THE RATES OF CHANGE OF ENTRANTS AND INCUMBENTS

IN A DEREGULATED INDUSTRY

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This study compares incumbents' and entrants' rates of change in assets in a new competitive environment characterized by price and entry deregulation. This comparison is made in the Trucking Industry from 1980 to 1993. By specifying deregulation as an unambiguous break in industry history, we are able to be clearer than earlier studies about how differences in firm histories give rise to variance in firm growth rates. The results demonstrate that, controlling for age, the asset growth rates of entrants and incumbents differ by size and within and across firm types. A baseline test shows that, after the industry deregulates, incumbents grow their asset base more slowly than entrants do. The findings suggest that two clocks, the industry clock and the internal firm clock, govern adjustment to industry change. After fundamental institutional change, the industry clock is reset but incumbents' internal clocks are not.

Keywords: institutional change, deregulation, rates of change, growth

A major theme in theories of industry evolution is how firm and industry histories shape entrants' and incumbents' rates of change (Klepper, 1996; Klepper & Simons, 2000; Nelson, 1991; Nelson & Winter, 1982; Schumpeter, 1934, 1950). When an industry undergoes a period of significant transformation, either regulatory or technological, entrants are firms that startup after the change and incumbents are firms that entered the industry in the old regime. The break in industry history initiates new competitive conditions as entrants expand by exploiting novel opportunities and incumbents innovate by replacing their out of date practices. If history matters, the speed with which an incumbent adapts after the transformation is determined in part by its participation in the previous regime (Ghemawat, 1991; Stinchcombe, 1965). We argue that exposure to competition under the old regime exerts a drag on incumbents' ability to grow in the new regime. Consequently, there should be a gap in the rates of asset growth between entrants and incumbents as competition advances.

Variance in the sizes of entrants and incumbents also underlie the differences in their growth rates (Aldrich & Auster, 1986; Ranger-Moore, 1997). Although large size provides both entrants and incumbents with endowments that facilitate investment in growth (Nelson & Winter, 1982; Schumpeter, 1934), large size is also associated with bureaucratic rigidity. Compared to incumbents, large entrants should suffer less from this rigidity, however, because their organizational structures and processes are designed specifically for competition in the new industry. Accordingly, large incumbents may change their asset bases at lower rates than large entrants. Further, while small firms often lack the resources necessary to compete with larger rivals, research often associates small firm size with entrepreneurial characteristics that facilitate innovation and change (Acs & Audretsch, 1990). Smaller firms, whether entrants or incumbents, may therefore have higher rates of asset growth compared to large firms that lack the ability to respond rapidly to environmental transformation. Moreover, the practices of small incumbents are likely to be sticky, limiting small incumbents' responsiveness to the new market conditions (Ghemawat, 1991) and lowering their rates of asset growth compared to those of small entrants.

Our model builds on Nelson and Winter's (1982: chapter 12) theory of growth in Schumpeterian environments where survival favors firms that repeatedly invent or adopt cost-reducing process technologies, and where firms sell only one product whose price they do not control. Both of these characteristics describe the trucking industry after the onset of deregulation. The dynamics of Nelson and Winter's model can be represented as the following cycle: large firms may have more resources to invest in searching for productivity improvements which increase their *efficiency* and improve their profit margins relative to rivals; *higher profit margins* make capital available for firms to invest in *capacity expansion*, which allows firms to *increase their asset stocks* relative to competitors, bringing us back to the beginning of the cycle. A firm's rate of change in assets should capture the relative success of the firm's growth cycle. If the history of a firm reduces its ability to change its operations in response to shifting industry conditions, history should also dampen the firm's rate of change in assets. Examining the change in firm assets over time allows us to estimate these rates explicitly; for simplicity, we refer to 'the rate of positive change in assets' as 'the rate of asset growth'.

This study compares entrants' and incumbents' rates of asset growth following a significant shift in the institutional environment of the trucking industry, the deregulation of pricing and entry. Deregulation has strong face validity as a crucial alteration in the rules governing how firms in an industry compete (Dobbin & Dowd, 1997; North, 1990). Aligning resources and capabilities with institutional constraints however, may handicap firms when the rule system changes (Ghemawat, 1991; Stinchcombe, 1965). Such change typically alters the rules of rivalry and creates opportunities for growth. Organizational growth is particularly important for firms operating in industries in the early stages of redevelopment. In such industries, incumbents must realign their operations to satisfy the new regime and must keep pace with the growth of new firms that enter to exploit the new opportunities. Lacking a continuous investment in the assets necessary to retain and attract customers, an incumbent firm will begin to decline in size and increase its risk of exit. Trucking is an excellent example of an industry where institutional change, aimed directly at the rules of competition, threatened the growth and viability of incumbent firms (see Boyer, 1993; Giordano, 1995; Tye, 1987). Figure 1 shows that by 1991, only about 51 percent of the trucking industry's incumbent population remained. Substantial entry of new trucking firms also occurred during the first decade of deregulation. Throughout this time frame, the entrant exit rate is substantially lower than the rate for incumbents, as Figure 2 shows, suggesting the introduction of new practices tailored to the requirements of the new rule system.

[Insert Figures 1 & 2 about here]

THEORY

Introduction. Separating firms into entrants and incumbents around a major shift in industry conditions, such as deregulation, helps clarify questions regarding variance in the asset growth rates of firms during periods of industry transformation. The first question concerns how differences in firm experience influence firm growth rates. Existing empirical and theoretical research reduces to competing themes regarding the effects of age and experience on firm growth rates, firm performance, and firm mortality rates. The liability of newness view suggests that old firms benefit from accumulated experience (e.g. Amburgey, Kelly & Barnett, 1990; Carroll & Delacroix, 1982; Carroll & Hannan, 1989; Freeman, Carroll & Hannan, 1983). The counter argument is that firms become increasingly ossified as they build experience (Amburgey, Dacin & Kelly, 1994; Barnett, 1990; Barnett & Hansen, 1996; Barron, West & Hannan, 1992; Baum & Mezias, 1992; Ranger-Moore, 1997). This ossification reduces firms' agility and makes it difficult for them to adjust to shifting market conditions in a timely manner (e.g. Barron, et al 1994; Ranger-Moore, 1997). The type of industry shift we observe turns the traditional view of industry evolution on its head in that the industry is roughly mature under regulation and is subsequently rejuvenated when price and entry are removed from governmental control. Such transformation may render incumbents' capabilities obsolete whereas entrants develop strategies *de novo* to compete in the newly opened market. These arguments suggest that the hurdles facing incumbents, based on their exposure to competition under regulation, can easily be overcome by entrants. Under these conditions, entrants may adjust their assets faster than incumbent firms during deregulation.

The second question concerns how size affects rates of asset growth. Organizational size is widely recognized as an important factor influencing firm growth or expansion rates (e.g. Barron, et al 1994; Barron, 1999; Evans, 1987; Haveman, 1993; Nelson & Winter, 1982; Ranger-Moore, et al 1995; Wilson & Williams, 2000). Early empirical research relating firm size to firm growth examined the validity of Gibrat's law, the idea that a firm's growth rate is independent of size, and found mixed support (Mansfield, 1962; Evans, 1987; Hall, 1987; Hannan & Ranger-Moore, 1990). Recent studies in economics and organizational ecology, which use more robust research designs and methods, find that growth rates tend to decline as firms become large (Barron, et al 1994; Barnett, 1994; Hart & Oulton, 1999; Ranger-Moore, et al 1995; Wilson & Williams, 2000)[1]. Large firms may have lower growth rates than small firms because they are approaching an optimal size or because the structures and behaviors they have developed constrain their speed of adaptation to industry transformation (Haveman, 1993). If the latter is true, differences in the growth rates between large and small firms should become more prevalent as competition increases (Barron, 1999)[2].

