HORIZONTAL DIVERSIFICATION AND VERTICAL CONTRACTING:

FIRM SCOPE AND ASSET OWNERSHIP IN TAXI FLEETS

by

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Abstract

This paper considers the vertical implications of horizontal diversification. Many studies have documented organizational problems following corporate diversification. We propose that selective vertical dis-integration – shifting asset ownership to agents – can mitigate rent-seeking and coordination failures in the diversified firm. We test this proposition in a particularly simple setting that allows us to isolate the effects of interest and control for the likely endogeneity of diversification: taxi fleets that diversify into the limousine, or black car, segment following a wave of entry deregulation in the early 1990s. The results show that taxi fleets are substantially more likely to use owner-operator drivers following diversification. Moreover, diversified fleets that use a greater share of owner operators are more productive than diversified fleets that own most of their vehicles. We interpret these findings as evidence that firms re-organize in response to the challenges of diversification, and that there are causal links between the horizontal and vertical boundaries of the fleet.

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1. Introduction

What determines the boundaries of the firm? Since Coase (1937), this fundamental question has captured the attention of firm scholars. In the last several decades, the transaction-cost literature that has made considerable progress addressing Coase's question by analyzing vertical boundaries as a series of independent transaction-level decisions (see Masten and Saussier 2002, and Macher and Richman 2007 for reviews). At the same time, a diversification literature with roots in both strategy and finance has focused on the causes and consequences of corporate agglomeration (for an overview see Montgomery 1994, or Martin and Sayrak 2003). This paper takes a small step towards integrating these two perspectives by studying the vertical implications of horizontal diversification. Specifically, we examine how firms adapt their existing vertical structures when they expand into a new market.

The primary motivation for our empirical work is the idea that diversification may create intra-firm conflicts problems that provide an impetus for re-organization.[1] Drawing on the make-or-buy literature, we develop a set of hypotheses that suggest conditions under which intra-firm rent-seeking and coordination problems produce a negative correlation between horizontal diversification and vertical integration. The central idea is that it can be costly for a firm to have two business units competing for access to a shared resource – even when sharing produces economies of scope in the aggregate. Selective vertical dis-integration may limit internal rent-seeking and improve resource allocation in a diversified firm by changing incentive structures at the agent or division-level.

We test these predictions in a particularly simple context: the taxicab industry. Taxi fleets present a unique opportunity to study lateral diversification and vertical contracting for several

[1]While practitioners are likely to describe this as the post-merger integration problem (Pautler 2003), the strategic management literature has focused on the idea that some firms are better at re-configuring themselves than others, i.e. they possess dynamic capabilities (Teece, Pisano and Shuen 1997; Helfat, 1997).

reasons. First, the industry contains a large number of firms, using a relatively simple production technology in discrete local markets. Second, there is considerable variation in the ownership of key assets – cars and medallions – across fleets and markets. Third, a wave of deregulation led many incumbent taxi fleets to diversify into the limousine, or black car, market during the early 1990s. Finally, through the 1992 and 1997 Economic Census, we have access to detailed data on firm size, diversification, asset ownership and performance for all taxi and limo fleets with one or more employees.[2]

As with any empirical research on the effects of lateral diversification, a key challenge is the endogeneity of each firm's decision to expand (Villalonga 2004a). Our identification strategy exploits an exogenous shock provided by entry deregulation of limousines during the early 1990's. Specifically, we use *ex ante* competitiveness (concentration) of the local limo market as an instrument for diversification, and estimate a model in first-differences to control for time-invariant firm-specific characteristics that might be correlated with both asset ownership and the propensity to diversify. Thus, in the terminology of Athey and Stern (1998), our empirical strategy utilizes a system-specific instrumental variable. If *ex ante* limo-market concentration is correlated with diversification, but independent of idiosyncratic firm-level factors that influence asset ownership, our approach will identify the underlying structural relationship between horizontal diversification and vertical integration.

Our main results show that diversifying taxi fleets increase the proportion of owner-operator drivers by approximately 30 percent relative to those not entering the limo segment. This result appears in the basic first-differences regressions, while instrumenting for diversification leads to a modest increase in the ordinary least-squares coefficients. We also examine fleet-level productivity and find that an average increase in the percentage of owner-operators following diversification is correlated with a 3 to 4 percent increase in paid ride-miles per vehicle. We do

[2] By examining organizational economics issues in the context of fleets we follow in the tradition of Baker and Hubbard (2003) and Nickerson and Silverman (2003) who study make-or-buy decisions in trucking fleets.

not place a causal interpretation on these productivity results (after all, our primary results emphasize that asset ownership is endogenous), but they do suggest a link between organization and performance, an idea that is central to virtually any theory of the firm.

A broad interpretation of these findings is that, given the opportunity to enter the limousine business, many taxi fleets began exploiting their sales and dispatching resources across driver types. This strategy of value-chain specialization – leveraging a narrow set of vertical capabilities across many related markets – can be found in other settings. For example, the electronics industry contains a number of contract manufacturers (e.g. Flextronics or Solectron) who assemble a divers array of products designed and marketed by their customers. In food services, firms like SYSCO specialize in logistics for customers ranging from high-end restaurants to stadiums and nursing homes. On the internet, eBay offers a vertically specialized service that spans an astonishing number of markets.

By emphasizing the interplay between horizontal and vertical integration, this paper contributes to a stream of research that provides empirical evidence of externalities across transactions within a firm.[3] For example, Kalnins and Lafontaine (2004) and Lafontaine and Shaw (2005) show that the balance between independent and company-owned outlets in a franchise systems responds to both geographic spillovers and advertising intensity (which produces a free-rider problem). Novak and Stern (2007) show that make-or-buy decisions are highly correlated across sub-systems within a given automobile, and attribute this finding to complementarities in design and production. Similarly, Forbes and Lederman (2007) find that major airlines are less likely to contract with independent regional carriers on routes serving hub airports, where schedule disruptions may have system-wide implications.

[3] Most of the papers in this literature are motivated by theoretical work in transaction cost economics (Williamson, 1985) or property rights and incomplete contracting (Grossman and Hart 1986; Hart and Moore 1990). As a critique of early theoretical work, the idea of intra-firm externalities dates back at least to Harrigan (1984), and can also be found in the work of Argyres and Liebeskind (1999). Segal (1999) provides the foundations for a formal analysis of contracting with externalities.

This paper also adds to a nascent strategic management literature that considers organizational change in response to diversification.[4] For example, Capron, Dussauge and Mitchell (1998) examine the re-allocation of resources between targets and acquiring firms in a sample of 253 horizontal acquisitions. Karim and Mitchell (2000) study the relationship between acquisitions and product-line changes in a large sample of medical firms. Rothermael, Hitt and Jobe (2006) examine the use of taper integration – a combination of vertical integration and strategic outsourcing – in the microcomputer industry. A key contribution of our paper is the empirical strategy: since a variety of (unobserved) industry and firm-level factors might influence both diversification and organizational change, we rely on instrumental variables to identify the parameters of the underlying organizational production function.[5]

2. Theoretical development

Our central proposition is that firms adjust their internal organization to reduce rent-seeking behavior and improve coordination between business units following diversification. Specifically, we consider a case where horizontal diversification, motivated by operational synergies, can lead to changes in asset ownership in order to mitigate intra-firm conflicts. Since asset ownership is commonly used as a measure of vertical integration, this simple theory links changes in the vertical and horizontal boundaries of the firm.

Diversification is often motivated by the potential for two formally independent business units to achieve synergies, or economies of scope, by operating under unified corporate management.

