061	−0.054
			(0.062)	(0.070)
Dereg	2.612***	2.548***	0.289***	2.441***
	(0.446)	(0.643)	(0.094)	(0.646)
Left-Censored	−0.131**	−0.100	−0.001	−0.116
	(0.069)	(0.107)	(0.102)	(0.107)
LnRevenue	−0.257***	−0.203***	−0.198***	−0.221***
	(0.025)	(0.026)	(0.028)	(0.027)
Births	0.169***	0.192**		0.191**
	(0.060)	(0.088)		(0.088)
Deaths	−8.192***	−8.332***		−7.672***
	(1.288)	(1.887)		(1.874)
LTL			−0.059	−0.144
			(0.284)	(0.290)
Leverage			0.975***	1.043***
			(0.221)	(0.226)
GDP	0.005	0.011	0.060**	0.003
	(0.026)	(0.036)	(0.020)	(0.037)
Future GDP	−0.070***	−0.087***	−0.011	−0.096***
	(0.019)	(0.027)	(0.017)	(0.027)
Constant	−59.623***	−61.176***	−0.605	−63.680***
	(5.916)	(8.223)	(0.467)	(8.396)
Chi-square	337.21***	200.08***	207.52***	349.92***
Log-likehood	−4861.78	−2240.26	−2223.76	−2178.62
N (d.f.)	18983 (13)	8541 (13)	8541 (11)	8541 (19)

* $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$; one-tailed tests.

lation ecology variables. Model 2 replicates this model, using only those observations for which economic data are also available. Model 3 presents an alternative baseline that consists of only the economic variables. Model 4 presents the results of our combined ecological and economic effects model. Of particular interest is the fact that the signs, magnitudes, and levels of significance for most of the independent variables remain virtually unchanged throughout these estimations.

Hypothesis 1 predicted that large carrier density

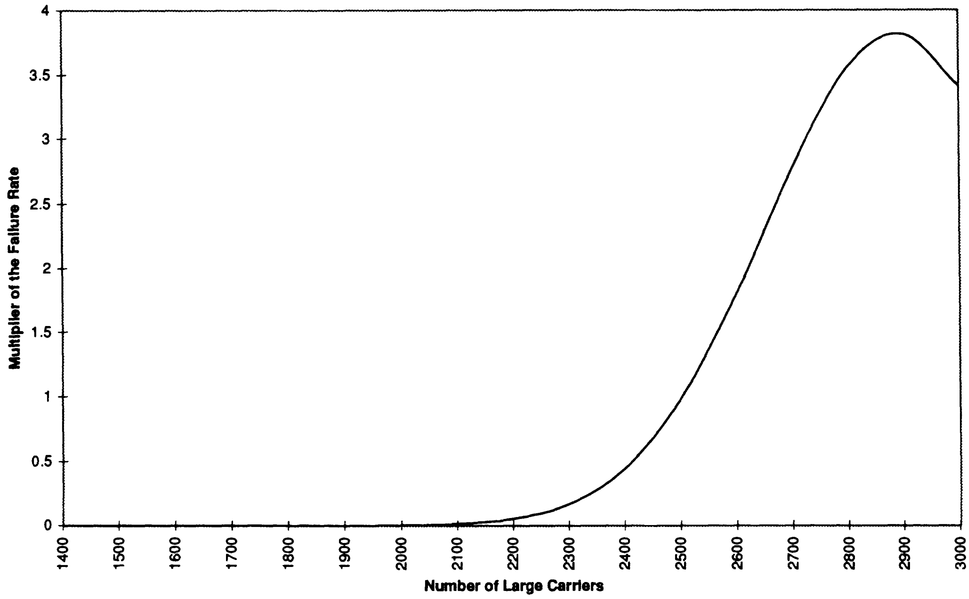

Figure 3. Multiplier effect of large carrier density and density^2 on large carrier mortality (all other variables set to mean values)

would have a positive effect on mortality, rather than the traditional U-shaped effect, due to the left-censoring of our data. Consistent with Hypothesis 1, the variable Large Density has a positive and significant effect on mortality, rather than having the traditional negative sign. Thus large carrier density has only a competitive effect on large carrier survival. While the variable Large Density^2 is significant and negative, giving the relationship an inverted U-shape, plotting the density multiplier demonstrates that the downward-sloping portion of this curve falls almost entirely outside the range of observed values in our data (see Figure 3). We interpret the second-order effect of Large Density, then, as moderating the rate at which mortality increases with Large Density.[12]

As is consistent with Hypotheses 2a and 2b, coefficients for Small Density and Small Density^2 had negative and positive values, respectively, thus yielding a U-shaped curve. However, our results suggest a limitation to mutualistic effects absent a nonmarket constraint on competition. Figure 4 plots the small density multiplier. As this figure shows, the downward-sloping portion of this curve falls almost entirely outside the range of observed values in our data. Thus, while mutualism may operate, the competitive effect on large carrier mortality appears to quickly swamp any mutualistic effect between the populations as of Small Density increases.