How do differences in the structures and behaviors among firms of varying size affect growth during periods of industry transformation? First of all, large size is often associated with a degree of institutional insulation and bureaucratization that tends to make firms less responsive to shifting industry conditions (Haveman, 1993). In contrast, when large size is related to the development of positional advantages, such as favorable reputation (Kreps, 1996), status (Podolny, 1993), market power and relationships with institutional actors, large firms, both entrants and incumbents, may be more agile, and respond more rapidly to industry transformation, than small firms. Large incumbents, however, based on their longer exposure to the industry, may have established stronger positional advantages than large entrants. If a portion of these positional advantages transfer successfully to the deregulated environment, the asset growth rates of large entrants should lag those of large incumbents. Consistent with this view is that small size poses a liability for firms, attenuating their ability to adjust to environmental conditions (Banaszak-Holl, 1992; Baum & Mezias, 1992; Baum & Oliver, 1991; Delacroix & Swaminathan, 1991). These arguments suggest that large firms can overcome the hurdles facing small entrants and small incumbents. After an industry is transformed, however, the entrepreneurial characteristics of small firms may provide them with an innovating advantage over larger rivals. If both large and small incumbents and entrants are well positioned to adjust to shifting industry conditions, then it is not clear how heterogeneity in organizational size influences firms' rates of asset growth during deregulation.

Hypotheses:

Entrants vs. Incumbents. Together, the preceding arguments separate firms that enter an industry after a significant change from incumbent organizations whose histories span the change. Entrants do not have a legacy; their experience is solely related to the current regime. These unconstrained firms are also more likely to be the first to introduce cost reduction innovations, new business combinations, or quality improvement innovations to an industry (Klepper & Graddy, 1990; Mitchell, 1989). As a result, entrants' practices may be more directly aligned with the deregulated environment and, in turn, enable them to expand their asset stocks more readily then incumbent firms.

As for incumbents, the shift in institutional regime splits their history into pre and post deregulation. Even though part of their history from the regulatory environment may likely be useful for the deregulated environment, another part is associated with practices that deregulation renders obsolete. When these obsolete practices persist after deregulation begins, they become competence traps (Levitt & March, 1988; Stinchcombe, 1965). The mismatch between incumbents' practices and the new industry demands should thereby limit incumbents' abilities to capitalize on growth opportunities. Although incumbents may develop new practices to adjust to deregulation, their behavior is shaped by exposure to two different institutional regimes whereas entrants' behavior is based solely on exposure to the new institutional environment. Considering their experience mix, incumbents may initially search internally for changes that enable growth while entrants may be able to direct a greater level of attention to the external environment. These arguments suggest that even if incumbents overcome some of their history-induced constraints, their rates of asset growth will still lag that of entrants who face fewer constraints in adjusting to the new regime. This leads us to the following baseline prediction:

Hypothesis 1: After the industry deregulates, entrants will have higher rates of asset growth than incumbent firms.

Subsequent sections decompose this baseline prediction to understand how heterogeneity in size, controlling for age, gives rise to differences in the asset growth rates of entrants and incumbents after deregulation.

Benefits of Large Size. Empirical research shows that as firms increase in size they develop positional advantages and structural characteristics that enhance their agility (Haveman, 1993; Ranger-Moore, 1997). First, the market power associated with large size allows firms to engage in predatory actions to undermine, and gain a lead over, small rivals (Haveman, 1993; Pfeffer & Salancik, 1978). Second, large firms may have privileged relationships with powerful institutional actors (DiMaggio & Powell, 1983). These relationships may allow large firms to influence the institutional rule system to support their own growth. Third, the availability of slack resources might enable large firms to modify their resource bases more readily than small firms (Cyert & March, 1963; Nohria & Gulati, 1996). Finally, large organizations typically hold a broad portfolio of routines, which makes them structurally differentiated and, in turn, facilitates the development of expertise through specialization (Haveman, 1993; Freeman & Hannan, 1975). A concentration of expertise increases the chances that a firm will develop some novel changes to its operations more rapidly then a firm that lacks a similar degree of expertise. These traditional arguments suggest that large firms should grow faster than small firms. They do not, however address how differences between large firms, such as whether a firm is an entrant or an incumbent, influence firm growth rates.

Large Incumbents vs. Large Entrants. Integrating research on the benefits of large size with the idea that incumbents and entrants have different histories that influence their development, we argue that the growth rates of large entrants will exceed those of large incumbents. Although expertise may confer a benefit to large firms, expertise can also become so specialized that the acquisition of knowledge from outside the firm is inhibited. This, of course, restricts internal diversity (Aldrich & Auster, 1986; Cohen & Levinthal, 1990) but also promotes exploitation behavior over exploration behavior. A focus on exploiting existing expertise may direct incumbents' attention away from the external environment and therefore, from the growth opportunities presented by deregulation. Large entrants, in contrast, are somewhat immune to the adverse effects of specialization initially because their external focus is likely to be greater than that of incumbents. Even if they are structurally differentiated, any specialization they have developed is directed specifically at the deregulated regime. By contrast, some portion of incumbents' specialization was developed purposively for competition in the regulated regime. These arguments suggest that large size may provide greater benefits toward growth for large entrants than large incumbents.

Yet, one might argue that the positional advantages developed by large incumbents might compensate for the weaknesses associated with their degree of specialization. For instance, large incumbents may have invested in activities to develop institutional relationships in the previous regime. To the extent that these ties can be leveraged after the industry changes, large incumbents may not need to build new institutional relationships as extensively as entrants do. This frees up resources for developing technologies that support growth. If large incumbents' structural characteristics inhibit search behavior, however, the availability of resources may not lead to investments in activities that satisfy the new industry conditions. This leads us to the proposition that the growth rates of large incumbents will lag those of large entrants:

Hypothesis 2: After the industry deregulates, large incumbents will have lower rates of asset growth than large entrants.

Constraints of Large Size. The preceding section also implies that small firms will have lower asset growth rates than large firms. The counter argument is that large firms' abilities to change their operations to support growth are thwarted by bureaucratic rigidity (Aldrich & Auster, 1986; Haveman, 1993; Merton, 1957). First, large firm size is often associated with the development of formal rules and processes to support consistency and efficiency in operations. Because a change in operations typically challenges, or requires a modification to, the established rule system, a residual effect of an increase in the degree of formalization is reduced agility (Aldrich & Auster, 1986; Haveman, 1993). Second, formalization is correlated with the number levels in a firm's hierarchy (Meyer, 1979). Together, formalization and the number of levels in the hierarchy, may constrain a firm's adjustment to new industry conditions. The explanation is that hierarchies can create official boundaries within a firm; these boundaries combined with the formal rule system may impede free interactions across the firm that can support the development of new ways of operating (Blau & Scott, 1962). These arguments are consistent with the idea that as the number of firm employees increases, the opportunity for each employee to interact one-on-one with each of the other employees declines. In response, large firms will tend to adopt impersonal rules to facilitate communication, thereby reinforcing bureaucratization. As the bureaucracy become more durable, large firms are likely to become more inflexible than small firms. The preceding arguments are consistent with Haveman's (1993) rigidity of size hypothesis, which predicts that the rates of change of large firms will lag those of small firms. The question is whether the effects of these differences in size on firms' rates of change vary for entrants and incumbents during a period of industry transformation.

Large Firms vs. Small Firms. We argue that the bureaucratization associated with large size is likely to dampen the rates of change in assets of both large entrants and large incumbents (Aldrich & Auster, 1986). Consistent with hypothesis one, the rigidity effects may be stronger for large incumbents when their standard operating procedures and organizational structures developed for competing under regulation are retained under deregulation. Even though small entrants and small incumbents lack the financial endowments and positional advantages of their larger rivals, the rates of asset growth of small firms is less subject to the adverse effects associated with bureaucratic rigidity. These differences lead us to predict that large entrants and large incumbents are likely to grow their assets more slowly than small entrants and small incumbents, respectively:

Hypothesis 3a: After the industry deregulates, large entrants will have lower rates of asset growth than small entrants.

Hypothesis 3b: After the industry deregulates, large incumbents will have lower rates of asset growth than small incumbents.

Small Incumbents vs. Small Entrants. How do differences between small firms, such as whether a firm is an entrant or an incumbent, influence firm growth rates? After the industry deregulates, the ability of small and large incumbents to modify their asset bases may be partially constrained by investment policies formed under regulation. Firms tend to make investments in factor markets in response to the institutional context in which they are embedded (Meyer &

Rowan, 1977). As a result, their bundle of assets is likely to be an outcome of historically defined routines (Nelson & Winter, 1982; Winter, 1990). When these investments limit firms' responsiveness to the new market conditions, the established factor market positions of small and large incumbent firms may lower their growth rates during deregulation compared to those of entrants. These arguments are consistent with hypothesis two, which predicts that large incumbents will have lower asset growth rates than large entrants. They also lead us to the expectation that small incumbents will grow more slowly than small entrants:

Hypothesis 4: After the industry deregulates, small incumbents will have lower rates of asset growth than small entrants.