[4] The theoretical literature on diversification is voluminous. Hypothesized benefits include fixed-cost sharing (Panzar and Willig 1981) and the ability to leverage firm-specific capabilities across multiple lines of business (Teece 1980; Levinthal and Wu 2006). Potential costs of diversification include a range of managerial and operational disturbances, capital budgeting problems, and distortions caused by intra-firm rent seeking at the division level (Lang and Stulz 1994; Lamont, 1997; Scharfstein and Stein 2000; Rajan, Servaes and Zingales 2000; Schoar 2002; Rawley 2007).

[5] A simple story might be that firms diversify in response to shocks (threats or opportunities) that also call for re-deployment of resources. The substantial diversification discount literature in finance is increasingly concerned with the same endogeneity problem (Villalonga 2004b).

Typically, the expectation of achieving synergies is based on the idea that some key slack asset – production equipment, technology infrastructure, a sales force or a talented manager – can be utilized more intensively when shared, thus lowering the average cost of production. Of course, this requires that internal coordination outperform market exchange (Teece 1982), which in turn depends on the cooperation of those who utilize or control access to the key assets.

The economic literature on vertical integration identifies two distinct forms of cooperation: *ex ante* investments that increase productivity and *ex post* negotiation over the resulting surplus. Different theories of the firm develop specific explanations why formal organization may outperform the market in either of these dimensions (Gibbons 2005). However, a common thread is that neither firms nor markets will produce optimal investment levels, or realize all potential gains from trade, in the absence of complete contracts and costless bargaining. Thus, we focus on the case where significant conflicts over access to a key asset are likely to arise, and neither selective intervention (Williamson, 1985) nor simple contracts can induce efficient cooperation.

Make-or-buy theories of the firm are typically motivated by vertical issues, such as conflicts between a manufacturer and distributor, particularly when the parties make transaction-specific investments. One contribution of our paper is to point out that similar problems can arise within firms between horizontally-related business units. Indeed, the logic of scope economies make it likely that conflicts will arise over access to common resources. Areas of potential conflict include access to customers (channel conflict), territorial rights (as in franchising), the capital budgeting process and promotions. Since these divisional conflicts typically lead to rent-seeking behavior and possibly resource mis-allocation (Rajan, Servaes and Zingales 2000), we expect diversified firms to organize in ways that limit the damage from conflicts.

Corporate managers have a variety of organizational tools for addressing this problem including monitoring, incentive contracts, job design, and recruiting policies. We focus on the idea that vertical boundaries can be used to address horizontal conflicts. In particular, firms may pursue a policy of selective vertical dis-integration – retaining assets that are shared across business lines, but transferring control over segment-specific resources to the division – to limit rent-seeking and promote efficient *ex ante* investments.[6] This idea builds on Grossman and Hart's (1986) insight that asset ownership conveys property rights, and these can alter incentives by shifting the bargaining power among parties to a given transaction.

An example may help to illustrate our hypothesis. Consider a multi-divisional firm that generates opportunities at the corporate level and fulfills them within divisions. If the divisions are substitutable, and the corporate parent cannot pre-commit to a mechanism for allocating opportunities, division managers will spend much of their time lobbying the parent.[7] In a model without horizontal externalities, Grossman and Hart (1986) suggest that firms will dis-integrate because the division under-invests in (non-contractible) production capabilities when the parent captures a large share of the joint surplus. In this setting, there is an added benefit: the dis-integrated division has weaker lobbying incentives. Note, however, that an independent division may still contract with the parent, especially if the internal division may be capacity constrained.[8] Thus, the dis-integrated firm provides swing capacity with limited coordination costs, but no guarantee of service. This may be more efficient than a fully integrated firm so long as the fixed costs of dis-integration (for example, setting up an independent sales capability) are not too high.

HYPOTHESIS 1: *Horizontal diversification will be positively correlated with vertical dis-integration (agent asset ownership) when (i) horizontal externalities are important; there are significant conflicts over access to shared resources, (ii) non-contractible efforts by the agent are important, and (iii) the fixed costs of dis-integration are relatively small.*

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[6] We are being intentionally broad about the boundaries of the firm here. For example, a firm might undertake dis-integration contractually by giving its employees (divisions) more discretion and stronger incentives, or it could terminate employment (ownership) and use them as a contractor.

[7] We assume the division managers' rewards somehow depend on sales, which are clearly outside their control in this very simple example.

[8] This discussion of Grossman and Hart (1986) is somewhat non-standard. Whereas most authors assume that it is always efficient for the two parties to transact, our story considers property-rights allocations in a world where the outside option matters not just for bargaining, but also because of lobbying and capacity constraints.

The specific conditions (i) through (iii) in Hypothesis 1 delimit our claims: we do not believe diversification will lead to dis-integration always and everywhere. However, we do think this argument generalizes beyond the taxi industry. Moreover, if Hypothesis 1 is valid, then vertical dis-integration facilitates a shift away from transactional mis-alignment, which may arise as firms and industries change, and we would expect this to have performance consequences (Nickerson and Silverman, 2003). This argument leads immediately to a second hypothesis.

HYPOTHESIS 2. *Under the conditions specified in Hypothesis 1, firms that remain vertically integrated following diversification will be less productive than firms that shift to the efficient organizational structure.*

To be clear, Hypothesis 2 is the mechanism behind Hypothesis 1: we assume that firms' choose their organizational form with productive efficiency (and ultimately profits) in mind.[9] However, separating the two propositions highlights an important empirical consideration. We test the first hypothesis by exploiting a natural experiment that produces exogenous variation in the horizontal boundaries of the firm. To test the second hypothesis, we would also need a source of exogenous variation in vertical boundaries since firms choose their vertical arrangements, and we recognize that these choices are not random.[10] Since we do not have a proper instrument, such as a source of random variation in firms' adjustment costs, we interpret our tests of Hypothesis 2 with some caution.

[9] Another way to make this point is by appealing to economic notion of duality. Hypothesis 1 is a statement about factor demands (where vertical integration is an input to the production process) that can be derived from a fleet's cost function. However, profit maximization implies that the cost function contains exactly the same information as the production function, which is the subject of Hypothesis 2.

[10] Put differently, even if diversification is randomly assigned, there might still be unobserved factors that are correlated with both productivity and vertical dis-integration.

3. Industry and Institutional Background

We use data from the private for-hire vehicle industry – taxi and limousine fleets – to test our hypotheses. This industry is particularly well-suited to the study of diversification and adaptation since firms rely on a simple production technology, operate in diverse local markets and exhibit substantial variation in contracting practices, horizontal diversification and vertical integration. This section describes the industry in greater detail, focusing on the legal factors that led to a wave of horizontal diversification between 1992 and 1997, and the economic factors that influence the decision to diversify into limos and/or contract with owner-operators who drive their own vehicles.[11]

Our measure of horizontal diversification is based on whether a fleet operates both taxicabs and limos. The primary difference between these two segments is that taxicabs can legally accept a hail (i.e., any passenger who solicits a ride), while all limo rides must be pre-arranged, usually through a centralized dispatcher. The number of taxi cab licenses granted in a given market is fixed by a local taxi commission, which provides medallions or permits that are associated with a specific vehicle and regularly inspected. Entry into the limo segment is considerably more flexible. While some cities or states certify each limo franchise, restrictions on the number of vehicles in use are rare.

The exclusion of black cars from the hail segment leads to some important differences in the organization of taxi and limo fleets. For example, taxi drivers typically have much stronger contractual incentives than black car drivers. A study by the Transit Cooperative Research Program (1998) found that 50 percent of limo drivers are paid a fixed hourly wage and 35 percent share a large portion of each trip's revenue with the firm, while 90 percent of cab drivers are full residual claimants – they pay the dispatcher a flat fee.