Consistent with Hypothesis 3a, we find a liability of pre-deregulation age. The older a carrier was at the time of deregulation (AgeAtD), the greater its probability of failure. As described above, given the context of this study—the period immediately surrounding deregulation, in which existing firms that had grown accustomed to a regulatory agency-oriented, cartelized environment suddenly found themselves subjected to severe market-based competition—it is not surprising that the advantages typically associated with incumbency are not evident here. Unexpectedly, we find a liability of post-deregulation age as well, for both incumbent and entrant carriers (AgePostD/Inc and AgePostD/Ent). The older a carrier is in the post-deregulation period (the more years the carrier has operated since 1980), the greater its probability of failure. Thus we reject Hypothesis 3b, which hypothesized a liability of newness in the post-deregulation era. This result is consistent with several recent stud-

[12] We also ran models that included log(Large Density) in lieu of Large Density and Large Density^2. In all cases, log(Large Density of the models incorporating log(Large Density) were consistently lower than those of the models reported here.

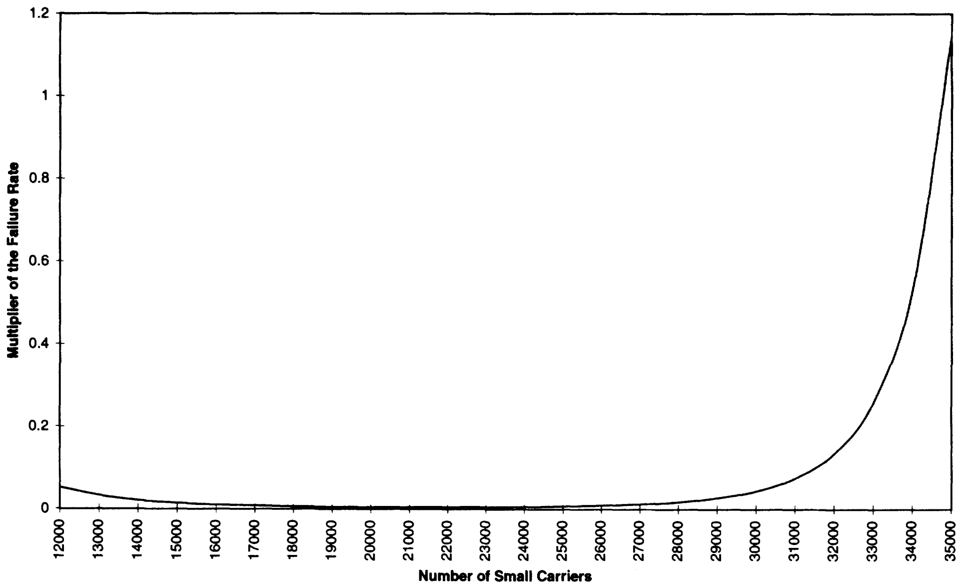

Figure 4. Multiplier effect of small carrier density and density^2 on large carrier mortality (all other variables set to mean values)

ies that have found a liability of age after controlling for size. It is also consistent with Mitchell's (1994, 1995) proposition that a liability of age will be especially pronounced in industries characterized by low merger and acquisition activity. Finally, this result may be interpreted as support for the idea of 'liability of senescence' as opposed to 'liability of obsolescence' (Barron *et al.*, 1994).

Estimates for misalignment of the employment relation (Models 3 and 4) do not support Hypothesis 4. While the coefficient for Misalign has the expected sign, it is insignificant. This result may be driven by the fact that, as Williamson (1985) asserts, weak-form selection may occur over a 5–10-year time frame. Data recorded in 1-year intervals over a 13-year period used in this analysis may preclude the statistically significant measurement of weak-form selection. It is also worth noting that in those sensitivity analyses described below that involved raising the revenue floor, Misalign became progressively more significant as we raised the floor (reaching $p < 0.05$ at \$1.2 million). It has been conjectured that transaction costs associated with monitoring employees rise monotonically with firm size (Rebitzer and Robinson, 1991). Perhaps transaction costs associated with driver employment mode are negligible for small firms, such as those at the low end of our sample distribution that frequently have fewer than a dozen vehicles, but remain important for larger motor carriers.

