The Economics of "Radiator Springs:" Industry Dynamics, Sunk Costs, and Spatial Demand Shifts*

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Abstract

We measure industry evolution following permanent changes in the level and location of demand for gasoline in hundreds of counties during the time surrounding the completion of Interstate Highway segments. We find that the timing and margin of adjustment depends on whether the new highway is located close to or far from the old route. When the new highway is close to the old one, there is no evidence that the number of stations changes around the time it opens. However, average station size increases by 6% before the highway is completed. When the new highway is far from the old one (say, 5-10 miles), the number of stations increases by 8% and average station size remains unchanged. Unlike the station size adjustment when the new highway is close, the entire increase takes place after construction. These results provide evidence on how this industry, which is characterized by high location-specific sunk costs, adjusts to demand changes. Our results are consistent with theories in which firms have strategic investment incentives to preempt competitors

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1 Introduction

The construction of the Interstate Highway System in the United States and its impact on local industries continues to be part of American folklore and popular culture, over 50 years after construction started and over 25 years after it was essentially completed. The plot of Disney/Pixar's 2005 animated feature "Cars" concerns a town ("Radiator Springs") whose population had severely declined after it was bypassed by an Interstate highway. Radiator Springs is nearly empty and devoid of through traffic, and had been so for years. However, several local businesses had yet to exit the market, including a gas station and an auto repair shop.

For economists interested in industry dynamics, the construction of Interstate Highways offers an interesting opportunity: completion of highways is observable, and represents permanent demand shifts for highway-related services. They increase the growth rate of traffic along a corridor and shift traffic spatially. The spatial shift is small when the new highway is right next to the old route – traffic clusters more around exits – but large when it is located miles away. From the perspective of local businesses that serve highway travelers such as gas stations (and potential entrants), the opening of a highway is an observable, anticipated change in the level of demand and sometimes demanders' locational tastes. Casual empiricism indicates obvious changes in industry structure that are associated with such changes: many highway exits have nearby service stations whose location can clearly be explained by the highway's presence. The industry dynamics, however, are less clear: how large are the supply-side changes, along what margins do these changes take place, and what is the timing of these changes? These questions are the topic of this paper.

We examine how industry structure adjusts to anticipated permanent demand shocks, and how the adjustment differs depending on the extent to which locational tastes shift, by examining how the number and size distribution of service stations changes in hundreds of counties during the time surrounding the completion of Interstate Highway segments in these counties. We find that the timing and margin of adjustment of industry structure differs, depending on whether the new highway is located close to or far from the old route. When the new highway is close to the old one, there is no evidence that the number of stations changes around the time it opens, but average station size increases by 6%, all of which takes place in the two years leading up to when the highway is completed. In contrast, when the new highway is far from the old one (say, 5-10 miles), the number of stations increases by 8% but there is no significant increase in average station size. Unlike the station size adjustment when the new highway is close, all of this increase takes place after the highway is completed.

These results provide evidence on how this industry, which is characterized by high location-specific sunk costs, adjusts to demand changes. Demand increases that have a limited spatial effect are met by increases in station size, not additional stations. Our results indicate that this expansion – measured as increases in employees/station – takes place ahead of the demand increase. They are consistent with theories in which firms have strategic investment incentives to preempt competitors, to the extent that increases in employees/station are correlated with irreversible investments (perhaps in new pumping capacity). In contrast, demand increases that are accompanied by spatial shifts are met primarily by new stations, not larger stations, and this happens only once demand increases.

The difference in the margin of adjustment is consistent with that predicted by a broad class of industry structure models incorporating product differentiation, such as Dixit and Stiglitz (1977) and Salop (1979), in which demand increases are met disproportionately by increases in the number of firms in markets where entry would leave price-cost margins unchanged (such as when buyers are sensitive to spatial differences) and by increases in firm size when entry would lead price-cost margins to drop substantially. The difference in the timing of the adjustment provides evidence against the proposition that spatial shifts – by opening new submarkets – increase firms' propensity to engage in pre-emptive entry (Spence (1977, 1979), Fudenberg and Tirole (1984), Bulow, Geanakoplos, and Klemperer (1985)) in this industry. This is interesting in light of the fact that opening a new service station near a new highway interchange involves industry- and location-specific sunk investments; such investments can function as credible commitments for firms not to exit in the face of competition. Such a proposition ignores the possibility that uncertainty about demand or the competitive environment might be greater when demand increases lead new segments to open than when they do not, and thus the (real options-related) cost of pre-emptive capacity investments might be higher in such cases. (Dixit and Pindyck (1994)) Our results indicate that industry adjustment occurs later when demand shocks are accompanied by spatial shifts than when they are not, which is consistent with the view that spatial demand shifts increase the cost of pre-emption relative to its benefits in this industry.[1]

Our analysis rests on our collection and combining of several data sets. These include (a) highly detailed data on when narrowly-defined Interstate highway segments opened, (b) county-level data from 1964-1992 describing the number, employment, and size distribution of service stations, and (c) hand-collected measurements of the distance between Interstate highways and the intercity routes they replaced. These data allow a far broader analysis of the effects of Interstate highway openings on local industry structure than in the previous literature on this topic, most of which examines the long-run effects of a small number of highway bypasses.[2] Our analysis goes beyond these studies by examining evidence from a far larger sample, examining the margins and timing of adjustments, and by comparing situations where there was a large and small spatial effect. These aspects afford us not only the ability to estimate effects more precisely, but also to shed light on how the adjustment process differs with the degree to which demand increases are combined with changes in tastes.

Our work is related to several lines of empirical work in addition to the "highway bypass" literature. Several recent papers, including Chandra and Thompson (2000), Baum-Snow (2007), and Michaels (2008) independently use the same highway openings data to investigate other issues such as the effect of public infrastructural investments on output, the effect of highways on suburbanization, and whether decreases in transportation costs lead to greater specialization. Campbell and Lapham (2004) use a similar empirical framework to ours to research how fluctuations in U.S.-Canada exchange rates – and thus temporary demand shifts – affect the average size and number of establishments in various retail segments in U.S. counties bordering Canada. Finally, our use of rural areas to investigate industry structure is similar in spirit to Bresnahan and Reiss (1990, 1991) and Mazzeo (2002) (see also Campbell and Hopenhayn (2005) for an extension of this analysis to larger markets). We are able to examine industry dynamics in a way these papers cannot, because we are able to observe the number and size distribution of firms over long periods, and how these change in response to demand shocks that are similar in nature but take place at different times in

[1] It appears unlikely that zoning or other local political constraints explain this result: contemporary accounts indicate that there was little local government planning associated with real estate development at most highway interchanges, particularly those that were not located near existing downtown areas.

[2] See for example, Texas Transportation Institute (1966).

different areas. Our data, however, limits our analysis. Like Bresnahan and Reiss (but unlike Berry (1992)), we have data on the number of producers but not their identities. This prevents us from investigating the details of the process through which firms expand and contract their output. Our results indicate that further investigation of this process with firm-level data is warranted.

The rest of the paper is organized as follows. Section 2 presents the analytical background to the paper. We summarize what monopolistic competition models conclude about how industries should adjust to demand shocks, and how the adjustment should differ according to the extent to which price-cost margins are expected to fall post-entry. We also discuss the benefits and drawbacks of capacity expansion, drawing from the pre-emption and real options literatures. Second 3 presents the institutional background, summarizing important trends in the industry between the 1960s and 1990s. This serves as the backdrop for our empirical analysis. Second 4 describes the data and shows aggregate relationships between the timing of highway completions and changes in average service station size. Second 5 presents and discusses our main results. Section 6 concludes.

2 Industry Adjustment to Demand Shocks

2.1 Industry Structure Models

A large class of models in industrial organization sheds light on how industry structure should adjust in the long run to permanent demand shocks.[3] A general principle from this class of models is that increases in market size can lead either to more firms or larger firms, depending on the extent to which price-cost margins decrease as the number of firms increases. In situations where price-cost margins do not change with entry, increases in market size will lead to more firms, but not larger firms.[4] In contrast, if price-cost margins decrease with entry, increases in market size should tend to lead to larger firms – industry adjustment will take more of the form of larger firms than if price-cost margins do not change with entry.

To illustrate this point, consider an industry with S identical potential demanders, each with demand $q(p)$ for the industry's good, so that industry-

[3] Spence (1976), Dixit and Stiglitz (1977), Salop (1979), Sutton (1991).

[4] We are ignoring here the possibility of endogenous sunk costs a la Sutton (1991).

level demand is $Q = Sq(p)$. Assume that there are a large number of potential suppliers, each of whom can produce at fixed cost F and marginal cost c. If N firms enter, each faces a residual demand curve $X = Sx(p, N)$, where $x(p, N)$ is the number of units they sell to each of the S demanders. We assume that $x_p < 0$, $x_N \leq 0$, $x_{pN} \leq 0$: firms' residual demand curves are downward-sloping, residual demand (weakly) decreases with the number of competitors, and demand is (weakly) more price-sensitive the greater the number of competitors. These assumptions summarize demanders' tastes for firms' goods in this market, and therefore substitution patterns. For example, the second and third of these assumptions imply goods are (weak) substitutes. The cross-derivative x_{pN}, which indicates the degree to which the slope of a firm's residual demand curve (per customer) changes with N is important to the analysis because it corresponds closely to how much equilibrium price-cost margins fall with N.

A symmetric equilibrium in this industry satisfies:

$$p(x) + p'(x)x = c$$

$$p = c + F/Sx(p, N)$$

$$Q = NX$$

These equations imply that marginal revenue equals marginal cost for each firm, price equals average costs for each firm, and supply equals demand in the aggregate. The equilibrium is a triplet (p^*,x^*,N^*) that solves these equations, subject to the expressions for industry- and firm-level demand above.

We are interested in how this equilibrium changes when S increases. An increase in S has no direct effect on the first equation: firms continue to produce at a point where their sales per customer x equates their marginal revenue per customer and marginal cost. Increases in S rotate firms' residual demand curves outward, leading them optimally to sell more at the same price. However, an increase in S leads the right side of the second equation to increase relative to the left: firms' average costs fall below price. At issue is how p, x, and N adjust to restore this relationship.

First consider the case where $x_{pN} = 0$: increases in N have no effect on the slope of firms' residual demand curves. This would be the case if the increase in market size elicited the entry of new products that are not substitutes to existing products. Then increases in N would affect the second equation only through x, and the condition $p = AC$ would be restored at a point where $X = Sx(p, N)$ was exactly the same as before. The number of firms would increase, but quantity per firm would not change.

Next consider the case where $x_{pN} < 0$: increases in N lead the slope of firms' residual demand curves to be shallower, as would be the case if the increase in market size elicited the entry of new products that are substitutes. Now increases in N lead to decreases in equilibrium prices; in terms of the second equation, they affect both the left side through p and the right side through $x(p, N)$. The decrease in price, and therefore price-cost margins, implies that X will be greater in the new equilibrium than the old, because if price-cost margins fall, firms must sell more units in order to satisfy the break-even condition $p = AC$. When increases in market size (potentially) elicit the entry of new products that are close substitutes, industry structure will adjust on different margins than in the case where such increases do not elicit the entry of close substitutes: adjustment will involve increases in firm size, not just in the number of firms.

We apply this to our context straightforwardly. Other studies have shown that the opening of new Interstate highways increased travel along the corridor the highway serves.[5] Suppose that this also increased the demand faced by service stations.[6] Consider first situations where new highways are located on top of the previous route. New highway openings would primarily affect traffic patterns by forcing vehicles to get on and off the road at exits, thus leading locations along the highway but between exits to have less traffic. However, the effect of this spatial change would be limited because service stations already tended to be located at important intersections between the previous road and other important roads, and the exits of the new highways were generally at these intersections. Such new highways would not lead to the creation of any new spatial segments: new entrants would be just as close substitutes to existing firms as in the previous equilibrium. In contrast, new highways might lead to the creation of new spatial segments

[5] Summarizing research on the impact of Interstate Highways on traffic in corridors, Federal Highway Administration (1970) reports that "traffic increases were steady...before opening, 3 to 5 percent annually. After opening, traffic increases on the Interstate accelerated to annual rates of 10 percent and more for as much as 10 years after opening." The growth rate of traffic through a county thus tended to increase after Interstates were completed.