THE U.S. FOR-HIRE TRUCKING INDUSTRY

Industry Background. The for-hire trucking industry is primarily segmented into two motor carrier or trucking firm types: less-than-truckload (LTL) and truckload (TL). LTL carriers use complex terminal network systems to deliver and pickup shipments of less than 10,000 pounds. The terminal networks are analogous to a hub and spoke system where shipments are consolidated at the hub for transport over standard routes across terminals (Silverman, Nickerson, & Freeman, 1997; Tye, 1987). The LTL firms also employ sophisticated information technology based management practices (Glaskowsky, 1986). In contrast, the TL carrier operates on a much smaller scale, at times, with only a single employee. These carriers move truckload shipments (typically 10,000 pounds or more) door-to-door and do not require terminals for shipment consolidation or substantial investments in information technology for managing logistics (Tye, 1987). However, electronic data interchange (EDI) adoption increased substantially among TL carriers in the late 1980s as barriers to EDI adoption declined and shipper demands for customer service increased (Crum & Allen, 1997).

Deregulation in the U.S. for-hire motor carrier industry began in 1978, when the Interstate Commerce Commission (ICC) made a series of minor regulatory changes, and was formalized in the Motor Carrier Act of 1980. Before deregulation, government policy constrained entry, pricing and incumbent firms' geographic expansion. The ICC certified motor carriers or trucking firms to transport specific types of freight from point to point and to provide particular types of service. Trucking firms were prohibited from pursuing traffic that enabled them to balance their truckloads and in turn productivity and operating efficiency suffered (Ying & Keeler, 1991). These conditions also contributed to excess capacity in equipment and manpower (Perry, 1986). "Rate bureaus", referred to as carrier cartels, conducted meetings of motor carriers and published collectively defined tariffs that established the prices and terms for carrier service. Regulation required all services to be made available to all shippers (customers) either for an ancillary charge or at no charge, regardless of whether the shipper used the service or not. Further, shippers were not compensated for not using a service or for performing the service themselves. In sum, the service controls coupled with collective ratemaking and entry constraints contributed to higher than average economic rents for trucking firms under regulation (Rose, 1987; Tye, 1987).

Deregulation dramatically influenced trucking firm operations and industry structure by eliminating operating authority restrictions, reducing regulatory restrictions on entry and reducing the rate bureau's power (Elzinga, 1994; Johnson & Schneider, 1990; Rakowski, 1990). First of all, deregulation allowed incumbent firms to expand geographically and to realign their route structures. This geographic expansion increased the four firm concentration ratio of the less-than-truckload (LTL) industry sector from 23% in 1978 to 42% in 1987 (Boyer, 1993; Kling, 1990; Rakowski, 1990; Tye, 1987). Geographic expansion and route realignment also contributed to gains in long-run technical efficiency (Giordano, 1995) and in productivity (Corsi & Stowers, 1991). For instance, carriers increased their annual vehicle miles per truck, annual average load and annual average length of haul during the first seven years of deregulation (Corsi & Stowers, 1991). Carrier route rationalization under deregulation also allowed shippers to reduce the number of firms they did business with and enabled trucking firms to serve their designated markets more economically. Even though geographic expansion and route realignment increased the size and efficiency of some firms, the combination of geographic expansion, route restructuring and entry gave rise to excess capacity post-1980. Consequently, the exit rate among incumbent firms, both small and large, was quite high (Johnson & Schneider, 1990; Rakowski, 1990); 41% of the firms existing in 1980 had disappeared by 1993.

The increased competition that accompanied deregulation motivated firms to act independently and to redefine their opportunities (Glaskwosky, 1986). Changes to the regulations on backhaul, the utilization of cargo space on the way back to the trucking hubs, presented one such opportunity. A traditional source of backhaul was agricultural products. Under regulation, industrial products could not be picked up and carried on the fly (Glaskowsky, 1986). Under the new regime, firms could pick up general commodities for backhaul. Potential shippers would announce availability of a truckload of goods from point A to point B and solicit bids. Firms that utilized national computer systems, had empty or light loads that required movement between A and B, and could respond in a timely manner, were in a position to quote extremely low prices and benefited substantially.

The reduction in the rate bureau's power contributed to increased service and competition. Deregulation created a market situation where negotiations for rates reflected the service mix provided. These conditions provided flexibility to shippers and allowed them to make tradeoffs in services/rates in the bargaining process. Shippers began to evaluate carriers on a number of dimensions (e.g. transit time, reliability, quality, financial stability, delivery service, willingness to negotiate rates) and became more involved in the carrier selection process (Bardi, Bagchi, Raghunathan, 1989). Firms responded by investing in a variety of promotional tools but personal selling and personal contact promotions, higher cost options, were perceived to have had the most impact on the shipper-carrier relationship in the 1990s (MacLeod, Garber, Dotson, & Chambers, 1999). In general, these trends resulted in economic benefits for shippers.

Process Innovation. In response to the increase in competition after deregulation, firms focused on process innovations to control costs. A steady increase in computer usage for traffic analysis, cost analysis, equipment scheduling and equipment maintenance helped firms maintain tighter control of the operations. New technologies such as automatic vehicle identification, bar coding, EDI, in-vehicle navigation systems, on-board computers, and two-way communication systems also helped firms reduce production costs and increase customer service (OECD, 1992). In the late 1980s and early 1990s the use of automatic vehicle location (AVL) and long-distance, two-way communication technologies grew exponentially. These technologies eliminated the costs associated with "frequent driver check calls" between drivers and dispatchers (OECD, 1992: 109). On average, drivers made three check calls to the dispatcher per day; priority shipments often required more frequent check calls. In the early 1980s, drivers typically had to locate a truck stop and wait in line with other truckers to use the payphone. Check calls often took up to 45 minutes because drivers were frequently put on hold while the dispatcher was speaking to other drivers. AVL and long distance, two-way communication technology allowed the dispatcher to identify a vehicle's location so the driver did not have to stop and make a check call. Messages could also be transmitted to drivers en route and drivers could notify the dispatcher if they needed additional route information. The adoption of these technologies reduced the cost of long distance communication for one U.S. trucking firm by 60% (OECD,1992). The technologies also allowed firms to match loads with equipment more efficiently and to reduce the number of empty miles traveled by as much as 8 percent (OECD, 1992). In addition to cost savings, these process innovations allowed firms to provide more accurate delivery and service information to shippers.

DATA

Data Sources

The data stem from annual reports, or "Form M" reports, provided to the Interstate Commerce Commission (ICC) from 1980 to 1993. The reports include data on firm income, assets, revenues, equipment, operating expenses, revenues from equipment, organizational relationships, general operations, and location. Data on firm age were provided separately by the ICC. Given that the annual reports were a reporting requirement of U.S. trucking firms with annual revenues equal to or exceeding $500,000, we lack information on trucking firms with revenues below this floor. The generalizability of our findings is thereby limited to firms of a minimum size. The size floor must also be considered when defining firm exit. It is possible that a firm that is missing from the ICC's database did not exit the industry but is still alive with revenues below $500,000. To verify that a true exit event occurred, we examined the Verizon Yellow Pages by state for the existence of the firm that had exited the ICC's database. If a firm did not exist in the Yellow Pages for two consecutive years, we crosschecked the world wide web and trucking industry periodicals for postings in the firm's name. A firm was considered to have exited the industry when it was absent from the industry for at least two years and never returned.