The coefficients of the variables related to capital structure (Models 3 and 4) yield support for Hypothesis 5. The interaction term LTL*Leverage is positive and statistically significant. This indicates that for a specified degree of leverage, the more a firm is engaged in LTL carriage (where assets are more idiosyncratic than in TL) as compared to TL carriage, the greater the likelihood of mortality. We interpret this as support for the transaction cost economics prediction that debt is more efficiently matched with generic assets than with specific assets.

As predicted by Hypothesis 6, the better a carrier's economic performance the less likely it will exit. ROS has a significant negative effect on a firm's likelihood of failure. While ROA is not significant in these models, it is significant and negative in models that exclude ROS.

Finally, it is worth noting that the combination of economic and ecological variables in the same model has little if any effect on the magnitude, sign, and significance of the variables. Ecological considerations such as age and density dependence retain their effect on organizational failure even after controlling for organization form and profitability. At the same time, the economic variables are not significantly affected by the inclusion of ecological variables. This underscores the complementary nature of economic and ecological approaches to understanding patterns of firm exit.

An alternative way of decomposing our model is to consider the separate effects of industry/environment-level variables and firm-level variables on motor carrier failure. To evaluate the relative significance of each set of variables, we ran a constrained version of Model 4 in which we omitted all industry/environment variables, and another constrained model that omitted all firm variables. Following Silber, Rosenbaum, and Ross (1995), we calculated a relative dispersion measure, which is used to evaluate the relative contributions of groups of predictors in hazard rate models.[13] Our relative dispersion measure for industry/environment variables as compared to firm variables equals 0.51, which indicates that the set of industry/environment variables explains half as much variance as the firm variables do.

Regarding the control variables, GDP and Future GDP generally have the expected negative coefficients, indicating that improved current or expected economic conditions will reduce firm exit. One anomaly occurs in Model 3, where GDP is significant and positive. This result may be an artifact of the secular trends in population size in the 1980s. When density measures are included, GDP's sign becomes negative. As expected, carrier size (LnRev) has a negative effect and Leverage and Dereg have positive effects on mortality. Births, Deaths, LTL, and Left Censor are generally insignificant.

Sensitivity analyses[14]

We ran several variations on the models presented in Table 3 to test the robustness of our results. First, as a further test of the implications of our size bias we reestimated our models with different cut-offs for the revenue floor of our large motor carriers ($1.2 million and $1.5 million). All coefficients retained their sign, magnitude, and significance. The one difference, as mentioned above, is that the Misalignment variable becomes progressively more significant with each raising of the floor. Next, we reestimated our models without firm size. While the likelihood ratio test indicated that addition of Size significantly improves our models' explanatory power, the signs of our remaining coefficients were unchanged. The coefficients retained the same levels of significance as well, with the exception of the age clocks (which lost significance) and Left Censor (which rose to 1% significance). Finally, we reestimated Model 1 using data only on firms that were born after 1977. Again, coefficients largely retained their sign, magnitude, and significance.

Given our earlier discussion about the distinctions between LTL and TL carriage, we also ran 'fully interacted' versions of the above five models, adding variables constructed by interacting LTL with all other independent variables. (We reiterate that LTL is not a category of carrier—rather, it measures the proportion of a carrier's traffic that is LTL carriage as opposed to TL carriage. Many carriers haul a mix of LTL and TL traffic. Thus we are not dealing with two distinct populations of carriers, but rather one carrier population whose members' reliance on LTL traffic varies across the continuum from 0 to 1.) These interactions had no effect on our ecological variables, nor were any of the LTL–ecological variable interaction terms significant. While some of the economic variables were affected, and some of the LTL–economic terms were significant, the likelihood ratio test led us to reject the argument that failure rates for firms that engage in either LTL or TL are determined by different processes, and therefore should be estimated by separate models. We reiterate that LTL carriage and TL carriage are frequently undertaken by the same firm, so that we do not have two distinct populations of carriers.

DISCUSSION AND CONCLUSION

In the postregulatory reform U.S. for-hire trucking industry, organizational mortality was affected by

[13] The relative dispersion measure is calculated as follows: $\mathrm{Var}(\beta_1\mathbf{X}_1) / \mathrm{Var}(\beta_2\mathbf{X}_2)$. For our sample, $\mathbf{X}_1$ and $\mathbf{X}_2$ are the set of industry/environment variables and the set of firm variables, respectively. Industry/environment variables include: Large Density; Large Density^2; Small Density; Small Density^2; Births; Deaths; Dereg; GDP; Future GDP. Firm variables include: LnRev; AgeAtD; AgePostD/Inc; AgePostD/Ent; Leverage*LTL; Misalign; ROS; ROA; LTL; Leverage; Left-censored.