[6] Evidence below will suggest that it did: highway openings are associated with long-run increases in service station employment in our sample counties.

when they are located far from their previous route. Here they would have a more significant effect on traffic patterns, leading service station demand to shift away from the old route and toward the new highway exits. Given this new set of spatial tastes, a new entrant could be a more distant substitute than it could have been given the previous set of spatial tastes. Its impact on price-cost margins would be less.

It follows that the margin upon which industry structure adjusts should be more along the lines of the number of stations when highway openings shift demand spatially and more along the lines of the size of stations when they do not.

2.2 Pre-emption and Real Options

Other literatures in which models are explicitly dynamic investigate firms' incentives with respect to the timing of new capacity additions or entry. A broad lesson of these literatures is that there can be strategic benefits from expanding or entering before competitors do, possibly ahead of demand shocks, but there are option-related costs of doing so.

The pre-emption literature focuses on the benefit side of the ledger: firms' strategic incentives for capacity expansion.[7] The main idea is that firms can benefit from expanding capacity or entering ahead of competitors to the extent that doing so weakens competition ex post. The logic, as applied to capacity expansions, is similar to that in Stackelberg games. If a firm is able to commit to expanding capacity or entering a market, and this diminishes (potential) competitors' marginal returns to investment or entry, this will lead to less investment or entry by competitors. This, in turn, benefits the preempting firm by leading it to face softer competition on the equilibrium path.[8] Note that for this logic to go through, it is necessary that (a) capacity expansions or entry involve irreversible market- and industry-specific investments that commit capacity to stay in the market irrespective of what competitors do, and (b) capacity expansions or entry diminish competitors' marginal returns to capacity additions or entry, perhaps by ensuring that price-cost margins would be low if competitors expanded or entered.

[7] This literature includes, for example, Spence (1977, 1979), Fudenberg and Tirole (1984, 1986), and Bulow, Geanakoplos, and Klemperer (1985).

[8] Pre-empting firms could also obtain competitive advantages, for example from better locations, that would persist in the face of entry. If so, the analysis is similar but provides for additional strategic incentives.

It follows from this logic that if firms foresee a positive demand shock and have the opportunity to expand ahead of demand, they may have an incentive to do so in order to preempt their competitors. Although this has short-run costs – their profits before the demand shock are lower than they otherwise would be – it may have long-run benefits to the extent that it provides them a competitive advantage or weakens price competition in the future.

It also follows that pre-emption incentives might be larger when demand shocks are associated with the opening of new spatial segments than when they do not, because pre-emption should have a greater marginal effect on ex post price-cost margins in such circumstances. This is analyzed explicitly in Fudenberg and Tirole's (1986) model of spatial preemption. These authors' analysis illustrates why both incumbents' and new entrants' preemption incentives are greater if they are able to enter parts of product space away from incumbents' existing capacity than if they are not. The reason is simple: an objective of preemption is to soften ex post competition, and the marginal effect of capacity additions (or entry) on other firms' capacity decisions (or entry decisions) will be greater in areas where firms have not yet made capacity commitments than in areas where they have done so.

The real options literature (Dixit and Pindyck (1994)) highlights the cost of capacity commitments. The general idea is that while such commitments can have the strategic benefits described above, they have option-related costs: making commitments now forecloses the option of making commitments later instead. These costs are greater in situations where there is greater economic uncertainty, because maintaining options is more valuable in such circumstances. This can lead firms optimally to delay capacity expansions or entry, relative to situations where there is less uncertainty.

These two literatures inform our empirical analysis in the following way. One implication is that if capacity investments or entry do not involve industry- and market-specific sunk costs, then there are neither strategic benefits nor option-related costs that affect how firms adjust to demand shocks. The timing of adjustment should be independent of these forces. Absent other factors the adjustment should coincide with the demand shock, irrespective of whether there is a spatial demand shift.[9] Thus, finding that the adjustment

[9]The qualifier here is important: other factors might be important in our context. For example, zoning or other regulatory factors may make it more difficult to expand or enter in some circumstances than others.

We will investigate this possiblity in more detail in future drafts. Our current under-coincides with the demand shock irrespective of whether there is a spatial demand shift is consistent with the proposition that investments and entry do not involve industry-specific sunk costs.

A second implication is that it is a priori unclear how the timing of adjustment to demand shocks should differ, depending on whether the demand shock is accompanied by a spatial shift in demand. On one hand, the strategic pre-emption related benefits might be greater, and this would lead the adjustment to begin sooner than when there is no spatial shift. On the other hand, demand uncertainty may be greater when there is a spatial shift – for example, firms might be uncertain regarding the extent to which demand from local "non-through" traffic will shift once the highway is completed. If so, this would offset the pre-emption effect, and may lead industry adjustment to take place later than when there is no spatial shift.

Our empirical work will provide evidence on whether the timing of adjustment differs with the extent to which highway openings involve a spatial shift. Finding that the adjustment takes place sooner when there is a spatial shift provides evidence supportive of the hypothesis that the preemption-related strategic incentives are strong relative to the uncertainty-related strategic costs. Finding instead that the adjustment takes place later in such circumstances provides evidence supportive of the hypothesis that any strategic-related benefits are more than offset by the option-related costs.

3 Service Stations

We first report general trends with respect to service stations during and slightly outside our 1964-1992 sample period. The numbers are as reported by the U.S. Census in either County Business Patterns or the Economic Census (as part of the Census of Retail Trade or, before 1972, the Census of Business).

3.1 General Trends

Figure 1 presents several series that track the number of service stations in the U.S., and subsets thereof. The top set of points represents all service

standing is that zoning and regulation played much less of a role in these markets in the 1960s and 1970s than they currently do (in part because environmental regulation was less restrictive), but we do not fully understand their effect at the time.

stations. It shows that the number of service stations increased slowly during the 1960s and early 1970s, growing by 7% from 1963 to its 1972 peak of about 226,000. This number decreased sharply during the 1970s and early 1980s, falling by more than one-third to about 135,000 in 1982, and has been relatively stable since then. The first third of our sample period is one in which new station openings were exceeding closings, but service stations were, on net, exiting the market during most of our sample period.

The second series tracks the number of service stations with positive payroll; the difference between this and the first series represents stations with no employees: these are stations where the owner or owners operate the station by themselves. This difference shows that nonemployer stations became increasingly rare starting in 1972, falling from 43,074 in 1972 to 19,326 in 1982. But about three-quarters of the overall decline in the number of stations is accounted for by the 67,000-station decrease in the number of stations with employees. The fact that the general trends above appear as well when looking only at such stations is worth noting because our main data source tracks only stations with employees.

The other series track the number of "reporting units," as published in County Business Patterns (CBP). The county-level data that we analyze later is from this source. There is a break in this series because the definition of a "reporting unit" changed in the middle of our sample period.[10] Starting in 1974, the CBP "reporting unit" is the establishment – in this context, the service station – and the numbers published in the CBP track those published in the Economic Censuses (EC) closely. But before 1974, the definition of a "reporting unit" was such that firms operating multiple service stations in the same county reported these stations as a single observation; the county-level data therefore reported the number of firms competing in the county, not the number of service stations. Time series of CBP data before 1974 reflect not only the entry and exit of single-station firms, but also any combinations or spin-offs of service stations within the same county. Comparing the reporting unit counts and the establishment counts before 1974 indicates the degree to which firms operated multiple stations in the same county: the number of establishments with payroll exceeds the number of reporting units by 10-12% in 1963 and 1967, but by 25% in 1972. This provides evidence that, starting

[10]This change corresponded to a change in how the Internal Revenue Service asked firms to report employment and payroll data. There was also a change in the employment size categories the Census used. Before 1974, the three smallest categories were 1-3, 4-7, and 8-19 employees; after 1974, these were 1-4, 5-9, and 10-19 employees.

in the late 1960s, it became increasingly common for firms to own multiple stations in the same county.

The size and composition of service stations changed during our sample period. Figure 2 reports time series on average employment size. The EC series show that the average employment size of service stations grew throughout our sample period, increasing by about 125% between 1964 and 1992. Turning to the CBP-derived series, the employment size of the average reporting unit – that is, average within-county firm size – increased by 41% between 1964 and 1972. Employment per station with payroll increased by about 30% during this time; hence, only about one-fourth of the increase in within-county firm size reflects increases in the number of stations per firm within counties rather than increases in the number of employees per station. Although it will be important in our main analysis to account for and investigate the degree to which the pre-1974 data reflect firm-level rather than station-level phenomena, overall the bulk of pre-1974 employment size increases appears to reflect increases in station size.

Other Census figures published on a consistent basis since 1972 show corresponding increases in size; we depict these in the first few columns of Table 1. Gallons per station increased steadily between 1972 and 1992, more than doubling during this time. This reflects both an increase in the number of gallons per pump, which grew by 63%, and the number of pumps per station, which grew by 37%. The increase in pumps per station during this period occurred entirely between 1977 and 1987. Employees per pump grew only slightly, and was almost constant between 1977 and 1992. These figures indicate that at the same time average employment per station was increasing, stations' pumping capacity was increasing, and this pumping capacity was being utilized more intensively.

The rest of Table 1 depicts two well-known changes in service stations that occurred duirng this time. One is the movement toward self-service. This began in the early 1970s, and the share of sales that are self-service exceeded 90% by 1992. The other is the change in service stations' ancillary services away from automotive services and toward convenience stores. These changes did not entirely coincide. The movement away from automotive services began in the early 1970s and was essentially complete by 1982; the share of service station revenues from tires, batteries, and accessories declined from 10% to 3% during this time, and has remained low ever since. In contrast, the increase in the revenue share of convenience store items – food, alcohol, and tobacco – occurred predominantly after 1982; the revenue share from these categories increased from 5% to 15% between 1982 and 1992, and has increased since then to about 25%.[11]

This study focuses on periods surrounding when Interstate highways were being completed, and the phenomena we uncover mainly reflect changes in the number and size distribution of service stations that occured during the 1960s and 1970s. The diffusion of self-service gasoline and the diminishing importance of auto repair occurred during this period, but the rise of convenience store-service stations took place later. Importantly, increases in the employment size of service stations pre-dates the rise of such stations, and coincides at least in part with the decline of the provision of auto-related services and the increase in self-service – two trends that would tend to decrease the use of labor. The increase in service stations' employment size therefore likely reflects some combination of (a) stations being physically larger, as manifested in more pumps, and (b) stations being open longer hours. The former is likely to be particularly important starting after 1977, when pumps/station but not gallons/pump was increasing; the latter is likely to be particularly important between 1972 and 1977 when the reverse was true.

4 Data

4.1 Description

Our two primary sources of data provide information about highway openings and local market structure for service stations.

Our data on highway openings come from the U.S. Department of Transportation's "PR-511" file. These data describe the milepost, length, number of lanes, pavement type, and opening date of segments of the Interstate Highway System that were open by June 30, 1993 and built using Interstate Highway funds. The data cover nearly the entire System.[12] Highway segments in these data range in length, but the vast majority are less than five

[11] A third change during this period was the movement from leaded to unleaded gasoline. This, like self-service, began in the early 1970s and was essentially complete by 1992. Many stations offered both leaded and unleaded gas by offering them at different pumps or islands; existing stations often replaced a pump that supplied leaded premium with one that supplied unleaded regular.

[12] A small fraction of the IHS includes highways that were not built with Interstate Highway funds, but were incorporated into the System later. (I-39 in Illinois is an example.) These highways are not in our data.

miles long and many are less than one mile long. Opening date is described as the month-year in which the segment was open for traffic. The milepost and length variables in the PR-511 indicate where the highway segment is located along the route. We hand-merged these variables with geographic mapping data from the National Highway Planning Network to identify the county in which each of the PR-511 segments is located.[13] This produced a highly-detailed dataset on the timing and location of Interstate Highway openings.

We then aggregated these data up to the route-county level. For each route-county (e.g., I-75 through Collier County, FL), we calculated the total mileage within the county, the total mileage completed by the end of each calendar year, and the share of mileage completed by the end of each calendar year. Highways were normally completed in stages, so it is not unusual for a route to be partially complete within a county for some period of time, then fully completed within the county a few years later. This cumulative share variable, $csmi_{it}$, is a key independent variable in our analysis.