[11] Sherer, Rogovsky and Wright (1998) also note that the taxi industry exhibits substantial observable variation in asset ownership patterns across firms.

There are three basic types of contract used in the taxi segment. The first is a shift driver who leases the car, permit and dispatching service from a fleet on a day-to-day basis. In 1990, fifty-one percent of the vehicles in US fleets were staffed via these day or half-day leases (TLPA 1990). The same survey suggests that roughly one-third of the vehicles in US fleets are leased on a weekly or monthly basis. Finally, there are a substantial number of owner-operators, who have purchased a vehicle and medallion and may or may not contract with a fleet for dispatching services. Our data show that owner-operators accounted for approximately 14 percent and 37 percent of vehicles in fleets in 1992 and 1997, respectively, (see Table 1), and a larger (but unknown) percentage of all taxicabs in the market. Note that vehicle ownership does little to change a taxi-driver's short-term incentive to locate rides—since both fleet-drivers and owner-operators are typically full residual claimants—but may solve moral hazard problems or promote long-term investments to acquire industry-specific knowledge.[12]

In fact, the level of fleet-ownership in the taxi segment is at first puzzling, given the obvious moral-hazard problems created by this arrangement (Schneider 2005). However, many shift drivers are recent immigrants with very few marketable skills, who would find it difficult to finance a car and medallion – which can cost over $300,000 (Luo 2004). Our discussions with a number of fleet managers suggested that attracting the appropriate labor force is a key challenge in this industry and can present difficult trade-offs. In particular, the leasing system allows fleets to tap a large low-skilled labor pool, but managing shift drivers, who are only weakly committed to their job, is a major challenge. These drivers were often characterized as having limited knowledge of the city, poor language skills, little patience for special requests and strong tendencies to drive very aggressively, to maximize the number of rides they can deliver. Owner-operators, by contrast, are characterized as professionals with an intricate knowledge of their city, fluent English, keep their vehicle clean and in good operating condition and perhaps, most

[12] We believe this is an attractive feature of the taxi market for organizational research: employees and contractors perform similar tasks and face similar (high-powered) incentives, but there is considerable variation in asset-ownership.

importantly, give the impression that they take pride in getting their passengers from point A to point B safely. Moreover, our interviews suggest that while shift drivers tend to rely on a combination of dispatch and serendipity to generate rides, owner-operators will invest in industry-specific knowledge, often developing their own relationships with repeat customers and a better sense of where the hails are likely to be at any point in time.

Before the early 1990s, the taxi and limo segments were kept separate through regulation. This situation changed in the early 1990s, following a series of legal challenges to local regulatory authority. One of the most famous examples was the 1993 "Freedom Cab" case (*Jones v. Temmer*) in Denver**,** which garnered national publicity over a small firm's challenge to the broad regulatory authority Colorado exercised over entry into the taxi market (Cox, 1993). Within four years of the Freedom Cab case, entry into the limo segment was effectively deregulated in all fifty states. The practical result of these changes was to remove any legal or political obstacles to cross-ownership, and it led to a wave of horizontal diversification. In our data, 54% of the taxi fleets that survived from 1992 to 1997 diversified into limos during that period (see Table 1).

The logic behind horizontal diversification into the limo segment is predicated on fixed cost sharing and improved vehicle utilization. While opportunities for cost sharing extend to a wide range of activities, from servicing vehicles to negotiating group rates for insurance, shared marketing and dispatch operations present the greatest opportunity. However, shared dispatching also creates significant challenges.

Whereas taxi-only firms dispatch vehicles based solely on proximity to the call, integrated taxi and limousine firms dispatch limousines to the highest value rides, in part because the firm captures a share of the receipts from limo rides. As long as taxi drivers pay a flat fee for leasing and dispatching, which gives them strong incentives to find the hails, the fleet will have an incentive to utilize all available limo capacity before providing any dispatch service to the cabs. Our discussions with fleet operators suggest that conflicts over shared dispatching present serious challenges for the firm. In some cases, taxi drivers scoop limo dispatches by arriving in advance of the limousine and giving customers the mistaken impression that their limo had been cancelled. At a minimum, integration creates confusion among shift drivers over contract terms (taxi drivers in diversified firms pay lower lease prices because they receive fewer and less attractive dispatches, but this is often not well understood by the shift drivers), engenders ill will between taxi and limousine drivers and lowers the price that a taxi driver is willing to pay for dispatch.

In addition to conflicts over access to shared dispatch, diversification creates a set of issues related to marketing incentives and demand sharing. In a diversified fleet, deploying taxicabs on limo calls can mitigate peak-load problems in the limo segment. However, in order to maintain the limo fleet's brand position this swing capacity must be a set of clean, well-maintained taxicabs operated by knowledgeable, polite drivers.

Thus, integrated fleets face the conditions described in Hypothesis 1. First, there are a broad set of operational synergies that lead to joint production of taxi and limo rides, but also create conflicts over the access to shared dispatch. Second, driver asset-ownership helps to mitigate this problem by creating incentives for drivers to invest in industry-specific knowledge that facilitates more efficient substitution of dispatching effort for driver search. Finally, the fact that most markets contain a mix of owner operators and fleet-owned vehicles suggests that the fixed costs of dis-integration are relatively small. Thus, Hypothesis 1 predicts a positive correlation between lateral diversification into limos and vertical dis-integration in the taxi segment.

Our discussion with operators suggests that this theory is broadly consistent with anecdotal evidence discussed in the industry. Diversified fleets seemed to have a strong preference for owner-operators as a form of swing capacity. There was also less conflict between these drivers and the limo operators, since they shared a level of professionalism. Owner operators more readily understood the *quid pro quo* inherent in their contract with a diversified taxi firm. And owner-operators' investments, in learning to drive a city and finding their own repeat business, made them less reliant on the dispatcher than the shift drivers.

Our empirical tests examine whether taxi fleets that diversified into limos between 1992 and 1997 became more vertically dis-integrated (i.e. shifted towards owner-operators) relative to non-diversifying fleets. We address the endogeneity of the diversification decision by developing a market-level instrumental variable based on conditions in the local limo market (as of 1992). But first, we pause to consider a question raised by our measure of vertical integration: If a fleet contracts to provide dispatching services to a formerly independent owner-operator, does that represent vertical dis-integration?

A substantial amount of the vertical dis-integration in our data comes from the arrival of owner-operators, who contract with taxi fleets for dispatching service. This is not particularly surprising, since increased competition in the limo market following deregulation drives owner-operators to contract with fleets in two different ways. First, independent taxi-operators face the direct effect of limousine competition in the pre-arranged ride market, an important component of their block of business. Second, as passengers substitute limos for taxis in the pre-arranged market, more of the (fixed) taxi supply will shifts to the hail market, increasing competition in an area where owner-operators' superior knowledge traditionally provided an edge over shift drivers.

While this suggests that owner operators will increasingly shift towards fleet affiliation – a trend that is readily observed in Table 1 – our theory makes a specific prediction about which fleets these owner-operators will seek to join: fleets that have diversified into the limo segment. The match between an owner operator and a diversified fleet creates more value because the fleet values the owner operator's professionalism and the driver values the dispatcher's efforts to find high quality rides.

This discussion of owner-operators and integration suggests a re-interpretation of our hypotheses in terms of the different firm-level capabilities that exist in even this relatively un-differentiated product market. In particular, fleets that are vertically-integrated and horizontally-specialized compete by minimizing capital investment in vehicles and managing a pool of low-skill drivers, while horizontally-diversified and vertically dis-integrated fleets compete by establishing a brand that attracts the high quality rides valued by independent limo and taxi drivers. Of course, as an empirical matter, we still want to identify the impact of diversification on a fleet's vertical contracting decisions, holding constant the driver's choice of whether to contract with a firm or remain independent.