Our data give us the ability to control for financial performance, net income, in predicting the rates of asset growth. Financial performance measures have rarely been included in research on firms' rates of asset growth even though they have an intuitive connection to expectations about the firm's future viability and therefore to the willingness of investors to continue to offer the firm support (exceptions, see Haveman, 1993). Measures of financial performance are available, however, only on trucking firms with revenues over $500,000 (Figure 3 shows the average revenues for incumbents and entrants over time after deregulation). Even though our focus is on large firms, it is important to ask how including trucking firms with revenues under the floor in the analysis might alter our results. We believe that their inclusion would have little substantive effect for a variety of reasons. Figure 4 shows that our current sample has a lognormal distribution, suggesting that no size-based competition exists. So it is likely that there is substantial churn among smaller firms. This also suggests that these firms are generally young and that there is a strong positive correlation between size and age in the trucking industry. If sensitivity to competitive pressures is associated with small size then one would expect that the smaller trucking firms not included in our sample should be even more sensitive. If this holds, then including these firms may decrease the rates of asset growth of both small entrants and small incumbents. As a result, some caution must be used in interpreting the results comparing the rates of asset growth of small firms to those of large firms. When the differences between the samples are marginal, including additional smaller firms in the small firm samples may further weaken the results. If the differences are quite large and significant, then the findings are likely to support the hypotheses, even in light of the data limitations. In addition, if the excluded firms also represent young organizations then including them might bias our analysis in support of the hypotheses.

[Insert Figures 3 & 4 about here]

Measures

Size. The dependent variable, firm size, is operationalized as the natural log of total operating assets. We use the natural log to reduce the skewness of the distribution.

Firm Level Effects. We include a set of firm level variables based on Nelson and Winter's growth model (1982, chapter 12) which emphasizes that differences exist in the growth rates of firms in dynamic environments. As previously stated, the dynamics of Nelson and Winter's model can be represented as the following virtuous cycle: large firms may have more resources to invest in searching for productivity improvements which increase their *efficiency* and improve their profit margins relative to rivals; *higher profit margins* make capital available for firms to invest in *capacity expansion*, which allows firms to *increase their asset stocks* relative to competitors, bringing us back to the beginning of the cycle. Hence, the main components of the growth model are size in assets, efficiency, financial performance and capacity expansion. These four components influence decisions at the micro level of the firm and in turn, the macro behavior of the model. Building on this framework, our model includes size, financial performance, efficiency and capacity expansion. Financial performance is measured using *Net Income,* a line item on the ICC Form M. *Efficiency* is operationalized using operating cost per revenue mile. An increase in this construct indicates that a firm's costs are rising for each revenue mile operated (e.g. the opposite of efficiency) therefore, the construct is reverse scored. We use the change in number of trucks operated by a firm from time *t-1* to time *t* as a proxy measure for *Capacity Expansion.* This measure captures the extent to which a trucking firm has expanded its primary units of production relative to the prior year.

All variables are time-varying and lagged one time period to reduce simultaneity effects. This results in a loss of two time periods of observation for each firm because capacity expansion is defined relative to the prior time period and then lagged.

Age. Entrant age is defined from the time a firm entered the industry. For incumbent firms, the models are tested using two different age variables. This approach allows us to determine if the asset growth rates for incumbent firms differ based on different mixes of experience. We first test the model using incumbent's age from the time of founding. We then test the model using incumbent's age under deregulation. Given that incumbents must combine their existing experience with new routines developed to compete under deregulation, their experience developed under deregulation may include some residual effects of their past. If incumbency exerts a drag on a firm's speed of adaptation to deregulation, then an incumbent's age under deregulation will partially capture this effect. Given these characteristics, the models that include incumbent age under deregulation should yield a relatively conservative test of the hypotheses. In all cases, we use the natural log of firm age to reduce the skewness of the distribution. The results are consistent across models using the different incumbent age measures. The tables report the results of models that use the log of incumbent's age from founding. An alternative approach is to include incumbent's age at deregulation and incumbent's age under deregulation in the same model. The model specification that we adopt, however, precludes using non-time varying variables (see Davidson & MacKinnon, 1993; Tuma & Hannan, 1984).

Industry Controls. Research shows that population density influences firm growth rates (Barron, et al 1994; Barron, 1999; Hannan & Carroll, 1992; Ranger-Moore, et al 1995). Density, defined as the number of firms operating in an industry, has a nonmonotonic (U-shape) relationship relative to firm growth rates as a result of legitimation and competition processes (Barron, 1999; Hannan & Carroll, 1992; Hannan & Freeman, 1989). Barron (1999) also finds that large organizations change their size at lower rates than small organizations and that the gap increases as density rises. Since we are interested in the competitive effects of entrants' behavior on incumbent firms' asset growth rates and vice versa, we distinguish the density effects of each class of firms. The *density of incumbent firms* is defined as the total number of incumbent firms the focal firm faces in a given year. The *density of entrants* is defined as the total number of entrants the focal firm faces in a given year. The models include both linear and quadratic density terms.

Density dependence assumes that each firm presents an equal competitive threat. Variation in firm asset stocks, however, contributes to variance in the competitive strength of firms (Barnett & Amburgey, 1990). These differences might make some firms more able to change their asset stocks compared to rivals. Including a mass variable, defined as the sum of the log(size) of all the firms minus the log(size) of the firm of observation, partially captures this heterogeneity in ability among firms (Barnett & Amburgey, 1990). With density included in the model, the mass variables indicate whether an increase in the average size of rival firms has a competitive effect on the focal firm's subsequent size. We control for this potential heterogeneity in the competitive strength of incumbent firms and entrants by including mass variables for each class of firms. For an incumbent firm, *mass incumbent firms* represents the sum of the sizes (size is the natural log of total assets) of all incumbent firms minus the size of the incumbent firm of observation. For entrants, mass incumbent firms is simply the sum of the sizes of all incumbent firms. *Mass of entrants* is operationalized in a similar fashion. All variables are time varying and lagged one year to control for simultaneity. Last, we include a dummy variable for each year of observation.

MODEL SPECIFICATION AND ESTIMATION

Our study focuses on comparing the rates of asset growth of entrant and incumbent firms after deregulation and generalizes to situations following a similar break in the institutionally governed rules of competition. Building on existing empirical research (Barnett, Greve & Park, 1994; Freeman & Hannan, 1975; Haveman, 1993; Henderson, 1999), we estimate firm rates of asset growth using a partial adjustment specification. We first test a baseline model to determine whether entrants and incumbents differ in their asset growth rates. Next, we decompose the entrant and incumbent populations into samples based on log size (e.g. small and large firms). The model is estimated for each sample and Wald statistics are used on the parameter estimates to test the hypotheses.

The partial adjustment model has the form:

$$\frac{d(S_i(t))}{dt} = r[S_i^*(t) - S_i(t)], \qquad (1)$$

Where $S_i(t)$ is the level of the continuous outcome variable at time t, $S_i^*(t)$ is a target value toward which forces are impelling $S_i(t)$ and r is the speed of adjustment toward the target (Davidson & MacKinnon, 1993; Tuma & Hannan, 1984). A lower value of r signals a slower or more inert change process. The $S_i^*(t)$ term is a linear function of firm level covariates, $\boldsymbol{\beta}\mathbf{X}(t)$. Substituting the value of $S_i^*(t)$ into equation 1 yields:

$$\frac{d(S_i(t))}{dt} = r[\boldsymbol{\beta}\mathbf{X}_i(t) - S_i(t)], \quad (2)$$

Partial adjustment models are quite useful for studying the evolution of firms. Importantly, they permit the target levels to be dynamic so that the parameters can be estimated without assuming that the system reaches equilibrium. The model specifically separates the rate of adjustment, r, from the actual and target levels (Tuma & Hannan, 1984). Estimates from the differential equation can also be compared across studies (Barnett & Carroll, 1995).

Equation 2 cannot be estimated directly and must be integrated to derive a model whose parameters can be estimated using regression analysis. Taking the integral of equation 2 yields:

$$S_{i,t} = \alpha S_{i,t-1} + \boldsymbol{\beta}_1 \mathbf{X}_{i,t-1} + \boldsymbol{\beta}_2 \Delta\mathbf{X}_{i,(t-1,t)}, \quad (3)$$

Where $S_{i,t}$ is the natural log of firm size at time t, $S_{i,t-1}$ is a lag of the dependent variable, $\mathbf{X}_{i,t-1}$ is a vector of time-varying firm-level covariates at time $t-1$, and $\Delta\mathbf{X}_{i,(t-1,t)}$ is a vector of changes in those predictors from $t-1$ to t. Using lagged values results in a loss of observations from the first year a firm was in existence. We also include the industry control variables and the year dummy variables in model 3. We use the estimates from equation 3 to calculate the parameters in the differential equation form of the model (equation 2) as follows:

$$r = -\ln(\alpha) \quad (4)$$

$$\boldsymbol{\beta} \approx -\boldsymbol{\beta}_1 r / (\alpha - 1) \quad (5)$$

$$\boldsymbol{\beta} \approx \boldsymbol{\beta}_2 r^2 / (\alpha - 1 - \ln(\alpha)), \quad (6)$$

Equations 5 and 6 define two approximations for $\boldsymbol{\beta}$ (Tuma & Hannan, 1984). Differences in the approximations stem from the extent to which the assumption of linear change in **X** over time is correct. Following Tuma & Hannan (1984: 344), we estimate $\boldsymbol{\beta}$ by taking the average of equations 5 and 6. Tables 3 and 4 report the parameter estimates based on the differential form of the partial adjustment specification (equation 2 above). The significance levels reported are based on joint F-tests on the $\mathbf{X}_{i,t-1}$ and $\Delta\mathbf{X}_{i,(t-1,t)}$ parameters from equation 3 (see Haveman (1993) and Henderson (1999) for a similar approach). This approach, however, does not yield standard errors for the estimated parameters therefore they are not reported.