We also develop a corridor-level version of this variable, $ccsmi_{it}$, which accounts for the possibility that traffic volumes in a county are not only affected by highway openings in the county, but are also affected by highway openings in other counties along the same traffic corridor. For example, traffic in Boone County, Missouri is not only affected when Interstate 70 was completed in Boone County, but also when it was completed in other counties between Kansas City and St. Louis. We describe the details of how we define corridors and how we assign highway segments to corridors in the Appendix. The basic idea is simple, however. Most corridors are defined as highways that connect two central cities with at least 100,000 population; Interstate 70 between Kansas City and St. Louis is an example. For each corridor, we calculate the share of Interstate Highway mileage completed in each year, and assign this variable to each county that lies along the corridor; for example, we calculate the share of Interstate 70 between Kansas City and St. Louis that was opened in each year, and assign this variable to each county through which I-70 passes between these two cities.

We utilize traffic count data on Interstates from the U.S. Department of Transportation's Highway Performance Monitoring System (HPMS), to

[13] These data are maintained at: http://www.fhwa.dot.gov/planning/nhpn/. The PR-511 file contains a variable that indicates the county in which the segment is located, but other researchers (Chandra and Thompson, 2000) have noted that this variable contains errors. We use the PR-511 data in checking our construction of this variable.

construct a variable that measures the amount of through traffic within each of our corridors. These allow us to develop a variable that distinguishes among counties by whether demand from through traffic is important relative to demand from locals. We develop a measure of through traffic in the county by taking the minimum daily traffic count on the Interstate within each of our corridors and assigning it to each county in the corridor. Call this $thru_i$.[14] We then construct a variable $thrushare_i = thru_i/(thru_i + emp_i)$ where emp_i is the county's 1992 employment. The mean value of $thrushare_i$ across our 677 counties is 0.55. The maximum value is 0.97, which is in Culberson County, TX – a very small county on a fairly heavily traveled stretch of Interstate 10 in west Texas. The minimum value is 0.01 in Kennebec County, ME, the largest county on the corridor which includes the least-traveled stretch on the Interstate Highway System (the northernmost part of I-95).

We augment these data with a measure of how far the Interstate highway shifted traffic. We did this via the following procedure. Using mid-1950s road maps, we first designated the route each segment of Interstate highway likely replaced (the "old route"). The general procedure was to look first at the major cities that the current Interstate connects, then assess the most direct major route between these cities as of the mid-1950s. For example, the "old route" for I-95 between Boston and New York is US1. Often, establishing the old route is more difficult because the old route either no longer exists or is a minor road. The "old route" for I-5 in Oregon is old US99, which in many places currently exists as a minor road adjacent to I-5. Once the "old route" was established, we measured the "crow flies" distance between each current Interstate exit and the old route. This was done using Google Maps and ancillary tools. Finally, we averaged this distance across the exits within each route-county. This produces a variable $dist_i$ (or "distance from old route") that characterizes the spatial shift in traffic brought about by the Interstate highway. This measure ranges from zero for many route-counties (where the Interstate merely was an upgrading of the old route) to over 20 miles. The median value in our sample is 1.25 miles;

[14] The HPMS data provide traffic counts measured periodically on the Interstates in our sample. These data are reported consistently starting in 1993. Our measure uses data from 1993-98 to reduce noise in the counts due to sample sizes. We constructed $thru_i$ by first calculating the minimum traffic count on the route*county in each of these years, then averaging this quantity across these years. We then took the minimum value of this county-level average across the corridor.

the 25th and 75th percentile values are 0.5 and 3.0 miles, respectively.

Our data on local market structure for service stations come from County Business Patterns, published annually by the U.S. Bureau of the Census since 1964. CBP contains county-level data on narrowly-defined industries, including "gasoline service stations," SIC 554. We obtained these data in electronic form from 1974-1992; we hand-entered these from published reports from 1964-1973. For each year and county, these data report employment and payroll in the industry within the county. They also report the total number of service stations and the number in several employment size categories. We describe above how the reporting unit and size categories reported in CBP changed starting in 1974.

Our data contain missing values for some county-years, especially in the very smallest counties. Missing values arise for industry employment and payroll when the Census deems that publishing these would disclose confidential information regarding individual firms. Such disclosure issues do not arise for the local industry structure variables; these are considered publicly-available information in any case. However, to economize on printing costs, the Census did not publish these data for industry-counties with small numbers of employees (typically fewer than 100); they are available only in electronic versions of the data. We therefore have missing values for these variables in very small counties, particularly in years before 1974.

The CBP data form our dependent variables, the most important of which are the number and employment size distribution of gas stations (before 1974, firms) within the county in an particular year. The bulk of our analysis relates these variables to the timing of highway openings.

4.2 Sample Criteria

Our analytic framework anticipates using highway openings to represent spatial shifts in demand for gasoline, and envisions contexts where these shifts are uncomplicated: for example, a situation where a new highway opens that parallels an existing road that had previously served both local traffic and "through" traffic. This is unreasonable in urban contexts, since one would expect the spatial distribution of demand for gasoline to be less dependent on the location of the most important "through" roads. We therefore conduct our analysis on a part of our sample that includes only less dense areas where traffic patterns are relatively uncomplicated. First, we use only counties with a single two-digit Interstate and no three-digit Interstates; this is a simple way of eliminating most large cities as well as other counties with complicated traffic patterns. We then eliminate all counties where 1992 employment exceeds 200,000 because some populous counties remain after this cut (for example, New York, NY). We also eliminate all counties through which the highway passes but there is no exit; most of these are cases where the highway clips the corner of a county. Finally, we employ our main analysis on a "balanced panel" which includes only counties where the number of service stations is nonmissing in each year between 1964-1992.

Our main sample ultimately includes 677 counties; we depict these counties in Figure 3. This map indicates that our sample counties come from all over the United States, tracing the non-urban parts of the Interstate Highway System. Differences in the shading of these counties indicate differences in when the highways were completed; broadly, they were completed later in west than in other regions of the country. In addition, differences in the shading of the highway indicate counties where the new highway was far from the previous intercity route, defined here as farther than 3 miles. It was more common for western Interstates to be completed close to the previous route than Interstates in other areas of the country, in large part because the population is less dense in the west than in east or south.

4.3 Patterns in the Data

Table 2 presents the timing of "two-digit" Interstate Highway completion as reported in the PR-511 data, and for our balanced panel counties. From the left part of the table, 20% of two-digit highway mileage was open by the end of 1960; most of this mileage consisted of toll roads in the east that predated the Interstate Highway System (such as the Pennsylvania Turnpike) and were incorporated into the System once it was established. About 55% of two-digit mileage in the System was completed during the 1960s; the peak construction year was 1965. Another 20% was completed during the 1970s, and the final 5% thereafter. The counties in our balanced panel account for 18,833 miles of Interstate Highways, about half of the two-digit mileage in the System as a whole. The timing of highway construction in this subsample sample mirrors that of the system as a whole, peaking in the mid-1960s, then steadily declining during the years that followed. The timing of Interstate Highway construction means that our analysis will center on events that mostly took place in the 1960s and early 1970s, and our creation of a dataset that examines changes in industry structure during this time exploits this.

Table 3 presents time trends in the number and size distribution of firms (starting in 1974, service stations) in our 677 balanced panel counties. The trends in these counties are very similar to those in the U.S. as a whole. The number of firms/county fell slightly between 1964 and 1973, and the number of service stations per county fell by about one-third between 1974 and 1992. The right four columns of this table indicate changes in industry structure and depict the movement toward fewer, larger firms and service stations; there are steady decreases in the number of businesses in the smallest size category and increases in the number of businesses in the other size categories.

Table 4 presents some initial evidence on whether the timing of industry structure changes are related to the timing of highway openings. We place counties into three categories according to the year the highway was completed in the county: 1965 or earlier, 1966-1971, and 1972 or later. We then calculate employees per firm (starting in 1974, per station) within these categories.[15] Table 4 indicates that average firm size was similar across these categories in 1964; in each, there were about three employees per firm. Employment size increases steadily during this period; in 1992, the average gas station in each of these county classes had roughly seven employees. But the timing of this increase differed across these categories. Firm size increased in the "early" counties relative to the "late" counties early in our sample; by the early 1970s, the difference was about 10%. The opposite was true late in our sample, after the mid-1970s, average station size increased in the late counties relative to the early counties. Figure 4, which depicts the ratios between the "late" and "early" counties each year, shows this pattern. This evidence indicates that increases in the size of service stations corresponded to the completion of Interstate highways.

Figure 5 contains further detail with respect to changes in industry structure. Here we report late/early ratios for the number of firms (or stations) per county for different employment size categories. Looking at these provides further information regarding the dynamics of changes in industry structure; we know from Table 4 that the general pattern is one of a decrease in small businesses and an increase in larger ones; here we investigate whether both of these changes correspond to highway completion. Figure 5 indicates that there is a difference in the time pattern between the small and the other size businesses. The late/early ratio decreases for the "large" cate-

[15] The quantites in Table 4 and Figure 4 use only counties where we observe service station employment in each year, N=470.

gory through 1974, then increases steadily throughout the rest of the sample. This indicates that the number of large firms increased more in the "early" counties than the "late" counties early in our sample, while the opposite was true at the station level later in the sample. A similar pattern appears for the mid-sized businesses. The increase in the number of large and mid-sized businesses took place earlier in counties where the highway was completed earlier. We do not observe such a pattern, however, when looking at the smallest size category: the number of small businesses declined at about the same rate in counties where the highway was completed early as late.

This evidence suggests something interesting about industry dynamics during this time. The Figure 4 relationship between the timing of highway construction and increases in employment size does *not* appear to be driven by a mechanism in which new highways lead to increases in the number of large firms or stations and corresponding decreases in the number of small ones. Small stations are exiting the market throughout our sample period, but there is no evidence that changes in the number of small stations are related to the timing of highway construction. Instead, this relationship is consistent with models in which new highways lead to increases in the number of large stations without changing the number of small ones. Below we will see this again in the econometric analysis and interpret the result in light of sunk costs and exit patterns.

5 Empirical Model and Results

Our empirical specifications follow Campbell and Lapham (2004). We estimate vector autoregressive specifications of the form:

$$y_{it} = \alpha_i + \mu_t + \Lambda y_{it-1} + \beta x_{it} + \varepsilon_{it}$$

In the first set of results that we will present, y_{it} is a 2×1 vector containing the logarithms of the number of service stations per capita in county i at time t (n_{it}) and their average employment (a_{it}). We used the county's population in 1980 for n_{it}'s denominator, and before 1974 n_{it} equals the number of firms per capita. The vector x_{it} contains our highway opening variables, including up to three leads and lags; we describe this part of the specification in more detail below. The parameters α_i and μ_t are county-specific and year-specific effects. The parameter α_i represents time-invariant factors that lead the number and size of service stations to differ across counties, and μ_t embodies trends and aggregate fluctuations that affect all counties' industries equally. Removing these county-specific and time-specific effects isolates the changes in the number and sizes of service stations around the time of Interstate highway openings relative to the county's own history and national developments. The specification's autoregressive structure allows the impact of an Interstate's opening to occur gradually. The coefficients of β give the initial impact, while $(I - \Lambda)^{-1}\beta$ measures the long-run change.

Setting aside for now leads and lags, the vector x_{it} includes up to three highway opening variables: $ccsmi_{it}$, $csmi_{it}$, and $csmi_{it} * dist_i$. Including $ccsmi_{it}$ accounts for the possibility that the level of demand for gasoline in a county depends on corridor-level construction; the interaction $csmi_{it} * dist_i$ allows for the possibility that the effect of the completion of a highway in given county has a different impact on local industry structure, depending on the size of the spatial shift in demand.

One would expect the impact of new highway openings on local industry structure to differ, depending on whether through traffic accounted for a small or large share of gasoline demand relative to the demand from locals. In some specifications we therefore interact $(1 - thrushare_i)$ and $thrushare_i$ with x_{it}. We think of the coefficients on the $(1 - thrushare_i)$ interactions as reflecting the extent to which highway openings affect local industry structure by changing the traffic patterns of locals, and the coefficients on the interactions wtih $thrushare_i$ as reflecting the extent to which they do so by changing through traffic. Although it is reasonable to think that the former effect could matter – for example, highway construction could increase locals' gasoline demand by decreasing their travel costs – the latter effect captures much of the spirit of the paper. Much of our focus will therefore be on the coefficients on the interactions with $thrushare_i$.