4. Data and Measurement

We use data from the 1992 and 1997 Economic Census of Transportation and Warehousing, which includes every taxi (SIC 412100) and limousine (SIC 411920) firm in the United States with at least one employee. These data contain establishment-level information on firm revenue, line of business revenue at the six-digit industry level, number of vehicles by type (taxi vs. limousine) and geographic identifiers. We focus on taxi firms ("fleets") with at least two taxicabs, $10,000 of taxi revenue and at least one other taxi fleet in their market (county). The 1992 and 1997 Economic Censuses contain 1,020 and 1,106 fleets, respectively, that meet these criteria.[13] Alternative samples, based on more or less stringent restrictions, led to qualitatively similar results. Our panel regressions are based on a set of 560 fleets that reported complete data in both years. Table 1 presents descriptive statistics for these fleets, which account for over 70 percent of industry revenue and approximately two-thirds of all vehicles.

As can be seen in Table 1, there were no diversified fleets in 1992. By 1997, 54 percent of the taxi fleets in our sample had entered the limo market. Average taxi-segment revenues increased from $675,000 to $849,000 between 1992 and 1997, while taxi-segment capital increased from $230,000 to $319,000.[14] Table 1 also shows a dramatic increase in the total number of taxis in our sample. This increase reflects the large number of formerly independent owner-operators who

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[13] Approximately 2,000 observations in both 1992 and 1997 do not indicate the number of taxicabs in the fleet. We discard these observations, which are primarily administrative record (AR) firms – very small establishments that the Economic Census does not actually survey but rather imputes values for.

[14] See the Appendix for a discussion of how capital stocks are measured.

decided to contract with taxi fleets during this time period. These independent drivers are only captured by the Economic Census when they contract with a fleet.[15]

We measure diversification using an indicator variable *DIVERSIFY* that equals one for fleets in SIC code 412100 with no limousines in 1992, and one or more limos in their fleet by 1997. Alternative measures, such as a threshold for the percentage of total revenue or capital in the limo segment, were highly correlated with the single limousine measure of diversification, yielding very similar results.

Our primary dependent variable *FLEETOWN* is the share of all taxis owned by the fleet. Table 1 shows that the mean fleet ownership rate fell from 86 percent in 1992 to 63 percent in 1997. Figure 1 foreshadows our main results by showing that there is a strong correlation between *DIVERSIFY* and changes in *FLEETOWN*. Moreover, this correlation does not appear to be driven by heterogeneity in fleet size, which might be the case if both diversification and increased use of owner operators were correlated with unobserved productivity shocks.

Finally, we measure fleet-level productivity using production-function residuals, following the methodology described in Foster, Haltiwanger and Syverson (2008). Specifically, we regress the log of taxi-segment revenues on the number of vehicles and a full set of market-year fixed-effects, and use the estimated residuals (*TFPQ*) as a fleet-specific productivity measure. This method allows us to use information from the full sample of fleets to estimate productivity, even though we use a balanced panel to test Hypothesis 2. Moreover, the fixed effects in our productivity model should pick up any variation in pricing, since fare schedules are fixed at the market-year level. Thus, *TFPQ* is a measure of physical productivity or asset utilization, unlike most productivity studies where the dependent variable (firm revenue) is contaminated by the impact of unobserved market power on prices. (Additional details on production function estimation are provided in the Appendix.)

[15] Davis, Haltiwanger, Jarmin, Krizan, Miranda, Nucci and Sandusky (2007) discuss the treatment of non-employer firms in Census data and show that taxi fleets are disproportionately represented in this category.

5. Methods

We test Hypothesis 1 using a simple OLS regression in first differences. Let *i* index the fleets in our sample and Δ represent the first-difference operator (between 1992 and 1997). We regress $\Delta FLEETOWN_i$ on $\Delta DIVERSIFY_i$ and a vector of control variables X_i that might plausibly directly or indirectly influence firms' asset ownership decisions, including: firm size (measured by lagged dollar value of a firm's capital stock), changes in local market population, changes in the share of taxis owned by other firms in the same market, changes in the number of taxis in other firms in the market, changes in the number of limousines in other firms in the market, a dummy for fleets that register as a corporation[16] and a dummy for urban markets. Thus, our initial specification is:

(1) $\Delta FLEETOWN_i = \alpha + \Delta DIVERSIFY_i\,\beta + X_i\,\delta + \varepsilon_i$,

where the parameter α measures the sample average change in *FLEETOWN*, and ε is the unexplained portion of any changes in vertical integration. Since we only observe two time-periods, taking first-differences is equivalent to introducing firm fixed-effects as either approach controls for unobserved time-invariant fleet-level factors that might influence *FLEETOWN*.[17]

While (1) controls for any correlation between diversification and time-invariant fleet-level unobservables that affect vertical integration, we might still worry about selection based on time-varying factors. In an experimental design, we would randomly assign diversification status and measure *ex post* differences in fleet asset-ownership across the treatment and control groups. In practice, we observe changes in both diversification and asset ownership following a regulatory shift that creates new opportunities for expansion into related markets. In this setting, we might expect diversifiers to be those fleets who will benefit most from expanding, which could

[16] We also ran models with a full set of legal form of organization dummies (indicators for corporation, partnership, sole proprietorship, co-operative) and obtained similar results.

[17] Two additional advantages of this estimator relative to the more common within estimator are that there is no need to adjust the standard robust errors, and it provides some additional flexibility in how we specify X_i. For example, we control for lagged size rather than size changes, which might be endogenous.

confound our estimates. For example, if fleets that experience a positive productivity shock expand through both diversification into limos and increased contracting with owner operators, the coefficient estimate on Δ*DIVERSIFY* will be biased.

We address the potential endogeneity of diversification by using the lagged concentration of limousines in a given market (*LIMOHHI92*) as an instrument for *DIVERSIFY*. In particular, we assume that *LIMOHHI92* is uncorrelated with factors in ε that influence taxi fleets' vertical integration decisions, and negatively correlated with the probability of diversification following deregulation. Why does limo concentration serve as a barrier to entry? Industry observers have suggested that diversification from taxis into limos is less attractive if there are strong limo incumbents that have already developed deep relationships in the lucrative corporate segment of the limo market (TLPA Fact Book, 2004). High limousine concentration also represents an entry barrier because of the increased threat of retaliation.[18] In practice we find that the first-stage results are very strong.

Our instrumental variables identification strategy would not be valid if *ex ante* limo concentration were correlated with factors that influence vertical integration of taxi fleets in local markets. However, the cross-sectional correlation between *FLEETOWN* and *LIMOHHI92* was not significant (raw correlation of 0.04) and our informal discussions suggest that the primary driver of limo entry was access to a base of corporate customers.[19] Another potential drawback of our instrumental variable is that it only generates market-level variation – we could not identify any fleet-level shifters of the costs or benefits of diversification that would satisfy the exclusion restriction for an instrument. In practice, we find that our IV generates substantial between-fleet

[18] Retaliation could be economic or physical. Celona, 2004a and 2004b reports explicit connections between organized crime and intimidation of limo drivers.