Estimating regression models using pooled, time series data increases the chances that the independence assumption of ordinary least squares regression is violated. To address this concern, the firm level variables are mean-centered by firm to remove unobservable firm-level fixed effects (Greene, 1993; Nickell, 1981). This approach is econometrically equivalent to introducing a dummy variable for each firm into the model but allows us to avoid introducing a large number of variables into the model (Greene, 1993). This fixed effects approach requires suppression of the intercept (Greene, 1993). We also control for heteroskedasticity which often occurs when a large gap exists between the largest and smallest observed values. A wide gap increases the likelihood that the error terms may have different variances across observations and, in turn, the likelihood of an upward bias in the coefficient variances. A proportionality variable can be used to correct for heteroskedastic effects when the error variance is proportional to one of the independent variables, typically size. With this approach, each variable is weighted by the proportionality variable (Greene, 1993). In our framework, the error variance is proportional to firm assets; thus we divide each variable in the partial adjustment equations by the square root of firm assets. Last, our analyses might suffer from correlation of the error terms for the dependent variable and the lagged dependent variable. If autocorrelation of the error terms exists then the standard errors of the parameters will be biased and the parameter estimates will be inefficient. Examinations of plots of the residuals for each model indicate that the error terms lack any systematic trend in their dispersion[3].

Finally, sample selection bias may result when parameters that influence the rates of asset growth also cause firms to be selected out of the sample (Heckman, 1979). The rate models include a parameter to control for the impact of selection processes on entrant and incumbent firms' rates of asset growth. Using a generalization of Heckman's (1979) two stage sample selection model according to Lee (1983), the selection parameter, λ, is calculated as follows (see Barnett, et al (1994) and Henderson (1999) for a similar approach):

$$\lambda = \frac{\phi[\Phi^{-1}(F(t))]}{1 - F(t)},$$

where ϕ is the probability density function, Φ is the cumulative distribution function and F(t) is the cumulative hazard function. The selection parameter, λ, is calculated for every firm-year. The results do not change when the selection parameter is included in the model, suggesting a lack of sample selection bias.

All models are estimated using weighted least-squares regression. We first estimate equation 3 for the population of entrants and incumbents separately. Next, the entrant and incumbent populations are classified into samples, as detailed below, based on their log size (small and large). Equation 3 is estimated for each sample and Wald statistics are used to identify whether differences in the rates of asset growth across the samples of firms are statistically significant.

Sample Definitions

The industry average log size is used to classify firms into the small or large firm categories. Firms with a log(size) less than the industry average ($\mu = 14.47$) are classified as small and firms with log(size) greater than or equal to the industry average are classified as large. This approach yields four samples: small entrants, small incumbents, large entrants and large incumbents. Before adopting this approach, we conducted sensitivity analysis to determine the appropriate size demarcation for the samples. We first segmented the distribution by quartiles to define samples of the largest and smallest firms. The results using these samples were consistent with the findings reported here. Nevertheless, the quartile approach might bias the analysis in the direction of our hypotheses (e.g. the largest firms are likely to be the slowest to change of the large firm sample). A similar effect may occur when partitioning the distribution into thirds. Last, the models were tested using cutoff points defined as plus or minus the standard deviation from the mean. Again, results were consistent with those reported here. Given these findings, we adopted the most straight-forward approach, which segments the distribution based on the industry average size.

Considering that incumbent firms have been members of the industry longer than entrants, the large incumbent firm sample includes firms at size levels that entrants have not yet had the opportunity to attain. We conducted sensitivity analysis on the samples to determine if these characteristics biased the analyses. We first tested the models using the entire population of large incumbents. Next, we omitted incumbent firms from the 'large size' sample that exceeded the size of the largest entrant. Bounding the incumbent size distribution on the right hand side allows us to compare firms within the same size range. Since we expect that large firms, and particularly large incumbents, would grow at lower rates than small firms, excluding these firms would serve to dampen our results. Test statistics also indicate that the size distribution for incumbent firms remains normally distributed after this transformation (Kolomogorov D: .12, $p<.01$). The results were consistent across both samples indicating that no substantial bias exists. We report results from the full sample of large incumbent firms or the untransformed sample.

Table 1 presents statistics on log(size) for each sample. These stats show similarities in average size across the entrant and incumbent samples. Table 2 presents the correlation matrix, means and standard deviations for the population. Consistent with the extant research, correlations among the industry control variables (density and mass) are relatively high (>.80). Of concern here is whether the correlations among the industry controls influenced the parameter estimates for the key growth system variables (size, net income, efficiency and capacity expansion) in the regression analyses. We performed a hierarchical analysis to determine if incorporating the various industry controls affected the main parameter results. The main results remained intact across the models. In addition, the standard errors for the industry controls did not inflate across models.

Table 2 also indicates that the correlation between entrant log (age) and density incumbents is (-0.42) and the correlation between entrant log(age) and mass incumbents variables is (-0.43). Such near dependencies among the variables may degrade estimates, by changing their values or standard errors, without harming their usefulness and validity (Belsley, Kuh and Welsch, 1980: 115). Belsley, et al (1980) further state that if one is interested in whether a given coefficient is positive or negative and this effect is statistically significant in the hypothesized direction across models that contain relevant combinations of the collinear variables, then near dependencies among the variables have not harmed the parameter estimates. The resulting confidence intervals may be wider under these conditions, but the collinearity has caused no practical harm. Again we tested a set of nested models and found the signs on the coefficients for entrants' log(age) to be consistent across various model specifications.

RESULTS

Tables 3 and 4 report the differential equation form of the partial adjustment models (equation 2 above). Table 5 summarizes the results of the hypothesis tests. The baseline test compares the asset growth rates of entrants and incumbent firms after the industry deregulation. Model 1 in Table 3 lists the results for entrants. The results for incumbents are listed in model 2. Controlling for log(age), the findings show that entrants grow at a higher rate than incumbent firms. This difference is statistically significant ($r_E = .46 > r_I = .41$, $X^2 = 73.14$, $p<.05$), providing support for hypothesis 1. The parameter estimate for log(age) in model 1 is positive and significant and the parameter estimate for log(age) in the incumbent model is negative and significant. These findings suggest that entrants' asset stocks grow as entrants accumulate experience in the new regime and that incumbents past experience impedes their growth even as they gain experience under deregulation. Consistent with Nelson and Winter's growth model, net income supports investment in assets; the parameter estimates for net income are positive and significant in models 1 and 2. Efficiency is not significant in either model. The results indicate that capacity expansion is positively related to future size for both entrants and incumbents. The coefficient for capacity expansion is positive and significant in models 1 and 2.

Regarding the industry effects, the parameter estimates for incumbent density are positive and significant in both models. The quadratic effect for incumbent density is negative in both models but only significant in the incumbent model (model 2). These findings suggest that incumbents' assets increase up to some threshold and then begin to decline as the number of incumbents grows large. The estimates for the quadratic form of entrant density are negative and significant in both models. These findings imply that as the entrant population grows large, the assets of entrants and incumbents decline. An increase in the mass of entrants is positively associated with entrants' future asset stock; the parameter estimate for mass entrants is positive and significant in model 1. By contrast, the results show that mass incumbents has a competitive effect on entrants' and incumbents' development. The parameter estimates for mass incumbents are negative and significant in both models.