This draft reports results when we estimate our specifications using OLS. Future versions will use estimators that account for the econometric endogeneity of y_{t-1}. Based on our experience with these estimators as applied to CBP data, we expect the results to change little when we do so.

5.1 Basic Results

5.1.1 Number and Average Size of Stations

Table 5 presents results from several specifications.[16] In the top panel, x_t contains no leads or lags, and includes only $csmi_{it}$. Looking first at the autoregressive coefficients, all are positive and significant: the impact of shocks to the number and average size of service stations in a county is therefore distributed over time. The highway opening coefficient is economically and statistically zero for the number of stations, and is positive and significant for the average employment size of stations.[17] The magnitudes of the highway opening coefficients, combined with the autoregressive coefficients, imply that the opening of a highway is associated with no change in the number of firms, but a 6% long run increase in the average employment size of service stations in the county, one-third of which (1.9%) occurs in the year that the highway opens.

The second panel adds a lead and lag to the highway opening vector. The main result is the positive and significant coefficient on the "-1 year" coefficient in the average employment size regression: the increase in average size of service stations begins before the highway opens. The sum of the lagged coefficients is approximately unchanged. The final two panels extend the analysis to two and three leads and lags. While the autoregressive coefficients and the sum of the lagged coefficients – and thus our estimate of the long-run impact of highway openings – are approximately the same as in the other panels, the individual highway openings coefficients are estimated with more noise. The positive estimates of the "zero, one, and two years before" coefficients suggest that average station size increased before opening; the coefficient on the "one year after" coefficient indicates that it fell somewhat the year after the opening.

[16] All specifications allow the autoregressive coefficients to vary for the year 1974, to account for the change in the Census definition of reporting units. We have also estimated specifications that allow these coefficients to vary before and after this change, and to vary in each year. The estimates on our highway openings coefficients vary little when we do so.

[17] Before 1974, the unit of observation in the data is the "county-firm." To avoid convoluted language, we will use the term "station" to refer to our unit of observation before and after 1974. This will be supported by empirical evidence that we present below: the results do not appear to differ before and after 1974, suggesting that highway openings were associated with changes in the number and size of stations rather than stations' propensity to be part of multiestablishment firms.

Figure 6 presents impulse-response functions for highway openings on $ln(a_{it})$ that are implied by these coefficient estimates. The specifications with two and three lags indicate that average service station size increases by about 5% in the two years leading up to a highway opening, decreased by 2-4% in the year after opening (though this is not statistically significant), and increased again thereafter. All specifications indicate a statistically significant long-run increase of 5-6%.

While we find these general results interesting, these specifications do not differentiate between highway openings with small and large spatial demand shifts. Below we find that once we do, the industry dynamics become clearer.

5.1.2 Size Categories

Table 6 presents more detail regarding these patterns by looking at how the number of stations in our size categories changed around the time of highway openings. This table reports results where the dependent variable y_{it} is a vector of the number of stations in each of the four employment size categories reported in Table 3. For brevity, we show results only for zero to two leads and lags; the three leads and lags specification produces results similar to the two leads and lags one.

The main result in this Table is that the patterns in Table 5 and Figure 6, which depict increases in average station size, are accounted for by a significant increase in the average number of "large" stations with 8-19 employees (or, after 1973, stations with 10-19 employees). Figure 7 plots the impulse-response function for highway openings on the number of stations in this category. Our estimates indicate that the number of large stations increased by 0.8 stations during the two years leading up to the highway opening, and in the long run increased by 1.2-1.4 stations. This is fairly large relative to the sample mean of 3.2, and about 1/3 of the average increase in the number of such stations between 1974-1992. In contrast, there is neither evidence of net entry or exit in the other size categories.

5.1.3 Do These Patterns Differ After 1973?

We next investigate whether our estimates of the relationship between highway openings and industry structure change after 1973. By doing this, we examine several hypotheses. One has to do with whether the patterns we uncover reflect firm-level or station-level effects. Recall that our data are reported at the firm level rather than the station level until 1974. One interpretation of the results in Table 5 is that owners of existing service stations in the county (perhaps the upstream refiner) may have added another station around the time that the highway opened in the county. If so, our results would reflect changes in the size distribution of firms but not stations. Finding that the effects we uncover are significantly weaker after 1973 would provide evidence that our results reflect the growth of chains not stations; in contrast, finding no difference in these effect would provide no evidence in favor of this hypothesis. A second reason for such a test is that, as Table 1 indicates, service stations changed starting around this time – self-service stations became more prevalent, and later on, service stations started to have convenience stores. Finding that the results we uncover are stronger after 1973 would provide evidence consistent with the hypothesis that the changes we uncovered are interrelated with changes in stations' format associated with self-service or convenience stores. Finding no differences would provide no evidence consistent with this hypothesis.

Results are in Table 7. In short, the "pre-1974" coefficient estimates for β look very much like the overall estimates, and there is no evidence of a significant change in this vector after 1973. For each specification and each equation, we fail to reject the null that the change in the vector is zero, using Wald tests of size 0.05. To some extent, this reflects the simple fact that over 3/4 of two-digit Interstate highway mileage (both overall and in our subsample) had opened by 1973. However, enough mileage was constructed after this time so that the test has some power, and finding no significant changes provides evidence that Interstate highways were having a similar impact on local service station market structure before and after this time. We find no evidence that our results reflect only the expansion of multiestablishment firms, or are driven by changes in station format.

5.1.4 Discussion

The estimates to this point indicate that on average, local markets adjusted to highway openings through increases in average station size, not in the number of stations, and that this adjustment began two years ahead of the highway's opening. A manifestation of average station size is in the increase in the number of large stations, which may either reflect the entry of new stations or a significant expansion at some existing stations.

They provide a preliminary indication of the industry dynamics associated with Interstate highway openings. On average, the margin of adjustment is on the intensive margin rather than the extensive margin: station size increased, but there is no evidence that the number of stations did. Increases in station size began well ahead of the year highways open, evidence suggestive of preemptive capacity additions.

The estimates also suggest that sunk costs shape industry dynamics. Recall that during our sample period, the number of large stations was increasing and the number of small stations was decreasing. Our results indicate that, at least during the time window that we investigate, highway openings are associated with an increase in large stations but there is no evidence that highway openings are associated with a decrease in the number of small stations. This fact is what one might expect in an industry where there are significant industry-specific sunk costs – the fact that it is costly to convert a service station to other purposes would lead exit to be relatively insensitive to demand shocks and competitive conditions.[18]

These patterns, while interesting, mask important differences in the margin and timing of adjustment between situations where the new highway was close to and far from the old route. We present and interpret evidence on these differences in the next section.

5.2 Highway Openings, Spatial Demand Shifts, and Industry Dynamics

We next extend the analysis by examining how the relationship between highway openings and industry structure differs, depending on how far the Interstate is from the previous major route.

We first run a series of simple specifications to examine whether the *margin* of adjustment differs with how far the new Interstate is from the old route, and if so whether any effects we find are nonlinear in distance from old route. Results are in Table 8; these are analogous to those in the top panel in Table 5 that include no leads or lags. We report here only the coefficients on the cumulative share of miles completed in the county and interactions between this variable and "distance from old route." The estimates in the top panel indicate that highway openings are associated with

[18] It is also what one might expect from watching the movie "Cars:" after all, the Radiator Springs service station had not yet exited the market, even though there apparently had been no through traffic in the town for many years.

a greater increase in the number of stations when the Interstate is farther from the old route. The estimate on the interaction in the second column is positive and significant. In the third column, we allow the distance effect to be nonlinear by including an interaction with the square of distance; the estimate on this coefficient is negative, but is not statistically significant. Within the range of our data, the linear and quadratic specifications have similar implications: no evidence of a relationship between highway openings and changes in the number of firms when "distance from old route" = 0, but a relationship that gradually increases in magnitude to about 0.025 as "distance from old route" increases to 10 miles (which is the 95th percentile "distance from old route" in our data). The bottom panel shows analogous results when examining the average employment size of service stations. In contrast to the top panel, there is no evidence of an effect that differs with "distance from old route." The long run increase of 5-6% we report above holds irrespective of distance.

Combined, these specifications indicate a systematic difference in how these local markets adjust to demand shocks: when the spatial demand shift is minimal, the industry adjusts through changes the average size but not in the number of stations. In contrast, when there is a significant spatial shift, it adjusts through the number of stations as well. These patterns are consistent with the view of the broad class of models described in Section 2: demand increases without taste changes primarily lead to increases in average firm size, but demand increases that are accompanied by taste shifts toward previously uncovered areas in "product space" are absorbed by increases in the number of firms.

Table 9 shows how the *timing* of adjustment varies with the magnitude of spatial demand shifts. These results are from specifications that include leads and lags, and allow the highway opening variables to interact with "distance from old route." In addition to the coefficient estimates, we show estimates of the sum of the leads and lags, evaluated at distance = 0 and distance = 10, in the right part of the table. The main finding from these specifications is that the timing as well as the margin of adjustment is different when comparing situations where the Interstate was near or far from the old route. This is suggested by the coefficient estimates in the middle panel: in particular, by the positive and significant coefficient estimates on the "+1 year" interaction in the number of stations regression and on the "-1 year" coefficient in the average station size regression. But it can be seen more easily in the impulse-response functions associated with these specifications, which we display in

Figure 8 and which use results from the middle specification. In each of these, the three lines represent impulse-response functions evaluated at three distances: 0 miles, 1.25 miles, and 10 miles; these are at the 5th, 50th, and 95th percentiles of the distance distribution in our sample. The functions for 0 and 1.25 miles are similar: there is little change in the number of stations, but an increase in the average size of 6% during the two years leading up to the highway opening. Thereafter, the average size levels off. The function is much different for 10 miles. There is an increase in the number of stations of about 8%, starting after the highway is complete, but no significant increase in the size of stations.

These patterns provide evidence that the timing of the adjustment process differs depending on whether there is a spatial demand shift: it happens earlier when the spatial demand shift is small than when it is large. When there is a limited spatial demand shift, average station size increases in the period leading up to year highway segments are completed, but there is no increase in the number of stations, and this increase occurs before the demand changes. When there is a spatial shift, the number of stations increases and this increase occurs after segments are completed.

In Section 2 we highlighted a central trade-off firms face when responding to anticipated demand shocks in industries where capacity additions involve industry-specific sunk costs. Adding capacity earlier can have strategic pre-emption related benefits, but can have the drawback of foreclosing the option of not to invest. We discussed how one would expect both the benefits and drawbacks to be greater when demand shocks open new segments than when they do not: pre-emption might be more attractive in new segments where there are not existing competitors, but uncertainty might be greater to the extent that demand and competitive conditions are harder to forecast. Our results here indicate that industry adjustment to highway openings is systematically slower when openings create new spatial segments than when they do not. Thus, our evidence is consistent with the proposition that, while the pre-emption-related benefits from expansion may be greater when spatial demand shifts are greater, this is more than offset by the effect of greater uncertainty.

5.3 Does The Timing of Adjustment Reflect Highway Openings In Other Counties in the Corridor?

The results above indicate that the adjustments to industry structure are earlier when new highway openings involve a small spatial demand shift than when they involve a large one, and that these adjustments take place before the highway opens when there is only a small spatial demand shift. One interpretation of the latter result is that it reflects highway openings in other counties along the same corridor: the demand for gasoline in a county may increase before the highway in the county is completed because the highway has been completed elsewhere in the corridor, and this has led traffic in the corridor to increase. If so, the latter result would not be evidence of pre-emption.

We investigate this by including $ccsmi_i$ in our specification. Table 10 shows the results. The top panel shows specifications with no leads and lags. The coefficient on $ccsmi_i$ in the number of stations regression is economically and statistically zero: the results are essentially the same as in our base specification. The story is somewhat different in the station size regression. The point estimate on $csmi_i$ declines to 0.016 (down from 0.020 in the base specification) and becomes not statistically significant; the point estimate on $ccsmi_i$ is 0.014 and not statistically significant. This specification indicates that it is difficult to separately identify the impact on station size of highway openings in a county and in a corridor.