[19] Another concern might be that the timing or nature of deregulation is correlated with both ex ante limo concentration and factors that influence *FLEETOWN*. However, our discussions with local regulators suggest that deregulation was often carried out at the state level with little concern for variation in local market conditions.

variation, since the 560 fleets in our balanced panel operate in hundreds of different local markets.[20]

To complement our instrumental variables analysis, we use propensity score methods (Rosenbaum and Rubin 1983; Imbens 2004) to control for correlations between *X* and *DIVERSIFY*. This approach is similar to the two-step selection correction originally proposed by Heckman (1979), but makes fewer functional form assumptions in the first stage. We begin by estimating propensity scores $Pr(DIVERSIFY_i = 1 | X_i)$ using a probit model. These scores are then used as inverse probability weights in an OLS regression of equation (1). We also exclude fleets that do not fall on the common support of the estimated propensity score distribution. Intuitively, this approach will outperform standard regression control methods when the response of *FLEETOWN* to *DIVERSIFY* varies with *X* (i.e. there is treatment heterogeneity), and *X* is correlated with *DIVERSIFY*.

Table 2 presents estimates from the probit model that we use to estimate a propensity scores: column (1) reports coefficients and column (2) reports marginal effects at the average value of each regressor. Only firm size, population density and limousines per capita had a statistically significant effect on the diversification decision. The effect of firm size is large and negative, though imprecise, perhaps indicating that organizational shocks are more costly for larger firms. Firms located in lower density areas are also less likely to diversify, perhaps reflecting an increased demand for limo service in more urban markets. Limousines per capita had a significant negative effect on diversification, which is consistent with the rationale offered for our IV estimator. Columns (3) through (8) in Table 2 examine the sample means of *X* for diversifying and non-diversifying fleets in both the full and matched samples. While the percentage differences are typically small, they are statistically significant for several variables, and trimming the sample produces only a modest improvement. This suggests that using propensity

[20] We also estimated (but do not report) an OLS model that allowed the intercept in equation (1) to vary across markets, so the effect of *DIVERSIFY* is identified by deviations from a market-level asset ownership trend. While this approach requires that we discard our IV, the results were qualitatively similar to those reported below

score weights is appropriate, though we do not expect large changes in β given the modest explanatory power of our first stage results.

Finally, we test Hypothesis 2 by estimating first-differenced model for *TFPQ* that includes interactions between diversification and fleet asset ownership as well as a set of additional control variables. Specifically, we estimate the following regression

(2) $\Delta TFPQ_i = \alpha + \Delta DIVERSIFY_i \times [\beta_0 + \beta_1 \Delta TOTALCARS_i + \beta_2 \Delta FLEETCARS_i] + X_i \delta + \varepsilon_i$,

where $TOTALCARS_i$ is the logged count of taxis in fleet *i*, $FLEETCARS_i$ is the logged count of taxis owned by the fleet, and X_i is a vector of fleet characteristics that includes all of the variables described above along with a main effect for both *TOTALCARS* and *FLEETCARS*. In (2) the parameters β_0 and δ capture the main effect of shifts in firm boundaries on productivity, β_1 allows scale economies to vary across diversified and undiversified fleets, and β_2 captures the relationship between diversification and asset ownership. We use this more flexible specification rather than simply interacting *FLEETOWN* and *DIVERSIFY* to allow changes in productivity to vary with changes in firm size independently of pure composition effects, as one may be concerned that changes in fleet size contain information about changes in productivity.[21] Hypothesis 2 predicts that $\beta_2 < 0$: firms that remain vertically integrated following diversification will have lower productivity than dis-integrated firms.

As discussed above, this method will not identify the causal impact of dis-integration on productivity if firms respond to unobserved variables that are correlated with *DIVERSIFY* when they choose a particular mix of asset ownership. While we report correlations that are consistent with Hypothesis 2, we are unable to distinguish between selection effects driven by firms that benefit the most from a combination of diversification and dis-integration, and true complementarities driven by exogenous variation in the firms' operating environment. A conservative interpretation of β_2 is that it provides an upper bound on the parameter of interest.

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[21] Equation (2) is derived from a Cobb-Douglas production function in Appendix B. We obtain similar results using the more restrictive specification: $\Delta TFPQ_i = \beta_0 + \beta_1 \Delta DIVERSIFY_i + \beta_2 \Delta \text{FLEETOWN}_i + \beta_3 (\Delta DIVERSIFY_i \times \Delta FLEETOWN_i) + X_i \delta + \varepsilon_i$.

6. Results

Table 3 presents our main results, which show the impact of lateral diversification into the limo market on the expected asset-ownership mix of a taxi fleet. We estimate five different versions of equation (1): OLS, Tobit, firm fixed-effects (the traditional "within" estimator), propensity score weighted regression and the instrumental variables analysis (2SLS). Column (1) contains the baseline OLS results. The average change in the fleet vehicle ownership rate for lateral diversifiers relative to incumbents who did not expand laterally is -27 percent, and this effect is significant at the 1 percent level.[22] This estimate suggests that diversification accounts for roughly half of the large secular shift towards driver-owned cabs shown in Table 1. In column (2) we estimate a Tobit specification to account for the truncated distribution of *FLEETOWN*, and find very similar results.[23]

Column (3) in Table 3 presents estimates from the traditional within estimator, in part to show that they are not substantially different from our preferred first-differences specification. While the point estimate on *DIVERSIFY* is 25 percent larger, the difference is not statistically significant. The substantial change between columns (1) and (3) in the coefficient on log(taxi capital) reflects a change in the control variable: the fixed-effects model includes changes in the stock of vehicles, which might be endogenous, while the OLS model includes only the 1992 vehicle stock.[24] In column (4) we report estimates from the propensity score model, which are essentially indistinguishable from those produced by OLS.[25]

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[22] The coefficient on *DIVERSIFY* in the OLS specification is -0.31 so the effect on *FLEETOWN* is 1-exp{-0.31} = 0.27.

[23] This is not surprising as we observe only 33 censored observations – establishments where *FLEETOWN* equals either 0 or 1.

[24] It is not especially surprising that changes in firm size are correlated with changes in asset ownership mix, as diversifying firms grew faster than non-diversifiers, due to their smaller initial size and the fact that they attracted many more formerly independent owner-operators.

[25] Note that the trimming procedure excludes 55 fleets, or roughly 10 percent of the total sample. These were among the very largest taxi fleets in our data, which generally did not diversify (see Table 2).

Since the decision to diversify laterally is endogenous, the results shown in columns (1) through (4) can only be interpreted as correlations. It is possible that other unobserved characteristics of the firm, or market, are correlated with both *DIVERSIFY* and *FLEETOWN*. In column (5) we present estimates from our instrumental variables model, which controls for the potential endogeneity of diversification by using *LIMOHHI92* as an instrument for lateral diversification. The first-stage relationship between limo-market concentration and diversification is strongly negative: the t-statistic on *LIMOHHI92* in an OLS regression is -6.5 and the first-stage F-statistic of 11 indicates a powerful instrument. At the top of column (5), we report the 2SLS coefficient on *DIVERSIFY* of -0.50, which is statistically significant at the 1 percent level. We interpret this result as evidence of a causal relationship between diversification and changes in firm asset ownership rates in this industry. While the 2SLS point estimate is larger than the OLS estimate in column (1), they are not statistically different. However, a Hausman test for the exogeneity of *DIVERSIFY* rejects the null hypothesis that the OLS results are unbiased. Taken together, the results in Table 3 support Hypothesis 1.

In Table 4, we test our second hypothesis: diversified fleets that remain vertically integrated will be less productive. Recall that Hypothesis 2 predicts a negative coefficient on the interaction between *DIVERSIFY* and *FLEETCARS* conditioning on *TOTALCARS* and all of the main effects. Column (1) in Table 4 presents OLS estimates that are consistent with this prediction. The change in *TFPQ* for an average diversifier, a fleet that increased driver ownership by 30 percent, compared to a fleet that made no vertical contracting adjustments, corresponds to a 4 percent increase in paid ride-miles per vehicle. Although the magnitude of the effect is relatively small, it is economically meaningful and statistically significant. Columns (2) through (4) show that this result does not change substantially if we trim and weight by the propensity score and/or include a number of additional control variables.