We also predicted that size would have differential effects on entrants' and incumbents' rates of asset growth. The findings, reported in Table 4, models 3 through 6, provide support for hypotheses 3a, 3b and 4 and counter support for hypothesis 2. Hypothesis 2 predicted that the asset growth rate of large incumbents would lag that of large entrants. Instead, Table 4 shows that large incumbent firms change their asset stocks faster than large entrants. This difference is statistically significant ($r_{LI} = .34 > r_{LE} = .30$, $X^2 = 65.64$, $p<.05$). The findings also demonstrate that after deregulation, large firms tend to grow slower than their smaller rivals. Models 3 and 4 in table 4 show that the estimated rate for large entrants is .30 and the estimated rate for small entrants is .73; the difference in the rates is statistically significant ($X^2 = 256.58$, $p<.05$). Models

5 and 6 in Table 4 show that the estimated rate for large incumbents is .34 and the estimated rate for small incumbents is .66; these differences are also statistically significant (X^2 = 504.62, $p<.05$). These findings are consistent with hypotheses 3a and 3b. In addition, the gap in the growth rates of large and small incumbents is less than the gap for large entrants and small entrants.

Finally, we predicted that small incumbent firms would grow at lower rates than small entrants. The estimated rate for small incumbents is equal to .66 and is less than .73, the estimated rate for small entrants. These differences are statistically significant (X^2 = 96.47, $p<.05$) and consistent with hypothesis 4. Similar to the entrant results reported in Table 3, entrants asset stocks tend to increase as entrants gain experience in the new regime; the parameter estimates for log(age) are positive and significant in models 3 and 4 in Table 4. The findings show that incumbents' future size tends to decline with experience; the parameter estimates for log(age) are negative and significant in models 5 and 6 in Table 4. These results are also consistent with the baseline model for incumbents listed in Table 3. The parameter estimates for net income are positive and significant in models 3 through 6. The findings show that efficiency has a negative and significant effect on future size of small incumbents. As expected, small and large entrants and incumbents grow as they increase capacity; the parameter estimate for capacity expansion is positive and significant in models 3 through 6. In addition, density incumbents has an inverted U-shape relationship relative to the asset stocks of small entrants and small incumbents. The linear term for incumbent density is positive and the quadratic term is negative. Both parameter estimates are significant in models 3 and 5. These findings suggest that the assets of small entrants and small incumbents increase up to some threshold and then begin to decline as the number of incumbents grows large. The findings also suggest that as the entrant population grows, the asset base of small entrants declines. The linear and quadratic effects for the density of entrants are negative and significant relative to firm assets for the small entrant sample. By contrast, entrant density has an inverted U-shape relationship relative to the assets of small incumbents. In addition, the quadratic effect of entrant density is negatively associated with large entrant and large incumbent size. These findings suggest that small and large incumbents and large entrants face a greater competitive threat from entrants as the entrant population grows large in number. The mass results provide some additional insights into the industry dynamics. The estimate for mass entrants is positive and significant relative to the future size of small entrants; these findings suggest a positive association between growth in the overall entrant population and growth of small entrants. The findings show the reverse effects for mass incumbents and suggest that increases in the size of incumbent firms is negatively associated with the growth of small entrants, small incumbents and large incumbents. The parameter estimates for mass incumbents are negative for all four models but only significant in models 3, 5 and 6.

DISCUSSION

In this paper we extend the research on industry evolution by identifying how histories of exposure to different institutional environments affect firms' rates of asset growth. We argued that deregulation fundamentally changes the way incumbent firms must compete. It therefore allows the artificial but useful separation of the industry into two types of firms: entrants, whose history is based solely on participation in the deregulated regime, and incumbents, whose history is based on participation in both the regulated and deregulated regimes. We find that after deregulation, entrants grow their asset stocks faster than incumbent firms, even as incumbents gain experience under deregulation. Thus, a firm's legacy of competing in the prior regime constrains its adjustment to the new regime.

Consistent with prior research, our results show that large firms, both entrants and incumbents, grow more slowly than small firms. Comparing entrants and incumbents within the same size category however, allows us to elaborate on the extant research. Large incumbents increase their asset stocks faster than large entrants. By contrast, small incumbents grow their assets more slowly than small entrants. These findings suggest that the growth rates of firms of similar size vary based on exposure to different institutional regimes. Thus, it would seem prudent to include this historical variable in studies of firm growth and industry evolution.

Consistent with prior research we find that large firms grow more slowly than small firms (Barnett, 1994; Barron, et al 1994; Barron, 1999; Ranger-Moore, et al 1995). Haveman (1993) however, offers counter evidence and suggests that the benefits associated with large size outweigh the constraints associated with large size. One explanation for the divergent findings lies with differences in the research contexts. Haveman's study was conducted in the California Savings and Loan Industry after deregulation where large firms tended to dominate their traditional markets due to scale and scope advantages that could not readily be matched by small firms. Such resource constraints did not pose a barrier for small firms in the trucking industry. After deregulation, small firms challenged large incumbents in their traditional markets and in markets they entered. In addition, one of Haveman's conclusions is that positional advantages, such as market power, dominate bureaucratic rigidity effects; this finding is based on the comparison of large and small firms. Comparing the growth rates of large incumbents to those of large entrants allows us to explore this conclusion a bit more directly. Both large entrants and large incumbents are subject to bureaucratic rigidity. Large incumbents however, based on their longer exposure to the industry, might have stronger positional advantages, in the form of privileged relationships with powerful institutional actors. Our findings suggest that large incumbents may have been able to leverage these relationships to support growth in the deregulated regime. Thus, the benefits of incumbents' institutional relationships seem to outweigh the adverse effects of bureaucratization and assist large incumbents in gaining an edge over large entrants. Exposure to different institutional rule systems therefore matters.

An alternative explanation for the general finding that entrants' have higher rates of asset growth than incumbents' stems from the influence of entrant heterogeneity on incumbents' abilities to grow. Incumbents must combine traditional practices with new routines developed for the deregulated environment in order to grow in the new regime. They must also thwart the development of entrants who are heterogeneous in their behaviors. Under conditions of uncertainty, entrants may innovate on a number of fronts increasing the diversity among the entrant population (Dahmen, 1984). This degree of heterogeneity is likely to contribute to increased search costs for incumbent firms as they try to determine which new firms pose the greatest threat and which entrant innovations will be critical to sustaining growth in the new environment. A high degree of heterogeneity among the entrant population coupled with incumbents' efforts to combine new routines and capabilities with past experience may increase the time required for incumbents to develop adaptive solutions. These conditions may be particularly challenging for small incumbents because they lack the financial endowments of large incumbents. These arguments are consistent with our finding that small incumbents tend to grow more slowly than small entrants. More generally, this alternative explanation implies that incumbents' rates of asset growth will lag those of entrants. Over time, however, as entrants age and unsuccessful incumbents exit, the surviving firms may become more similar in their operations and the gap in their growth rates may narrow. Thus, the survivors of deregulation, both incumbents and entrants, eventually become the set of incumbents facing the next major industry change to refresh the system.

Our study only covers a period of fourteen years after deregulation, while larger studies on growth rates in an industry typically extend over a much longer time period, say 75 to 100 years. During this extended period, it is likely that at least several changes in the institutional environment have occurred. One could assume then that the results of analyses performed over such a long time frame are smoothed across these changes, merging incumbents and entrants as each institutional event fades more or less slowly back into history. Extrapolating our results to earlier studies of more complete industry histories therefore entails asking the following questions. First, how many significant institutional changes occurred during the time period examined? If there was only one change, then the results presented here might be found again. If there were many changes, the problem of incumbents and entrants losing their distinctiveness over time appears. Second, how many firms entered the industry after each change? If few firms entered, then it would be clear that the industry was consolidating over time, assuming incumbent attrition. One might contend then that the institutional changes were virtually insignificant in their implications for incumbents' ability to grow based on outdated capabilities, since there was no important challenge from new firms with innovative practices. In short, the number and severity of institutional changes over the history of an industry, coupled with the amount of entry after each change, should determine how well our results extrapolate to studies of other industries spanning longer time periods.