The bottom panel, however, provides evidence that our pre-emption result does not reflect highway openings in other counties. Here we include a lead and a lag. We find that the results on $csmi_i$ are almost identical to those in Table 9; in particular, there is a positive and significant coefficient on the one-year lead that is nearly identical in magnitude to our previous result. The fact that average station size in a county increases take place ahead of highway openings in the county does not appear to reflect the opening of highway sections outside of the county.

5.4 Do Our Results Differ With the Importance of Through Traffic In the County?

Table 11 presents results where we interact $(1 - thrushare_i)$ and $thrushare_i$ with x_{it}. We find that the estimates on interactions between $thrushare_i$ and $csmi_{it}$ and $csmi_{it} * dist_i$ are similar to what we show in Table 9. In contrast, none of the none of the estimates on interactions between $(1 - thrushare_i)$ and these variables are positive and significant; indeed, the coefficient on $csmi_{it}$ in the number of firms regression is negative and significant. As one might expect, our main results reflect changes in industry structure in counties where highway traffic is large relative to local employment. There is no evidence that either the number or size of service stations in a county increased with the highway opened in the county in counties where highway traffic is small relative to local employment, and there is some evidence that the number of stations decreased.

6 Conclusion

As described in the introduction, the opening of Interstate highway segments provides a fertile environment for studying how industries adjust to demand shocks. This paper presents evidence on the margin, timing, and magnitude of these adjustments in the case of service stations. We show how this industry, one in which a significant share of capital investments are sunk to the industry and market, adjusts and how the adjustment process differs depending on whether demand shifts spatially.

Our empirical analysis shows the following. First, our sample period is one in which there is net exit in the aggregate which takes the form of an increase in the number of large stations and a decrease in the number of small ones. Second, we show that the increase in the number of large stations is associated with highway openings but the decrease in the number of small ones is not. The latter is consistent with the hypothesis that industry- and market-specific sunk investments make exit less sensitive to demand shocks than entry. Third, we show that the margin of adjustment systematically differs, depending on whether the highway is located near to or far from the old route. When it is near, the adjustment takes the form of larger stations; in the long run, the increase in average station size is on the order of 6%. When it is far, it primarily takes the form of more stations; the estimated magnitude is on the order of 8%. The difference in the margin of adjustment is what one would expect in light of monopolistic competition models, which imply that market size increases should lead to more firms if price-cost margins are relatively insensitive to entry but larger firms if they are sensitive to entry. Fourth, we show that the timing of adjustment systematically differs along these lines as well. The adjustment begins two years before the new highway opens when the new highway is close to the old route, and is complete the year the highway opens. In contrast, it begins the year the highway opens when the new highway is far from the old route. This difference in timing is consistent with the hypothesis that, although preemption incentives might be greater when demand shocks create new market segments than when they do not, uncertainty is greater as well, and the latter leads firms to delay investments in new capacity.

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8 Appendix

8.1 Definition of Corridors

Defining corridors first involves establishing the locations where corridors begin and end. These locations include most prominently major cities. After various trial definitions, we found that a useful and parsimonious way to generate a set of cities that serve as corridor endpoints is to look at the U.S. map in a standard road atlas. We found that cities listed in bold provided reasonable endpoints in the vast majority of cases. We spoke to cartographers at the firm that produced the map, and asked the criteria for including a city in bold. We learned that all cities in bold have at least 100,000 population (for the map we use, in 1996), but not all cities that exceed this level are included on the map – suburban cities (e.g., Fullerton, CA) are excluded both because they are not major destinations and because including them would make the map cluttered. We asked the criteria for including these cities and were told "cartographic license."

In any case, this rule produces a very useful set of cities; central cities with at least 100,000 population. A list of these cities is in Table A1.

In addition, we included the beginning and end of interstate highways as corridor endpoints, when the beginning or end of a highway (a) was not in a endpoint city, and (b) did not end at a junction with an interstate with the same orientation. One example of a corridor endpoint that satisfies this is Interstate 5's northern terminus at the Canadian border. Another is Interstate 4's northern terminus at its intersection with Interstate 95; this is an intersection between a (even-numbered) east-west route and an (odd-numbered) north-south route.

Within cities, we defined the beginning/end of the corridor to be at major intersections. The most common situation is where two interstates intersect near the heart of a city; when this occurs we use the interstate intersection as the placement for the node. (Sometimes the interstate intersection close to downtown is with a 3-digit highway.) In cities where there is a "dual-signed" segment where a single road is part of two two-digit interstate highways (e.g., Interstate 5-Interstate 10 in downtown Los Angeles), we use one of the endpoints of this dual-signed section. Where there is no interstate intersection near downtown, we use an important intersection close to downtown.

This produces an easy division of some Interstate Highways into distinct corridors. For example, it divides Interstate 25 into 4 corridors: start-

Albuquerque, Albuquerque-Colorado Springs, Colorado Springs-Denver, and Denver-end. This is simple because every mile of Interstate 25 belongs to only one corridor.

8.2 Highway Segments and Multiple Corridors

Some segments of the interstate highway system belong to multiple corridors. The most common examples of this occur when an east-west interstate divides into two east-west interstates, and this division takes place outside one of our city endpoints: forks in the road. For example, Interstate 10 west of Tucson divides between Interstate 8, which goes to San Diego, and Interstate 10, which goes to Phoenix. The stretch of Interstate 10 that is west of Tucson but east of this fork is part of two corridors: Phoenix-Tucson and San Diego-Tucson. Another example of this is when highways merge then separate. For example, Interstate 70 and Interstate 76 come together southeast of Pittsburgh, continue together for a long stretch, then split. The "I70-I76" stretch is part of four corridors: Pittsburgh-Philadelphia, Pittsburgh-Baltimore, Columbus-Philadelphia, and Columbus-Baltimore. The adjacent segments are each part of two corridors; for example, the stretch of Interstate 76 west of this dual signed stretch is part of Pittsburgh-Philadelphia and Pittsburgh-Baltimore. This pattern is common within metropolitan areas, albeit for much shorter stretches than I70-I76; as noted above, Interstate 5-Interstate 10 in Los Angeles is an example.

A full list of highway stretches that are part of multiple corridors, and the corridors to which they are assigned, is available upon request from the authors.

8.3 Measuring Corridor Completion When Segments Are Part of Multiple Corridors

An issue arises with respect to how to quantify how much of the corridor is complete in a county when highway segments are part of multiple corridors. For example, consider a county on Interstate 10 west of Tucson. This stretch of Interstate 10 is part of both Phoenix-Tucson and San Diego-Tucson. We construct our measure of corridor completion by first calculating the cumulative share of construction along each corridor, then weighting construction along the two corridors according to the traffic volume on each of the branches, measured at a point as close as possible to the "fork in the road;" in this case, traffic volumes on Interstate 8 and Interstate 8 just west of where Interstate 10 splits into these two roads. We compute corridor-level construction variables analogously for all counties that are part of multiple corridors.

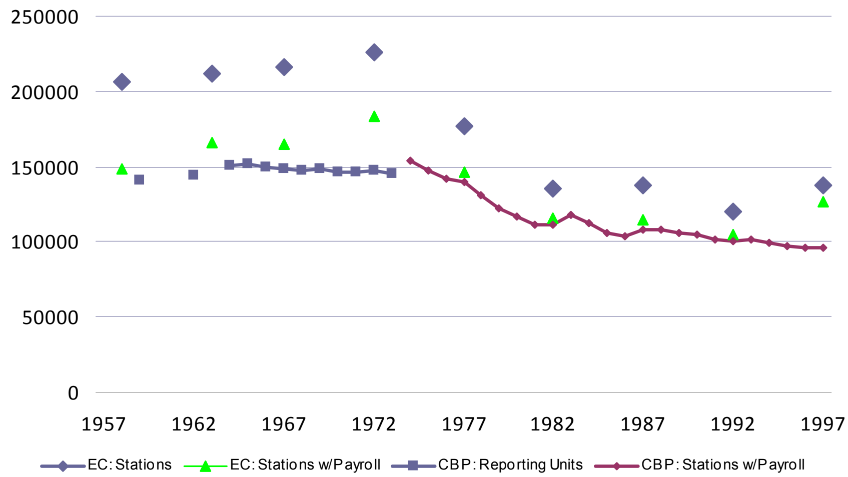


Figure 1. Service Stations in the United States. This Figure depicts Census counts of the number of service stations in the United States, and subsets thereof; these come from the Economic Census (EC) and County Business Patterns (CBP). The EC series show that the number of stations increased from the late 1950s to the early 1970s, then dropped sharply from then until the early 1980s. The CBP figures report the number of firms operating in each county before 1974, then the number of stations thereafter. The former falls relative to the EC-reported number of stations during the late 1960s and early 1970s, indicating that an increasing share of stations were owned by firms that operated other stations in the same county.

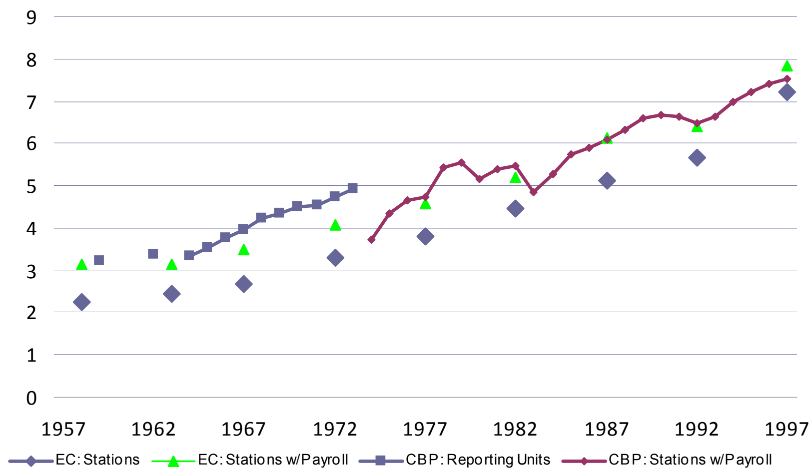


Figure 2. The Employment Size of Service Stations in the United States. This Figure depicts various measures of the employment size of service stations using data from the Economic Census (EC) and County Business Patterns (CBP). The EC series, which report employees per station using all stations and only stations with positive payroll, show that station size increased steadily throughout our sample period, increasing from 2.5 in 1964 to 5.6 in 1992. The CBP series report employees per "reporting unit" (firm*county) before 1974, then employees per station thereafter. The former increases by more than employees per station during the late 1960s and early 1970s. Combined, the Figure indicates that stations' employment size roughly doubled between 1964-1992, and that about 1/4 of the increase in within-county firm size between 1964-1973 is accounted for by an increase in the share of firms that operated multiple stations in the same county.

Service Station Size, Characteristics

	Gallons/ Station	Gallons/ Pump	Pumps/ Station	Employees/ Pump	Share Self-Service Sales
1972	360.7	68.0	5.3	0.77	
1977	508.8	97.4	5.2	0.88	30%
1982	543.1	90.2	6.0	0.86	63%
1987	697.4	97.1	7.2	0.85	75%
1992	802.8	110.8	7.2	0.88	91%
Change 1972-1992	123%	63%	37%	15%	

Share of Revenues by Product Category

	Fuel, Oil	Tires, Parts	Food, Alcohol, Tobacco	Other
1972	82%	10%	2%	6%
1977	85%	5%	4%	6%
1982	88%	3%	5%	4%
1987	81%	2%	12%	6%
1992	79%	2%	15%	5%

Source: Census of Retail Trade, Various Years.

Table 1. Service Station Size, Characteristics, and Revenue Sources. This Table reports how service stations' business and characteristics have changed between 1972-1992, using data from the Economic Census. Gallons per station more than doubled, reflecting increases in both gallons per pump and pumps per station. Employees per pump was constant starting in 1977. The self-service share of sales steadily increased to 91% by 1992. Automotive parts and accessories' share of station revenues decline between 1972-1982. The increase in convenience store-related sales increased sharply starting in 1982.