[14] The results of all sensitivity analyses are available from the authors upon request.

several firm and industry factors. In particular, density effects of both large and small carrier populations generated competitive pressure on large carriers, decreasing their survival chances. Younger firms were less likely to fail, as were larger firms. In addition, firms that aligned their capital structure according to transaction cost principles were less likely to fail. Finally, more profitable firms were more likely to survive, and carriers' survival chances improve with corresponding improvements or expected improvements in macro economic conditions.

These results provide several strategic implications for firm survival in newly deregulated industries. First, managers who focus on optimizing organizational characteristics along only one dimension are not necessarily maximizing firm survival chances. Maximizing profitability by limiting growth, for example, or vice versa, does not guarantee the greatest survival chances. Indeed, the combined significance of both ecological and economic variables suggests that managers should not rely solely on profit measures, efficient relationships with resource providers, or indicators of legitimation and competition to enhance their firms' performance—the greatest survival chance, at least in the trucking industry, is achieved by focusing on all three influences contingent on the firm's characteristics at the beginning of deregulation. With regard to the latter, a firm with high revenues when deregulation occurs, for example, would maximize survival chances by focusing on profitability and efficient alignment of its debt-to-equity whereas a smaller firm might maximize survival chances by growing rapidly even if at the cost of low profitability. Our empirical analysis provides parameter estimates, at least for the trucking industry, for evaluating survival benefits of these alternative strategies.

Second, this work reiterates the argument that a firm's capital structure has an important strategic dimension. Our results expand this argument to suggest that in determining their firm's capital structure, managers should take into account the specific nature of the firm's assets.

Finally, these results suggest that in the trucking industry, complex interactions exist between large and small motor carriers. Large trucking firms must manage their relationships with smaller carriers carefully, recognizing that today's subcontractor can be tomorrow's competitor.

The empirical results presented in this paper have several limitations. Our data cover a recent 13-year period from a 90-year-old industry. While remarkably detailed in some ways, our data base excludes information on thousands of small organizations, thus reducing our ability to fully model the dynamics of this population. The short time span, left-censored, and size-censored nature of our data may limit the generalizability of our results. Nevertheless, as the first study to include several economic measures of organizational heterogeneity in an analysis of organizational mortality in a population, we believe that the above results offer promise to strategic management scholars interested in integrating elements of economics and organization theory.

We envision at least three avenues for future research in this vein. First, subsequent studies on this or related populations should elaborate the nuances underlying density effects. Several studies have disaggregated population-wide density effects into subpopulations that offer varying degrees of competition (or even mutualism) to a focal firm (e.g., Barnett, 1990; Baum and Mezias, 1992; Baum and Singh, 1994). It should be possible to use motor carrier HQ location and average length of the carrier's haul to generate a crude radius in which much of its business takes place. While a motor carrier's activities are not necessarily geographically bounded as are, say, those of a day care center, this could provide some measure (albeit noisy) of geographically localized density. In addition, given the Form M's information on LTL vs. TL traffic, primary commodity carried, and use of company drivers or independents, it should be possible to enhance our understanding of localized density effects by measuring the degree of overlap between firms as a function of the degree to which they compete for similar sets of these resources. Finally, the impact of local competitors' profitability on a focal firm's survival chances is particularly intriguing—will low-profit competitors generate severe competitive effects (e.g., by engaging in drastic price-cutting) that hurt the focal firm, or will the interaction between a firm's characteristics (e.g., deep pockets) and local competitors' profitability be more complex?

Similarly, different types of freight and different geographic areas are likely to experience distinct patterns of environmental variation, due both to seasonality and to business cycle effects. Given information on the geographic location of firms' HQs and on their primary commodity carried (which can be 'general freight' rather than a specific commodity type such as automobiles or agricultural products), it should be possible to explore in great detail the dynamics of niche width (Freeman and Hannan, 1983) among motor carriers.

Second, subsequent research should investigate the possibility of interactive effects between economic performance ecological factors such as density. It is not yet clear how significant a carrier's profitability is in buffering it from other firm- and industry-level effects. It is also not clear to what extent the firm's profitability is affected by these or other effects—is a carrier highly profitable because it is in a niche that faces low localized density, or is it simply better at certain as-yet-unmeasured activities? Further research that carefully unpacks this issue, perhaps through the use of profitability cohorts, may be promising.

Finally, the addition of data on smaller motor carriers would allow for a fuller study of this industry. While the reporting requirements for small motor carriers are much lower than those of large carriers, at the very least simple birth and death information for all carriers in a given state might be available. In addition to facilitating a more generalizable study, such data would allow for more rigorous testing of the interactions between large and small carriers, and in particular the competitive effects of large carriers on small carriers. Such research would allow more concrete interpretation of the competition and mutualism effects discussed in this paper.

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