It is worth noting some of the limitations of this work. Critical to the integrity of the adjustment process is the inclusion of factors in the partial adjustment model that impel the system toward a target value. Misspecification can lead to mixed findings and a lack of generalizability. Integrating the existing research on firm size and growth from organizational ecology with Nelson and Winter's traditional growth system allows us to define a fairly robust adjustment model. Consistent with research on evolutionary dynamics, income and capacity expansion underlie the growth process. Firms with greater profit levels tended to invest more in their assets stocks and to expand their capacity. The role of efficiency on trucking firms' asset growth is less clear. Although geographic expansion and route realignment increased the size and efficiency of some firms, these two factors, combined with entry, contributed to excess capacity post-1980. Firms focused their attention on rapid expansion to attract and retain customers, sacrificing efficiency in the process. Even though efficiency is positively correlated with firm size, income and capacity expansion as Table 2 shows, the effects may have been dampened by the intense battle for market share during deregulation.

In sum, this study demonstrates that, controlling for age and size, exposure to different institutional regimes and in turn, different types of competition, represents a stickiness variable. This effect gives rise to variance in entrants' and incumbents' rates of asset growth after deregulation. These differences illustrate the significance of institutional change and firm histories for the study of firms' growth rates and inform the extant research on firm growth. Comparing entrants' and incumbents' rates of asset growth with respect to firm size also sheds light on which firms pose the most formidable threat after deregulation ensues. In the trucking industry, controlling for age effects, entrants with less then 2 million in assets grow their assets faster than other firms and appear to pose the greatest threat. The most agile incumbents are also firms with less then 2 million in assets. More generally, once an industry is transformed, firm histories can represent an important source of distinction for firm evolution.

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Figure 1. Exit Rates of the Incumbent and Entrant Populations, 1981-1991

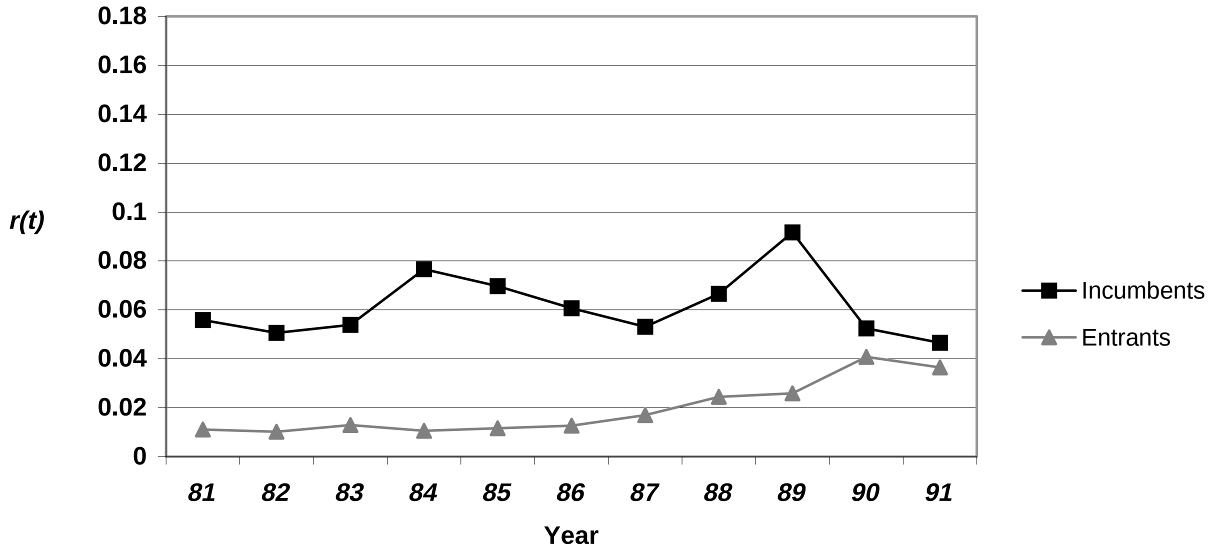

Figure 2. Density of Incumbents & Entrants by Year

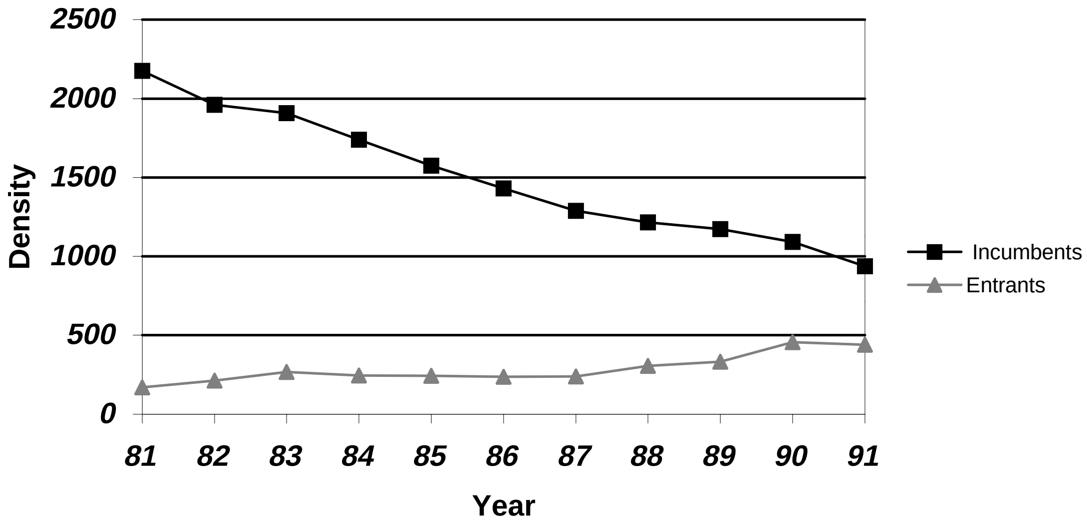

Figure 3. Average Revenues of Incumbents & Entrants, 1981-1993

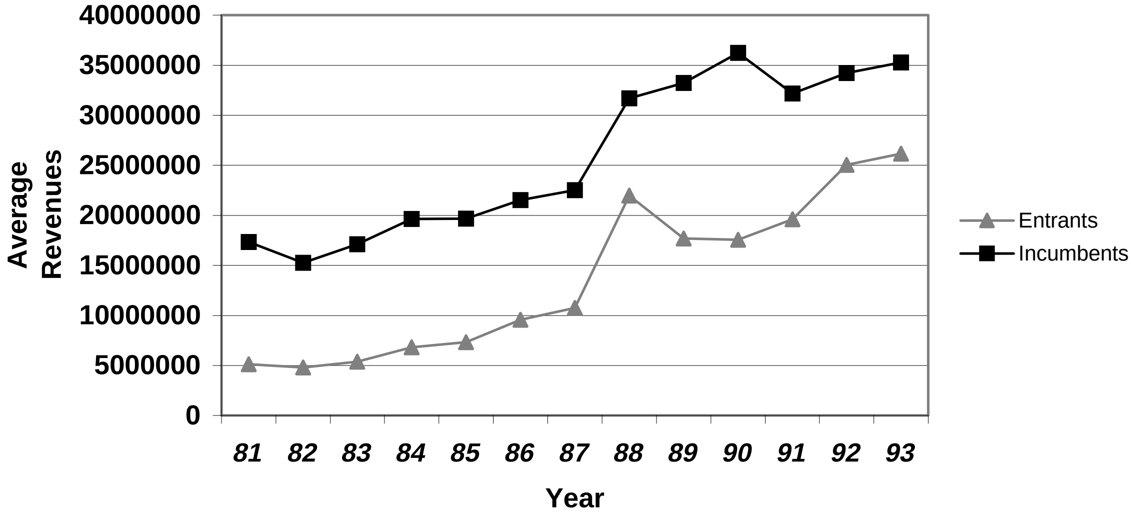

Figure 4. Size Distribution for the Population (1981, 1985, 1989, 1993)