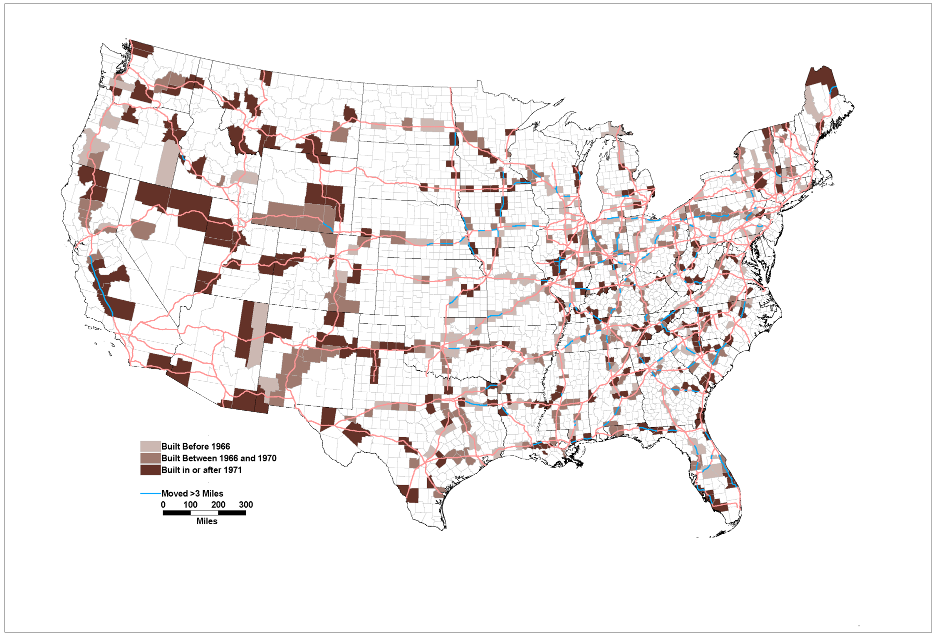


Figure 3. Sample Counties, Timing of Highway Completion, Distance from Old Route.

	All Two-Digit Highways		*Two-Digit Highways In Balanced Panel Counties*	
Year	Cumulative Miles	Share of Total	Cumulative Miles	Share of Total
1960	7732	20%	3494	19%
1965	19423	50%	9273	49%
1970	29260	76%	14334	76%
1975	34884	90%	17138	91%
1980	37238	96%	18119	96%
1985	38065	98%	18571	99%
1990	38597	100%	18785	100%
1992	38665	100%	18833	100%

Table 2. Two-Digit Interstate Highway Completion. This Table depicts cumulative completed mileage of construction of "two-digit" Interstate highways in all U.S. counties, and for the 677 counties in our balanced panel. Most of the mileage was completed during the 1960s and 1970s. The pace of highway completion in our balanced panel counties was similar to that overall.

Number of Firms/County

	Total	by Employment Size Category 1-3	4-7	8-19	20 or more
1964	45.8	35.7	7.6	2.2	0.4
1965	45.9	34.7	8.4	2.4	0.5
1966	45.8	33.4	9.1	2.8	0.5
1967	45.2	31.8	9.8	3.0	0.6
1968	45.2	30.3	10.7	3.5	0.7
1969	46.0	30.2	11.4	3.8	0.7
1970	45.3	29.2	11.5	3.9	0.7
1971	45.3	29.1	11.7	3.8	0.8
1972	45.7	27.9	12.6	4.3	0.8
1973	44.9	26.4	12.8	4.8	0.9

Number of Service Stations/County

	Total	by Employment Size Category 1-4	5-9	10-19	20 or more
1974	47.4	37.9	7.4	1.6	0.6
1975	44.9	33.3	9.0	2.0	0.6
1976	43.5	31.4	9.2	2.3	0.6
1977	43.3	30.8	9.7	2.2	0.6
1978	40.4	26.4	10.3	3.0	0.8
1979	37.6	23.7	10.2	2.8	0.9
1980	35.6	24.0	8.6	2.2	0.9
1981	33.8	22.2	8.7	2.2	0.7
1982	33.7	21.5	9.0	2.5	0.8
1983	35.9	23.0	9.7	2.5	0.7
1984	34.0	20.5	10.1	2.5	0.8
1985	32.1	18.3	9.9	3.0	1.0
1986	31.5	17.6	9.7	3.2	1.0
1987	33.6	18.2	10.6	3.6	1.1
1988	34.1	16.8	12.0	4.2	1.1
1989	33.4	15.8	11.8	4.5	1.3
1990	33.3	15.1	12.1	4.7	1.3
1991	32.4	14.9	11.7	4.5	1.4
1992	31.9	13.8	12.3	4.6	1.2

Table 3. Number of Firms and Service Stations per County, Overall and by Employment Size Category. This Table depicts the average number of firms per county (in 1964-1973) and service stations per county (in 1974-1992) for counties in our balanced panel. Between 1964 and 1973, there is a decrease in the number of small firms and an increase in the number of larger firms. Between 1974 and 1992, the average number of service stations decreased by one-third, reflecting a large decrease in the number of small stations and a smaller increase in the number of large ones**.**

	Date of Highway Completion			Late-Early
	Early	Mid	Late	Ratio
1964	3.0	3.1	2.9	97%
1965	3.2	3.3	3.1	96%
1966	3.5	3.5	3.2	94%
1967	3.6	3.7	3.4	93%
1968	3.9	4.0	3.6	92%
1969	4.0	4.1	3.7	93%
1970	4.2	4.2	3.9	93%
1971	4.3	4.3	3.9	92%
1972	4.4	4.6	4.2	93%
1973	4.7	4.8	4.4	94%
1974	3.6	3.9	3.4	95%
1975	4.2	4.4	4.0	94%
1976	4.5	4.7	4.3	94%
1977	4.7	4.7	4.3	92%
1978	5.4	5.4	5.1	94%
1979	5.6	5.8	5.3	95%
1980	5.3	5.3	5.0	95%
1981	5.4	5.3	5.2	96%
1982	5.5	5.7	5.3	97%
1983	4.8	5.0	4.8	100%
1984	5.2	5.3	5.2	100%
1985	5.6	5.8	5.8	103%
1986	5.7	5.9	6.0	105%
1987	6.0	6.1	6.2	105%
1988	6.4	6.4	6.5	101%
1989	6.7	6.7	6.9	102%
1990	6.9	6.8	7.0	102%
1991	6.7	6.9	7.1	105%
1992	6.7	6.9	7.0	104%

Table 4. Average Employment Size of Firms/Stations, by Date of Highway Completion. This Table depicts average employment per firm (in 1964-1973) and employment per station (in 1974-1992) for counties in our balanced panel with nonmissing employment for each sample year (N = 470). Highway completion is "early" if completed in 1965 or earlier, "mid" if completed between 1966-1971, and "late" if completed in or after 1972. N=167, 150, and 153 for early, mid, and late counties, respectively. The Table shows that while the employment size of firms and stations increased in each of these categories, it took place earlier for the "early" counties than the "late" counties.

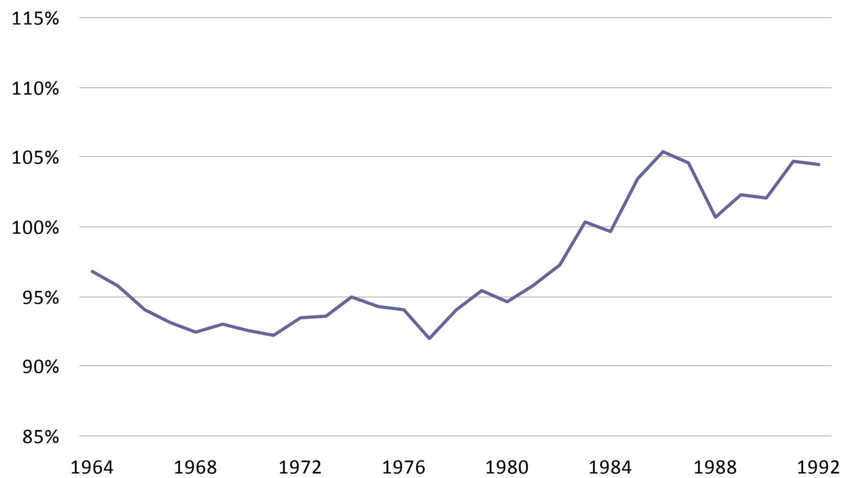


Figure 4. Employment Size Ratios: "Late" Counties to "Early" Counties. This Table depicts the ratio of the average employment per firm (in 1964-1973) and employment per station (in 1974-1992) for "late" and "early" counties in our balanced panel with nonmissing employment for each sample year (N = 470). Average firm size increased in "early" counties relative to "late" counties early in our sample; average station size increased in "late" counties relative to "early" counties later in our sample.

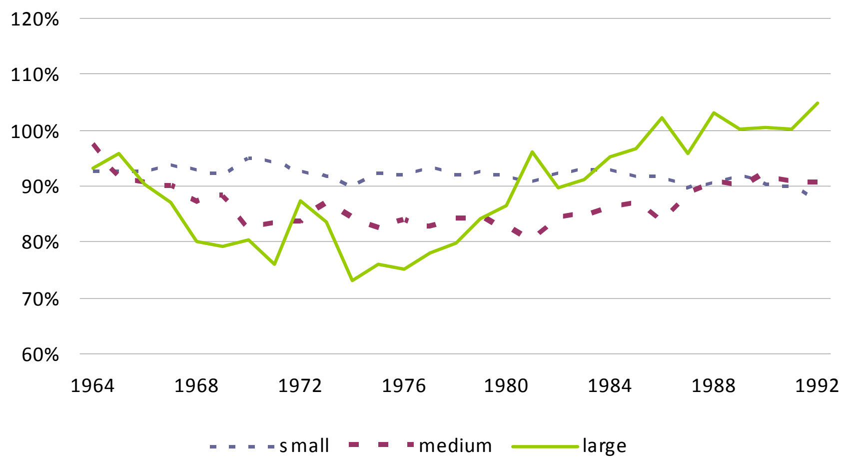


Figure 5. Firm and Station Count Ratios: "Late" Counties to "Early" Counties. This Table depicts the ratio of the average number of firms (in 1964-1973) or stations (in 1974-1992), by size category, in "late" and "early" counties in our balanced panel (N = 677). In 1964-1973, "small," "medium," and "large" include firms with 1-3, 4-7, and 8-19 employees, respectively. In 1974-1992, "small," "medium," and "large" include stations with 1-4, 5-9, and 10-19 employees, respectively. This Table shows increases in the number of large, and to some extent medium-sized, firms and stations took place earlier in the "early" counties than the "late" counties. It shows no evidence that changes in the number of small firms and stations were related to highway completion dates.

Table 5

VARs of the Number and Average Employment Size of Service Stations on Highway Openings

	Autoregressive Coefficients		Cumulative Share of Highway Opened in County Distributed Lag: Years From Highway Opening							Sum of Lag Coefficients
	ln(nit-1)	ln(ait-1)	-3	-2	-1	0	1	2	3	
No Leads or Lags										
ln(nit)	**0.768**	**0.029**				0.002				0.002
	(0.005)	**(0.004)**				(0.005)				(0.005)
ln(ait)	**0.032**	**0.638**				**0.019**				**0.019**
	(0.007)	**(0.006)**				**(0.007)**				**(0.007)**
One Lead and Lag										
ln(nit)	**0.766**	**0.032**			-0.006	-0.003	0.011			0.003
	(0.005)	**(0.004)**			(0.011)	(0.014)	(0.010)			(0.006)
ln(ait)	**-0.035**	**0.635**			**0.030**	0.002	-0.010			**0.022**
	(0.007)	**(0.006)**			**(0.015)**	(0.019)	(0.013)			**(0.008)**
Two Leads and Lags										
ln(nit)	**0.754**	**0.033**		-0.010	0.003	-0.001	0.009	0.002		0.002
	(0.005)	**(0.005)**		(0.013)	(0.016)	(0.015)	(0.014)	(0.010)		(0.007)
ln(ait)	**0.040**	**0.618**		0.011	0.018	0.007	-0.036	0.025		**0.025**
	(0.008)	**(0.007)**		(0.018)	(0.022)	(0.021)	(0.019)	(0.013)		**(0.009)**
Three Leads and Lags										
ln(nit)	**0.737**	**0.032**	-0.022	0.019	-0.013	0.000	0.015	0.007	-0.012	-0.007
	(0.006)	**(0.005)**	(0.015)	(0.019)	(0.018)	(0.016)	(0.015)	(0.014)	(0.009)	(0.008)
ln(ait)	**0.039**	**0.598**	-0.001	0.013	0.016	0.013	-0.055	0.032	0.006	**0.024**
	(0.008)	**(0.007)**	(0.021)	(0.026)	(0.025)	(0.023)	(0.021)	(0.020)	(0.013)	**(0.012)**

These results are from county-level VAR specifications that relate the number of service stations (per 1980 employment) and the average employment size of service stations to Interstate highway openings.
The specifications also include county and year fixed effects (not reported). We also allow the autoregressive coefficients to differ in year 1974 to accommodate Census' change in reporting units between 1973 and 1974.