A number of the ancillary parameter estimates in Table 4 deserve some comment. First, the large and statistically significant constant term indicates that the (relative) productivity of fleets in our balanced panel increased between 1992 in 1997. This is not particularly surprising, since the sample conditions on survival over that time period. Second, the negative coefficient on *DIVERSIFY* suggests a decline in taxi-segment productivity following diversification, which is consistent with the anecdotal evidence on ride cannibalization and organizational conflict described in Section 3. Finally, the coefficient on *TOTALCARS* and its interaction with *DIVERSIFY* have a more subtle interpretation (since *TOTALCARS* appears in the denominator of *FLEETOWN*). Our main estimates suggest that fleets with higher *TOTALCARS* are more productive, and that this effect is less pronounced for diversified fleets.[26]

Overall, we interpret the estimates in Table 4 as suggestive evidence in favor of Hypothesis 2. While we are not able to control for the potential endogeneity of changes in asset ownership, we do find correlations that are consistent with complementarities between diversification and the use of owner-operators. Moreover, since these complementarities are the mechanism we use to explain the relationship between diversification and dis-integration in the organizational input equation (Hypothesis 1), it is reassuring to find supporting evidence in the corresponding output equation.

7. Conclusions

This paper examines the vertical implications of horizontal diversification. Our goal is to bring together two large streams of literature on firm boundaries: the (vertical) make or buy literature and the (horizontal) diversification discount literature. We develop a relatively simple story that predicts vertical dis-integration – contracting out or agent asset ownership – following horizontal diversification, as a way to mitigate the problems of divisional rent-seeking and organizational conflicts that arise in an integrated firm. We test these predictions using novel data on taxicab

[26] The main scale effect is found by subtracting the coefficient on *FLEETCARS* from the coefficient on *TOTALCARS* (which yields a point estimate of 0.37) while impact of diversification on this scale effect is the difference in corresponding interaction terms (which yields -0.15). See the Appendix for a derivation.

firms collected by the Economic Census of Transportation and Warehousing. This industry has several advantages from empirical work; notably the very simple production and contracting environment and the fact that fleets operate in a set of heterogeneous local markets under regulated prices. Our empirical strategy exploits both a regulatory change and variation in local market conditions to show that, diversification into the limo market-segment causes a 20-30 percent shift toward agent ownership of taxis in diversified taxi fleets. We also use a fleet-level productivity measure to show that taxi firms that do not shift towards owner operators following diversification experience less productivity growth than fleets that do adjust their mix of asset ownership.

Taken together these results reinforce the idea that diversification creates managerial challenges that firms subsequently manage through organizational adaptation. This idea is prominent in work by Capron, Dussauge and Mitchell (1998), Capron (1999) and Karim and Mitchell (2000), and in practitioners' emphasis on the problems of post-merger integration (Uhlaner and West, 2008). This paper contributes to the dialogue on corporate diversification and organizational adjustment in two ways: first, by emphasizing vertical organization as a specific margin of response; and second, by focusing on a simple empirical setting where it is possible to deal with the likely endogeneity of the decision to diversify.

Finally, by examining diversification and vertical integration strategies as interrelated organizational choices, we shed some new light on how corporate strategies are developed. These insights may be particularly relevant in settings such as the hospitality industry or restaurant franchising, where firms engage in product diversification within a geographic market, frequently through co-investments with agent-operators, and seek synergies by coordinating certain activities across establishments. These industries may provide a promising setting for future research on the links between firms' horizontal and vertical boundaries.

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Table 1 – Descriptive statistics

	1992		1997	
	Mean	Std dev	Mean	Std dev
Test sample (n=560)				
TFPQ	0.05	0.71	0.11	0.80
Taxi revenue ($000)	675	1890	849	2739
Taxi capital ($000)	230	673	319	934
Total taxis	24	64	35	83
Fleets with 2 taxis	0.27	0.44	0.09	0.29
Fleets with 3-5 taxis	0.19	0.39	0.22	0.42
Fleets with 6-10 taxis	0.19	0.39	0.20	0.40
Fleets with 11-25 taxis	0.17	0.38	0.21	0.40
Fleets with 26-50 taxis	0.09	0.29	0.10	0.30
Fleets with >50 taxis	0.10	0.30	0.17	0.38
Fleet owned taxis (fraction)	0.86	0.33	0.63	0.36
Taxi and limo firm (fraction)	0.00	0.00	0.54	0.50
Taxis in the county	231	480	474	673
Limos in the county	103	228	221	414
Limo market concentration (HHI)	0.05	0.13	0.32	0.36
County population (000)	885	1036	985	1147
County square miles	861	1642	878	1714
Sole proprietor	0.14	0.35	0.14	0.35
Partnership	0.02	0.13	0.02	0.15
Corporation	0.80	0.40	0.80	0.40
Cooperative	0.04	0.19	0.04	0.19
All firms	Total 1992		Total 1997	
Taxi revenue ($M)	521		669	
Number of taxis	20,014		29,960	
Number of fleet owned taxis	16,426		18,303	
Number of fleets	1,020		1,106	

The test sample includes firms that meet all of the following criteria: SIC code 4121 (taxicabs) in 1992, {taxi revenue ≥ $10K, at least 2 taxicabs, and at least 2 taxi fleets in their market (county)} in both 1992 and 1997.
"All firms" includes firms that meet the sampling criteria in at least one year (1992 or 1997).
Census Bureau restrictions prohibit publication of minimum and maximum variable values.

Table 2 – Probit model of diversification from taxicabs to limos

Dependent variable (y) = Diversified from taxis to limos between 1992 and 1997 {0,1}									
				Full Sample			Common Support		
	(1)	(2)		(3)	(4)	(5)	(6)	(7)	(8)
	Coef.	dy/dx at avg. val. of x		Focus.	Divers.	t-test on Δ	Focus.	Divers.	t-test on Δ
1992 TFPQ	-0.05	-0.02		0.11	-0.00	1.98	0.02	-0.02	0.54
	(0.09)	(0.03)		(0.05)	(0.04)		(0.05)	(0.04)	
1992 Fleet taxi ownership rate	0.17	0.07		0.89	0.83	1.95	0.88	0.83	1.65
	(0.22)	(0.09)		(0.02)	(0.02)		(0.02)	(0.02)	
1992 log (taxi capital)	-0.86	-0.34	*	4.75	3.93	7.42	4.34	3.82	5.25
	(0.52)	(0.21)		(0.09)	(0.07)		(0.07)	(0.06)	
1992 log (taxi capital^2)	0.02	0.01		9.50	7.86	6.35	8.68	7.64	4.26
	(0.02)	(0.01)		(0.21)	(0.15)		(0.20)	(0.14)	
Partnership indicator	-0.37	-0.15		0.03	0.01	0.56	0.02	0.01	0.36
	(0.46)	(0.18)		(0.02)	(0.03)		(0.02)	(0.02)	
Corporation indicator	0.20	0.08		0.80	0.81	-0.24	0.79	0.81	-0.64
	(0.16)	(0.06)		(0.03)	(0.02)		(0.03)	(0.02)	
1992 log (county population)	0.11	0.04		12.88	12.86	0.19	12.71	12.84	-1.02
	(0.11)	(0.04)		(0.09)	(0.09)		(0.10)	(0.09)	
1992 log (county population^2)	0.00	0.00		6.15	5.73	3.67	6.06	5.71	3.02
	(0.00)	(0.00)		(0.08)	(0.08)		(0.09)	(0.08)	
Log (county square mile)	-0.11	-0.04	*	3.14	2.85	1.02	3.13	2.87	0.96
	(0.06)	(0.02)		(0.22)	(0.18)		(0.21)	(0.17)	
1992 log (taxis in the county$_{-i}$)	-0.03	-0.01		2.18	1.70	3.55	2.05	1.71	2.29
	(0.08)	(0.03)		(0.10)	(0.09)		(0.11)	(0.10)	
1992 log (limos in the county)	-0.16	-0.06	***	0.25	0.34	-2.27	0.23	0.35	-2.83
	(0.06)	(0.02)		(0.03)	(0.03)		(0.03)	(0.03)	
Urban	0.07	0.03		0.43	0.61	-1.41	0.44	0.60	-1.33
	(0.26)	(0.10)		(0.08)	(0.10)		(0.08)	(0.09)	
Constant	0.28	0.03							
	(1.05)	(0.10)							
Pseudo R^2		0.09							
N		560		254	306		213	292	

*** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level

Table 3 – Diversification and asset ownership: equation (1)

Models 1,2,4,5: $FLEETOWN_{i1997} - FLEETOWN_{i1992} = a + B_1\sigma_i + \mathbf{X_{ic}B_c} + e_i$

Fixed Effects model: $FLEETOWN_{it} = a + B_1\sigma_{it} + \mathbf{X_{itc}B_c} + FIRM_i + YEAR_t + e_i$

Dep. variable = Change in the % of vehicles in the fleet owned by the firm (ΔFLEETOWN)	(1) OLS		(2) Tobit		(3) F.E.		(4) P-score		(5) 2SLS	
DIVERSIFY	**-0.31**	***	**-0.29**	***	**-0.40**	***	**-0.27**	**	**-0.50**	***
	(0.07)		**(0.04)**		**(0.05)**		**(0.11)**		**(0.09)**	
1992 log	-0.03		-0.03	*	0.21	***	-0.09	*	-0.05	
(taxi capital)	(0.02)		(0.02)		(0.05)		(0.05)		(0.03)	*
ΔCounty taxi	0.09	*	0.09		0.08		0.04		0.09	
ownership rate$_{-i}$	(0.05)		(0.05)		(0.06)		(0.04)		(0.05)	*
Δlog(taxis in	0.03	**	0.04	*	-0.00		0.03		0.03	
the county$_{-i}$)	(0.02)		(0.02)		(0.02)		(0.02)		(0.02)	**
Δlog (limos in	-0.02		-0.02		0.02		-0.03		-0.02	
the county$_{-i}$)	(0.02)		(0.02)		(0.02)		(0.02)		(0.02)	
Δlog (county	-0.13		-0.14		-0.04		-0.12		-0.13	
pop.)	(0.15)		(0.19)		(0.10)		(0.19)		(0.15)	
Corporation	0.10	**	0.10	**			0.11	**	0.12	
	(0.05)		(0.05)				0.05		(0.05)	**
Urban	-0.05		-0.07				-0.09		-0.05	
	(0.07)		(0.07)				(0.11)		(0.06)	
Year dummy					-0.02	**				
					(0.01)					
Constant	0.11		0.10		34.51	**	0.28		0.29	
	(0.11)		(0.12)		(16.58)		(0.21)		(0.18)	
560 firm fxd effects	N		N		Y		N		N	
R^2 /Psuedo-R^2	0.12		0.07		0.23		0.09		n/a	
N	560		560		1120		505		560	
1st stage summary statistics										
F-statistic									11	
t-statistic on IV									-6.5	
Adjusted R^2									0.13	

Standard errors are robust and clustered at the market (county) level except in the fixed effect model where they are clustered at the firm level

There are 22 left censored and 11 right-censored observations in the Tobit specifications

The 2SLS IV = Herfindahl index of lagged (1992) market (county) concentration of limos.

The Durbin-Wu-Hausman test rejects the null hypothesis that the instrument is not necessary at the 1% level (χ^2= 20 in column 5)

*** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level

Table 4 – Diversification, vertical dis-integration and productivity: equation (2)

$TFPQ_{i1997} – TFPQ_{i1992} = a + B_1\sigma_i + B_2T_i + B_3T_{FLEETOWNi} + B_3(\sigma_i \, x T_i) + B_3(\sigma_i \, x T_{FLEETOWNi}) + \mathbf{X_{ic}B_c} + e_i$

Dependent variable = change in total factor productivity (ΔTFPQ)

	(1a) OLS		(1b) P-score		(2a) OLS		(2b) P-score	
ΔDIVERSIFY x ΔFLEETCARS	**-0.14**	**	**-0.14**	*	**-0.16**	**	**-0.18**	**
	(0.07)		**(0.08)**		**(0.08)**		**(0.08)**	
Δ*DIVERSIFY* x Δ*TOTALCARS*	-0.29	***	-0.35	***	-0.23	**	-0.31	**
	(0.11)		(0.11)		(0.11)		(0.12)	
ΔDIVERSIFY	-0.14	*	-0.19	**	-0.15	*	-0.21	**
	(0.07)		(0.07)		(0.08)		(0.09)	
ΔFLEETCARS	-0.38	***	-0.45	***	-0.38	***	-0.43	***
	(0.07)		(0.11)		(0.10)		(0.10)	
ΔTOTALCARS	-0.01		0.06		-0.04		-0.04	
	(0.10)		(0.12)		(0.10)		(0.12)	
Corporation Dummy					0.00		-0.05	
					(0.06)		(0.06)	
ΔCounty taxi ownership $rate_{-i}$					0.16	**	0.19	**
					(0.07)		(0.08)	
Δlog(taxis in the $county_{-i}$)					0.04		0.02	
					(0.03)		(0.03)	
Δlog (limos in the $county_{-i}$)					-0.05		-0.01	
					(0.03)		(0.03)	
Δlog (county pop.)					0.16		0.17	
					(0.30)		(0.32)	
Constant	0.30	***	0.31	***	0.36	***	0.26	**
	(0.05)		(0.06)		(0.11)		(0.12)	
Adjusted R^2	0.40		0.45		0.41		0.42	
N	560		505		560		505	

Standard errors are robust and clustered at the market (county) level

The results in this table include all firms with SIC codes 412100 (taxicabs) or 411920 (limousines), taxi revenue ≥ \$10K, at least 2 taxicabs, and at least 2 taxi fleets in their market (county) in either 1992 or 1997.

The excluded status category is incumbents who did not laterally diversify.

*** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level

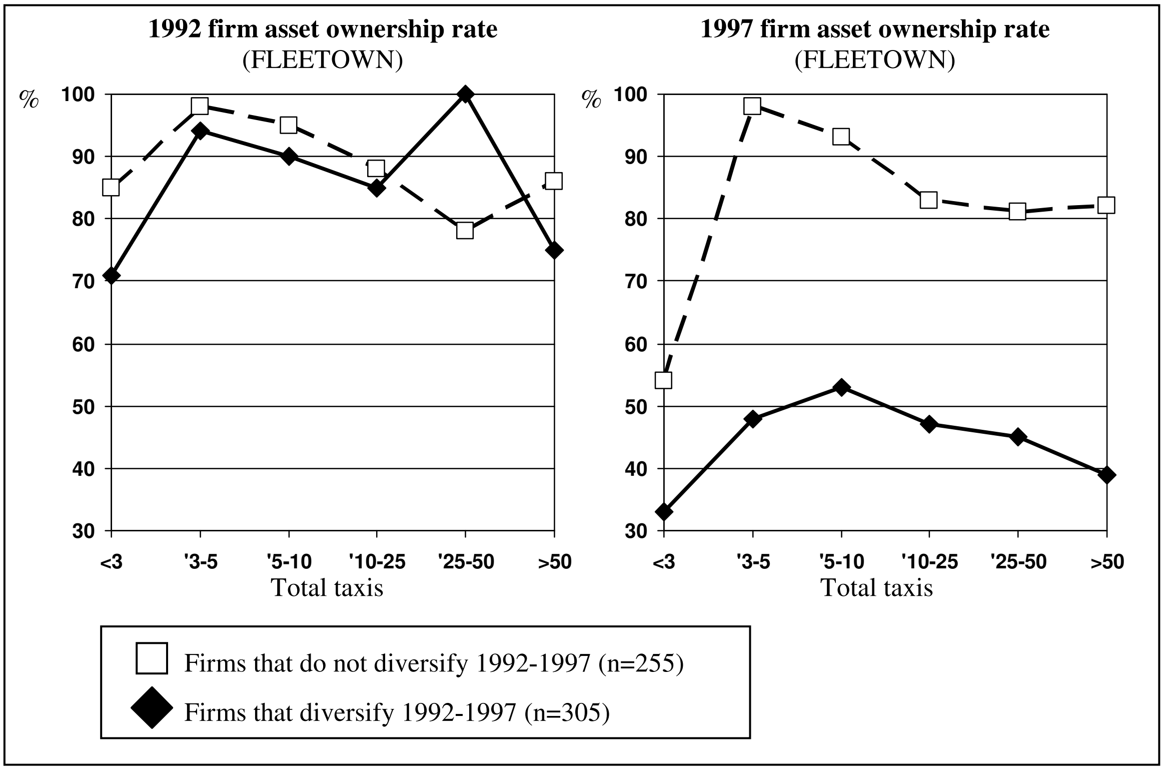

Figure 1: Diversification and asset ownership by firm size

Appendix: Productivity measurement

Our starting point for measuring productivity is a standard Cobb-Douglas production function:

(A1) $Y = K^{\gamma 1} L^{\gamma 2} \eta$,

where K is a measure the fleet's capital stock, L are labor inputs and η is a residual that captures all other factors, including the organization of the fleet, that influence productivity. In practice, since taxi fleets use cars and drivers in fixed proportions we do not include a separate measure of labor inputs, so the coefficient on capital may be interpreted directly as a returns-to-scale parameter.

The Economic Census does not report dollar-valued capital for taxi firms, only physical measures of capital. We convert the stock of physical capital to a dollar-valued flow measure using conversion factors from the Taxi Limousine and Paratransit (TLPA) annual Factbooks (1992 and 1997) that describe the relative costs of operating fleet-owned versus driver-owned taxicabs.

As is common in the productivity literature, we use revenues to measure output (Y). The fact that revenue contains information about both prices and quantities typically creates an identification problem: if two firms generate different revenues from the same inputs, do we attribute the difference to production technology, market power (i.e. differences in demand), or statistical noise? If the answer is market power, firms are likely to respond to information about demand that is contained in η when they choose inputs.

While Foster, Haltiwanger and Syverson (2008) addresses this problem using detailed measurements of physical output at the plant level, the taxi industry provides a unique opportunity to recover production function parameters from data on revenues. Since all taxi fleets in the same market face a common price schedule, we include a full set of market-year fixed effects to absorb any between-fleet variation in prices. Taking the log of (A1) and introducing these fixed effects leads to the following specification:

(A2) $\log(Y_{it}) = \lambda_{mt} + (\gamma_1 + \gamma_2) \log(K_{it}) + \log(\eta_{it})$,

where the unit of observation is fleet *i*, operating in market *m* in year *t*, and λ_{mt} are a complete set of market-year effects that capture pricing and other market-level productivity shifters.

Total Factor Productivity in Quantities (*TFPQ*) is the residual in this regression: $\log(\eta_{it})$. It is a measure of asset utilization relative to other fleets in the same market that is standardized to have mean zero within a given market (county). We specify this residual as a function of diversification and asset-ownership, and include a term that allows scale effects to differ for specialized versus diversified fleets. For notational convenience let *D=DIVERSIFY, FC=FLEETCARS, TC=TOTALCARS*, and *FO=FLEETOWN=FC/TC*. We can write our specification for *TFPQ* as follows:

(A3) $\eta = FO^{\{\alpha 1 + D\alpha 2\}}\, TC^{\{\alpha 3 + D\alpha 4\}}\, exp\{D\beta_0 + \varepsilon\}$,

where (α, β) are parameters to be estimated, and ε is a statistical error term that we assume is uncorrelated with *D*, *FC*, *TC*, and *K*. Hypothesis 2 predicts that $\alpha_2<0$: vertical integration leads to lower productivity in diversified fleets. Note that $log(FO) = log(FC) - log(TC)$. Therefore, taking the log of (A3) and rearranging terms yields the following expression:

(A4) $\log(\eta) = \{\alpha_1 + D\alpha_2\}\, log(FC) + \{(\alpha_3-\alpha_1) + (\alpha_4-\alpha_2)D\}\, log(TC) + D\beta_0 + \varepsilon$.

This expression is equivalent to equation (2) in the paper, with $\beta_1 = \alpha_4-\alpha_2$ and $\beta_2 = \alpha_2$.

In principle, we could substitute (A4) into (A2) and estimate this model in a single step, using pooled data from all fleets-years with revenue as the dependent variable. In practice, we proceed in two steps as is common in the productivity literature (Foster, Haltiwanger and Syverson 2008).[27] First, we estimate (A2) using data from all fleet-years, and recover estimates of *TFPQ* =

[27] The two-step approach offers significant practical advantages as it allows the econometrician to estimate a standardized (relative) production function in the first stage using information from all firms in the sample, whether they are included in the second stage or not. The two-step approach also facilitates control over extreme outliers, which we do by winsorizing TFPQ at the 1st and 99th percentile after the first stage.

$log(\eta)$ from the regression residuals.[28] In the second step, we keep only the balanced panel of fleets that survived from 1992 to 1997, and estimate equation (A4) in first differences, using the estimated *TFPQ* as our dependent variable. Table A1 presents our first stage production function estimates.

Appendix references

See references list in the main paper.

Foster, L., J. Haltiwanger, C. Syverson. 2008. Reallocation, Firm Turnover, and Efficiency: Selection on Productivity or Profitability? *The American Economic Review* **98**(1) 394-425.

TLPA Taxicab/Paratransit Fact Book. 1992. Kensington, Maryland. *International Taxicab Association.*

TLPA Taxicab/Paratransit Fact Book. 1997. Kensington, Maryland. *International Taxicab Association.*

[28] We also explored a more flexible version of (A2), where we allowed β to vary by market over time to capture the effect of market variation in the relative value of owning versus renting permits and found very similar results.

Table A1 Total factor productivity calculations

Panel A – Total factor productivity calculations

Dependent variable = Log revenue

	(1)		(2)	
Year	1992		1997	
Log capital	0.85	***	0.83	***
	(0.03)		(0.03)	
Constant	1.54	***	1.41	***
	(0.13)		(0.14)	
County fixed effects	Y		Y	
N	1020		1106	
R^2	0.71		0.68	
Panel B – Summary statistics for TFPQ (Panel A residuals)				
TFPQ				
Mean	0.00		0.00	
Std. deviation	0.74		0.81	

Standard errors are robust.

TFPQ is estimated using all firms with SIC codes 412100 (taxicabs) or 411920 (limousines), taxi revenue ≥ $10K, at least 2 taxicabs, and at least 2 taxi fleets in their market (county) in either 1992 or 1997.

*** significant at the 1% level, ** significant at the 5% level