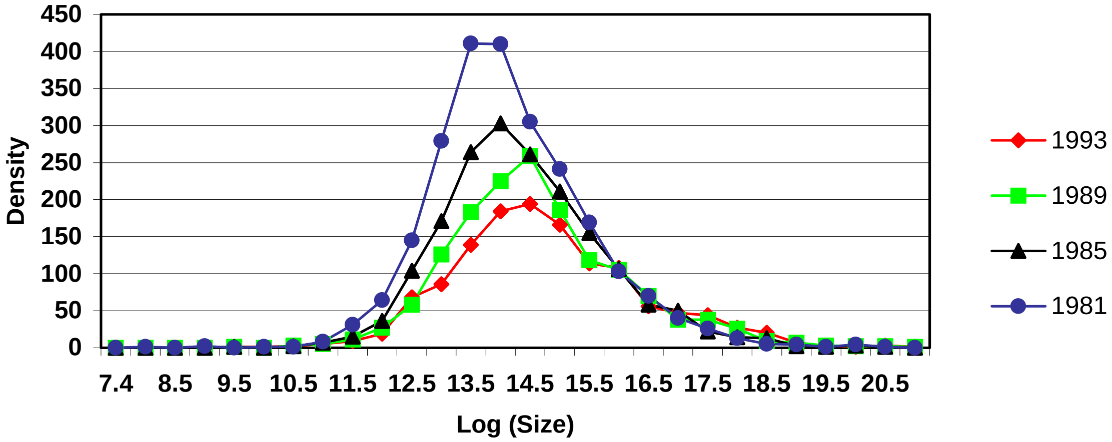

Figure 5 Test results:
Shapiro-Wilk Statistics for Normality

Year	W:Normal
1993	.79****
1989	.78****
1985	.77****
1981	.73****

****p<..0001

Table 1

Descriptive Statistics by Sample for the Trucking Industry, (1980- 1993)

Sample	# of Firms	Mean Log(Size)	Std. Deviation Log(Size)
Small Entrants	573	13.48	.74
Large Entrants	502	15.66	1.05
Small Incumbents	1510	13.58	.71
Large Incumbents	1418	15.73	1.09

Table 2

Means, Standard Deviations and Correlations, Trucking Industry (1980-1993)

		Mean	**Std. Dev.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1	Log (Size)	14.69	1.42	1.0								
2	Net Income	499217.01	5306295	.23	1.0							
3	Efficiency	7.91	213.58	.003	.001	1.0						
4	Capacity Expansion	7.78	552.18	.03	.07	.0006	1.0					
5	Log (Age) Entrants	1.17	.81	.04	.006	.01	.01	1.0				
6	Log (Age) Incumbents	3.00	.71	.19	.04	.01	.001	.33	1.0			
7	Density Incumbents	1428	408	-.13	-.01	-.008	-.007	-.42	-.14	1.0		
8	Density Entrants	283	91	.13	.01	.008	.006	.27	.12	-.84	1.0	
9	Mass Incumbents	21801.71	5918.10	-.14	-.01	-.01	-.007	-.43	-.15	.98	-.86	1.0
10	Mass Entrants	4218.17	1457.44	.12	.01	.007	.006	.28	.12	-.86	.98	-.87

Table 3
Differential Equation Form of the Partial Adjustment (PA) Models for the Asset Growth Rates of Entrants and Incumbents, Trucking Industry (1980-1993)[1,2,3,4]

	Entrants	Incumbents
Variable	(1)	(2)
r	.46•••	.41••••
Log(Age)	.03••••	-.017•••
$Income_{(t-1)}$	5.92E-8••••	3.93E-9••
$Efficiency_{(t-1)}$	-.0001	.000017
Capacity $Expansion_{(t-1)}$	.0006•••	.00059••••
Density (Incumbents)	.31••	.26••••
$Density^2$(Incumbents)	-.0000039	-.000004••
Density(Entrants)	-.15	.07
$Density^2$(Entrants)	-.000089••	-.000008••••
Mass(Incumbents)	-.02••	-.017••••
Mass(Entrants)	.013•	-.001
λ	-.32••••	-.14••••
$AdjR^2$	.53	.52
N	2376	9765

•p<.05, •• p<.01, •••p<.001, ••••p< .0001

1. In PA models, r refers to the rate of adjustment; in our specification, r refers to the rate of asset growth.
2. The differential equation parameters were calculated using the coefficient estimates from the PA models (See equations 4, 5 and 6 under model specification). The significance levels were defined using a joint F test on the *X* and *ΔX* components of the PA models.
3. λ is the adjustment for sample selection bias (Lee, 1983).
4. The PA models are fixed effects using mean-centering approach according to Greene (1993). Weighted least squares estimation was used to correct for heteroskedastic errors.

Table 4
Differential Equation Form of the Partial Adjustment (PA) Models for the Asset Growth Rates of Small and Large Entrants and Incumbents, Trucking Industry (1980-1993)[1,2,3,4]

Variable	**Small Entrants** (3)	**Large Entrants** (4)	**Small Incumbents** (5)	**Large Incumbents** (6)
r	.73••••	.30••••	.66	.34••••
Log(Age)	.029••	.023•••	-.011••••	-.029••••
$Income_{(t-1)}$	4.73E-7•••	5.53E-8•••	9.74E-7••••	9.93E-9•••
$Efficiency_{(t-1)}$	-.002	-.0003	-.0002•	.000005
Capacity $Expansion_{(t-1)}$	.0078••••	.00041•	.005••••	.00055••••
Density (Incumbents)	.91••	-.005	1.28••••	.12•
$Density^2$(Incumbents)	-.000017•	.000011	-.000022••••	-.0000014
Density(Entrants)	-.69••	.24	.36•	.02
$Density^2$(Entrants)	-.00015•	-.00016••	-.0003••••	-.000042•
Mass(Incumbents)	-.06••	-.0018	-.086••••	-.0087•
Mass(Entrants)	.052••	-.00088	-.009	.00048
λ	-.66••••	-.035	-.08	-.105••••
$AdjR^2$	.39	.68	.48	.64
N	1269	1107	3292	6473

•p<.05, •• p<.01, •••p<.001, ••••p< .0001

1. In PA models, r refers to the rate of adjustment; in our specification r refers to the rate of asset growth.
2. The differential equation parameters were calculated using the coefficient estimates from the PA models (See equations 4, 5 and 6 under model specification). The significance levels were defined using a joint F test on the *X* and *ΔX* components of the PA models.
3. λ is the adjustment for sample selection bias (Lee, 1983).
4. The PA models are fixed effects using mean-centering approach according to Greene (1993). Weighted least squares estimation was used to correct for heteroskedastic errors.

Table 5
Summary of Results: Comparison of the Asset Growth Rates for Entrants and Incumbents following Deregulation in the Trucking Industry (1980-1993)

Hypotheses	**Comparison of Rates**	**Wald X^2**	**Hypotheses Supported**
H1: r(Entrants) > r(Incumbents)	Trucking: .46 > .41	73.14•	H1✔
H2: r(Large Incumbents) < r(Large Entrants)	Trucking: .34 > .30	65.64•	
H3a: r(Large Entrants) < r(Small Entrants)	Trucking: .30 < .73	256.58•	H3a✔
H3b: r(Large Incumbents) < r(Small Incumbents)	Trucking: .34 < .66	504.62•	H3b✔
H4: r(Small Incumbents) < r(Small Entrants)	Trucking: .66 < .73	96.47•	H4✔

•p<.05; ✔indicates hypothesis is supported.

NOTES

1 . For reviews see Carroll & Hannan, 2000: 315-319 and Sutton, 1997. The economics and organizational ecology studies differ in several aspects, most notably in their data sets. The data used in organizational ecology studies tends to cover one population and spans the lifetime of the population. In constrast, the economic research in this area uses heterogeneous population data that spans shorter time periods (e.g. all the non-manufacturing firms in a country over a five-year period (Hart & Oulton, 1996). Traditional economic studies do not seek to explain the historical development of populations as many ecology studies do.

2. The context we study is the trucking industry following the deregulation of pricing and entry. Deregulation opened the industry to entrants but also created opportunities for incumbents firms to gain operating efficiencies via geographic expansion. This expansion contributed to an eighty percent increase in the four firm concentration ratio for the less-than-truckload sector during the first seven years of deregulation (Tye, 1987). This observation suggests that incumbent firms' growth may not have been limited by an optimal size threshold, at least during the initial periods of deregulation. Subsequent sections describe the industry in further detail.

3. Since we include a lagged dependent variable on the right hand side of the equations, the standard test for autocorrelation, the Durban-Watson statistic, is not appropriate (Greene, 1993). Alternatively, we examined plots of the residuals for each model to identify whether systematic variability exists. No disparity exists. These findings are available from the authors.