These results use all counties with non-missing reports for number of firms/establishments from 1964-1992, N=677.
Standard errors are in parentheses; bold indicates that the estimates is statistically significantly different zero using a test of size 0.05.

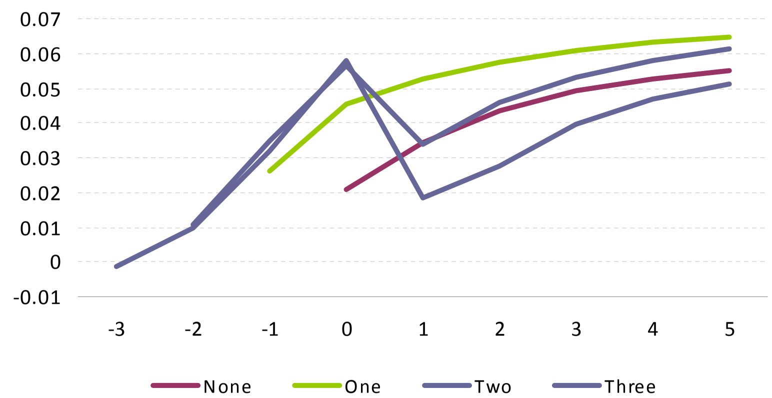


Figure 6. Impulse-Response Functions for Highway Openings on Employment Size of Service Stations, For Specifications with Zero to Three Leads and Lags. This graph depicts how the average size of service stations change around the time that Interstate highway segments are completed in a county, for specifications that use zero to three leads and lags. The vertical axes scaled in log-points; 0.04 represents a 4% increase. The horizontal axis is years from segment completion; "-2" means two years before a segment is completed. These graphs illustrate that average station size began to increase during the two years preceding the new highway's completion. All specifications capture a similar long-run change in average station size.

Table 6
VARs of the Number of Service Stations in Employment Size Categories on Highway Openings

	Autoregressive Coefficients				Cumulatiive Share of Highway Opened in County Distributed Lag: Years from Highway Opening					Sum of Lag Coefficients
	s1	s2	s3	s4	-2	-1	0	1	2	
No Leads or Lags										
s1	**0.802**	**0.149**	-0.017	-0.063			0.179			0.179
	(0.004)	**(0.007)**	(0.015)	(0.036)			(0.156)			(0.156)
s2	**0.077**	**0.650**	**0.271**	**0.114**			0.080			0.080
	(0.003)	**(0.006)**	**(0.011)**	**(0.026)**			(0.110)			(0.110)
s3	**-0.005**	**0.082**	**0.579**	**0.325**			**0.234**			**0.234**
	(0.002)	**(0.003)**	**(0.006)**	**(0.015)**			**(0.064)**			**(0.064)**
s4	**-0.002**	-0.001	**0.063**	**0.519**			0.010			0.010
	(0.001)	(0.001)	**(0.003)**	**(0.006)**			(0.028)			(0.028)
One Lead and Lag										
s1	**0.794**	**0.158**	-0.001	-0.021		0.214	-0.401	-0.450		0.263
	(0.004)	**(0.008)**	(0.016)	(0.038)		(0.333)	(0.429)	(0.295)		(0.172)
s2	**0.079**	**0.640**	**0.268**	**0.144**		0.008	-0.088	0.193		0.113
	(0.003)	**(0.006)**	**(0.011)**	**(0.027)**		(0.236)	(0.303)	(0.208)		(0.122)
s3	**-0.004**	**0.086**	**0.573**	**0.293**		**0.304**	-0.052	0.038		**0.290**
	(0.002)	**(0.003)**	**(0.006)**	**(0.016)**		**(0.136)**	(0.175)	(0.121)		**(0.070)**
s4	**-0.004**	**-0.003**	**0.064**	**0.545**		0.020	-0.031	0.031		0.020
	(0.001)	**(0.001)**	**(0.003)**	**(0.007)**		(0.058)	(0.074)	(0.051)		(0.030)
Two Leads and Lags										
s1	**0.778**	**0.172**	0.010	-0.007	0.035	0.336	-0.428	0.273	0.017	0.232
	(0.004)	**(0.009)**	(0.017)	(0.040)	(0.384)	(0.489)	(0.459)	(0.431)	(0.298)	(0.206)
s2	**0.082**	**0.622**	**0.277**	**0.179**	-0.058	-0.143	-0.071	0.358	0.031	0.117
	(0.003)	**(0.006)**	**(0.012)**	**(0.029)**	(0.271)	(0.345)	(0.325)	(0.305)	(0.210)	(0.145)
s3	**-0.006**	**0.083**	**0.569**	**0.303**	**0.408**	0.022	-0.016	-0.183	0.226	**0.457**
	(0.002)	**(0.004)**	**(0.007)**	**(0.016)**	**(0.156)**	(0.198)	(0.186)	(0.175)	(0.121)	**(0.083)**
s4	**-0.003**	0.002	**0.059**	**0.525**	-0.065	0.104	-0.031	-0.040	0.052	0.021
	(0.001)	(0.002)	**(0.003)**	**(0.007)**	(0.066)	(0.084)	(0.079)	(0.074)	(0.051)	(0.035)

These results are from county-level VAR specifications that relate the number of service stations in different size categories to the share of interstate highway mileage in the county that had opened by year t. S1, S2, S3, and S4 consist of firms with 1-3, 4-7, 8-19, and 20 or more employees in the county (these categories are 1-4, 5-9, 10-19, and 20 or more after 1974).
The specifications also include county and year fixed effects (not reported). We also allow the autoregressive coefficients to differ in year 1974 to accommodate Census' change in reporting units between 1973 and 1974.

These results use all counties with non-missing reports for number of firms/establishments from 1964-1992, N=677.
Standard errors are in parentheses; bold indicates that the estimates is statistically significantly different zero using a test of size 0.05.

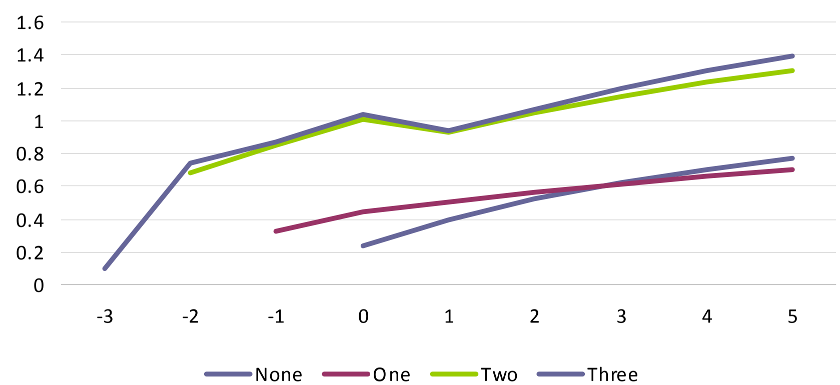


Figure 7. Impulse-Response Functions for Highway Openings on Number of "Large" Service Stations, For Specifications with Zero to Three Leads and Lags. This graph depicts how the number of "large" service stations change around the time that Interstate highway segments are completed in a county, for specifications that use zero to three leads and lags. The vertical axis is the number of stations (before 1974, firms). The horizontal axis is years from segment completion; "-2" means two years before a segment is completed. These graphs illustrate that the number of large service stations began to increase during the two years preceding the new highway's completion.

Table 7

VARs of the Number and Average Employment Size of Service Stations on Highway Openings

Interactions with Post 73 Dummy

	Autoregressive Coefficients		Cumulative Share of Highway Opened in County Distributed Lag: Years from Highway Opening					Post 73*Cumulative Share of Highway Opened in County Distributed Lag: Years from Highway Opening				
	ln(nit-1)	ln(ait-1)	-2	-1	0	1	2	-2	-1	0	1	2
No Leads or Lags												
ln(nit)	**0.768**	**0.029**			-0.001					0.013		
	(0.005)	**(0.004)**			(0.005)					(0.011)		
ln(ait)	**0.032**	**0.638**			**0.020**					-0.007		
	(0.007)	**(0.006)**			**(0.007)**					(0.016)		
One Lead and Lag												
ln(nit)	**0.766**	**0.032**		-0.006	-0.003	0.009			0.009	0.002	0.008	
	(0.005)	**(0.004)**		(0.012)	(0.015)	(0.010)			(0.017)	(0.021)	(0.017)	
ln(ait)	**0.039**	**0.617**		**0.035**	0.002	-0.013			-0.024	0.002	0.020	
	(0.008)	**(0.007)**		**(0.016)**	(0.020)	(0.014)			(0.023)	(0.029)	(0.023)	
Two Leads and Lags												
ln(nit)	**0.754**	**0.033**	0.005	-0.008	-0.001	0.008	0.000	-0.043	0.040	0.001	0.000	0.010
	(0.005)	**(0.005)**	(0.014)	(0.017)	(0.016)	(0.015)	(0.010)	(0.017)	(0.022)	(0.021)	(0.021)	(0.017)
ln(ait)	**0.039**	**0.618**	0.004	0.029	0.008	-0.032	0.017	0.025	-0.038	-0.003	-0.009	0.044
	(0.008)	**(0.006)**	(0.019)	(0.024)	(0.022)	(0.021)	(0.014)	(0.024)	(0.030)	(0.030)	(0.029)	(0.025)

These results are from county-level VAR specifications that relate the number of service stations (per 1980 employment) and the average employment size of service stations to Interstate highway openings.
The specifications also include county and year fixed effects (not reported). We also allow the autoregressive coefficients to differ in year 1974 to accommodate Census' change in reporting units between 1973 and 1974.

These results use all counties with non-missing reports for number of firms/establishments from 1964-1992, N=677.
Standard errors are in parentheses; bold indicates that the estimates is statistically significantly different zero using a test of size 0.05.

Table 8
Interaction Specifications with Distance From Old Route: No Leads or Lags

Dependent Variable: ln(nit)			
Cumulative Share of Highway Opened ("CSHO")	0.002 (0.005)	-0.006 (0.006)	-0.013 (0.008)
CSHO*distance from old route		**0.0027** **(0.0012)**	**0.0076** **(0.0035)**
CSHO*(distance from old route)^2			-0.0004 (0.0002)
Dependent Variable: ln(ait)			
Cumulative Share of Highway Opened ("CSHO")	**0.019** **(0.007)**	**0.019** **(0.008)**	0.016 (0.011)
CSHO*distance from old route		-0.0002 (0.0017)	0.0022 (0.0049)
CSHO*(distance from old route)^2			-0.0002 (0.0003)

These results are from county-level interactions that relate the number of service stations (per 1980 employment) and the average employment size of service stations to interstate highway openings.

The first column is the same as the top panel of Table X. The second and third interact the cumulative share of highway opened in the county (CSHO) with the average distance between the interstate and the old route that it replaced in the county.

The results indicate that highway openings have a stronger effect on the number of firms when the old route is farther from the interstate, and that distance has a diminishing incremental effect. In contrast, there is no evidence the relationship between average service station size and highway openings varies with distance from old route.

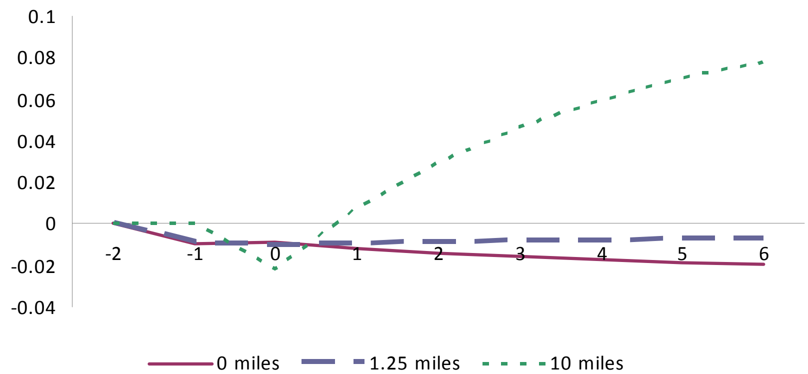
Table 9
VARs of the Number and Average Employment Size of Service Stations on Highway Openings
Distance Interactions, Two Leads and Lags

	Autoregressive Coefficients		Cumulative Share of Highway Opened in County Distributed Lag: Years from Highway Opening					Distance*Cumulative Share of Highway Opened in County Distributed Lag: Years from Highway Opening					Sum of Lag Coefficients	
	ln(nit-1)	ln(ait-1)	-2	-1	0	1	2	-2	-1	0	1	2	d=0	d=10
No Leads or Lags														
ln(nit)	**0.768**	**0.030**			-0.006					**0.003**			-0.005	**0.021**
	(0.005)	**(0.004)**			(0.006)					**(0.001)**			(0.006)	**(0.010)**
ln(ait)	**0.039**	**0.617**			**0.020**					0.000			**0.020**	0.018
	(0.008)	**(0.007)**			**(0.009)**					(0.002)			**(0.009)**	(0.014)
One Lead and Lag														
ln(nit)	**0.765**	**0.032**		-0.010	0.007	-0.005			0.001	-0.003	**0.005**		-0.007	**0.024**
	(0.005)	**(0.004)**		(0.015)	(0.018)	(0.013)			(0.003)	(0.005)	**(0.002)**		(0.007)	**(0.011)**
ln(ait)	**0.039**	**0.617**		**0.054**	-0.016	-0.011			-0.008	0.006	0.000		**0.028**	0.010
	(0.008)	**(0.007)**		**(0.020)**	(0.026)	(0.017)			(0.005)	(0.005)	(0.003)		**(0.010)**	(0.015)
Two Leads and Lags														
ln(nit)	**0.754**	**0.033**	-0.010	-0.010	0.016	-0.010	-0.003	0.000	0.001	-0.005	0.006	0.001	-0.008	0.024
	(0.005)	**(0.005)**	(0.017)	(0.021)	(0.020)	(0.188)	(0.013)	(0.004)	(0.005)	(0.004)	(0.004)	(0.003)	(0.009)	(0.013)
ln(ait)	**0.039**	**0.617**	0.025	0.038	-0.011	-0.028	0.010	-0.005	-0.007	0.006	-0.002	0.005	**0.035**	0.005
	(0.008)	**(0.007)**	(0.024)	(0.030)	(0.028)	(0.026)	(0.018)	(0.005)	(0.006)	(0.006)	(0.005)	(0.003)	**(0.012)**	(0.018)

These results are from county-level VAR specifications that relate the number of service stations (per 1980 employment) and the average employment size of service stations to Interstate highway openings.
The specifications also include county and year fixed effects (not reported). We also allow the autoregressive coefficients to differ in year 1974 to accommodate Census' change in reporting units between 1973 and 1974.

These results use all counties with non-missing reports for number of firms/establishments from 1964-1992, N=677.
Standard errors are in parentheses; bold indicates that the estimates is statistically significantly different zero using a test of size 0.05.

Number of Service Stations and Year From Interstate Highway Opening



Average Service Station Employment Size and Year From Interstate Highway Opening

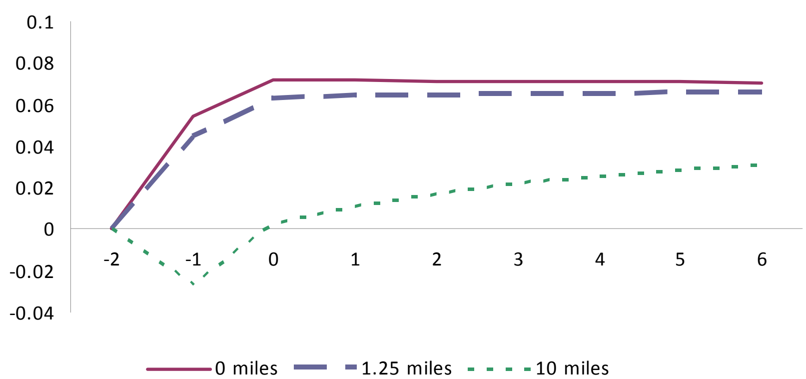


Figure 8. Impulse-Response Functions for Highway Openings on Market Structure of Service Stations, by Distance from Old Route. These graphs depict how the number and average size of service stations change around the time that Interstate highway segments are completed in a county, and how this differs with how close the Interstate is from the previous route. The vertical axes scaled in log-points; 0.04 represents a 4% increase. The horizontal axis is years from segment completion; "-2" means two years before a segment is completed. These graphs illustrate that

when the Interstate was close to the old route, the industry adjustment was in an increase in average station size during the two years preceding the new highway's completion. When it was far, the adjustment was an increase in the number of stations that took place after the new highway was completed.

Table 10

VARs of the Number and Average Employment Size of Service Stations on Highway Openings

Distance Interactions, One Lead and Lag

	Autoregressive Coefficients		Cumulative Share of Highway Opened in Corridor			Cumulative Share of Highway Opened in County			Cumulative Share of Highway Opened in County*Distance			Sum of Lag Coefficients	
	ln(nit-1)	ln(ait-1)	-1	0	1	-1	0	1	-1	0	1	d=0	d=10
No Leads or Lags													
ln(nit)	**0.768**	**0.030**		0.005			-0.008			**0.003**		0.005	0.019
	(0.005)	**(0.004)**		(0.010)			(0.007)			**(0.001)**		(0.010)	(0.010)
ln(ait)	**0.031**	**0.637**		0.014			0.016			0.000		0.016	0.012
	(0.007)	**(0.006)**		(0.014)			(0.010)			(0.002)		(0.010)	(0.015)
One Lead and Lag													
ln(nit)	**0.765**	**0.032**	-0.025	0.009	0.011	-0.006	0.009	-0.008	0.001	-0.002	0.005	-0.004	**0.026**
	(0.005)	**(0.004)**	(0.019)	(0.022)	(0.016)	(0.015)	(0.019)	(0.013)	(0.003)	(0.004)	(0.002)	(0.008)	**(0.012)**
ln(ait)	**0.034**	**0.634**	0.001	0.009	0.009	**0.052**	-0.013	-0.019	-0.008	0.006	0.000	0.021	0.001
	(0.007)	**(0.006)**	(0.027)	(0.031)	(0.023)	**(0.020)**	(0.026)	(0.018)	(0.005)	(0.006)	(0.003)	(0.012)	(0.016)

These results are from county-level VAR specifications that relate the number of service stations (per 1980 employment) and the average employment size of service stations to Interstate highway openings.
The specifications also include county and year fixed effects (not reported). We also allow the autoregressive coefficients to differ in year 1974 to accommodate Census' change in reporting units between 1973 and 1974.

These results use all counties with non-missing reports for number of firms/establishments from 1964-1992, N=677.
Standard errors are in parentheses; bold indicates that the estimates is statistically significantly different zero using a test of size 0.05.

Table 11

VARs of the Number and Average Employment Size of Service Stations on Highway Openings

Distance Interactions, One Lead and Lag

	Autoregressive Coefficients		Cumulative Share of Highway Opened in County			Cumulative Share of Highway Opened in County*Distance			Sum of Lag Coefficients	
	ln(nit-1)	ln(ait-1)	-1	0	1	-1	0	1	d=0	d=10
No Leads or Lags										
					Interactions with "thrushare"					
ln(nit)	**0.766**	**0.029**		0.017			**0.005**		0.017	**0.071**
	(0.005)	**(0.004)**		(0.012)			**(0.003)**		(0.012)	**(0.020)**
ln(ait)	**0.030**	**0.636**		**0.067**			-0.005		**0.067**	0.019
	(0.007)	**(0.006)**		**(0.017)**			(0.004)		**(0.017)**	(0.028)
					Interactions with (1-"thrushare")					
ln(nit)				**-0.034**			-0.001		**-0.034**	-0.044
				(0.015)			(0.003)		**(0.015)**	(0.026)
ln(ait)				-0.037			0.006		-0.037	0.019
				(0.020)			(0.005)		(0.020)	(0.035)
One Lead and Lag										
					Interactions with "thrushare"					
ln(nit)	**0.764**	**0.032**	0.011	-0.020	0.029	0.003	-0.001	0.004	0.019	**0.079**
	(0.005)	**(0.004)**	(0.030)	(0.039)	(0.026)	(0.007)	(0.008)	(0.005)	(0.014)	**(0.022)**
ln(ait)	**0.032**	**0.633**	0.077	-0.023	0.024	**-0.023**	0.012	0.002	**0.077**	-0.016
	(0.007)	**(0.006)**	(0.042)	(0.054)	0.036	**(0.009)**	(0.010)	(0.007)	**(0.018)**	(0.031)
					Interactions with (1-"thrushare")					
ln(nit)			-0.030	0.038	-0.046	-0.003	-0.004	0.005	**-0.038**	-0.049
			(0.038)	(0.049)	(0.033)	(0.009)	(0.011)	(0.007)	**(0.016)**	(0.028)
ln(ait)			0.018	0.004	-0.057	0.014	-0.003	-0.003	-0.036	0.044
			(0.053)	(0.068)	(0.046)	(0.012)	(0.015)	(0.011)	(0.023)	(0.039)

These results are from county-level VAR specifications that relate the number of service stations (per 1980 employment) and the average employment size of service stations to Interstate highway openings.
The specifications also include county and year fixed effects (not reported). We also allow the autoregressive coefficients to differ in year 1974 to accommodate Census' change in reporting units between 1973 and 1974.

These results use all counties with non-missing reports for number of firms/establishments from 1964-1992, N=677.
Standard errors are in parentheses; bold indicates that the estimates is statistically significantly different zero using a test of size 0.05.

Table A1
Cities that Are Corridor Endpoints

Abilene, TX	Detroit, MI	Madison, WI	San Bernardino, CA
Akron, OH	Durham, NC	Memphis, TN	San Diego, CA
Albany, NY	El Paso, TX	Miami, FL	San Francisco, CA
Albuquerque, NM	Erie, PA	Milwaukee, WI	Savannah, GA
Allentown, PA	Eugene, OR	Minneapolis, MN	Seattle, WA
Amarillo, TX	Flint, MI	Mobile, AL	Shreveport, LA
Ann Arbor, MI	Fort Lauderdale, FL	Montgomery, AL	Sioux Falls, SD
Atlanta, GA	Fort Wayne, IN	Nashville, TN	South Bend, IN
Austin, TX	Fort Worth, TX	New Haven, CT	Spokane, WA
Baltimore, MD	Gary, IN	New Orleans, LA	Springfield, IL
Baton Rouge, LA	Grand Rapids, MI	New York, NY	Springfield, MO
Beaumont, TX	Greensboro, NC	Newark, NJ	St. Louis, MO
Birmingham, AL	Hartford, CT	Norfolk, VA	Stockton, CA
Boise, ID	Houston, TX	Oklahoma City, OK	Syracuse, NY
Boston, MA	Indianapolis, IN	Omaha, NE	Tacoma, WA
Bridgeport, CT	Jackson, MS	Orlando, FL	Tallahassee, FL
Buffalo, NY	Jacksonville, FL	Peoria, IL	Tampa, FL
Charlotte, NC	Kansas City, MO	Philadelphia, PA	Toledo, OH
Chattanooga, TN	Knoxville, TN	Phoenix, AZ	Topeka, KS
Chicago, IL	Lafayette, LA	Pittsburgh, PA	Tucson, AZ
Cincinnati, OH	Lansing, MI	Portland, OR	Tulsa, OK
Cleveland, OH	Laredo, TX	Providence, RI	Waco, TX
Colorado Springs, CO	Las Vegas, NV	Raleigh, NC	Washington, DC
Columbia, SC	Lexington, KY	Reno, NV	Wichita, KS
Columbus, OH	Lincoln, NE	Richmond, VA	Winston Salem, NC
Corpus Christi, TX	Little Rock, AR	Rockford, IL	
Dallas, TX	Los Angeles, CA	Sacramento, CA	
Dayton, OH	Louisville, KY	Salem, OR	
Denver, CO	Lubbock, TX	Salt Lake City, UT	
Des Moines, IA	Macon, GA	San Antonio, TX	