Title
The Effects of Transportation Services On the Scale of Food Retailing

Permalink
https://escholarship.org/uc/item/52638309

Author
Yim, Youngbin

Publication Date
1992-07-01
The Effects of Transportation Services
On the Scale of Food Retailing

Youngbin Yim

July 1992
Working Paper, No. 112
The University of California
Transportation Center

The University of California Transportation Center (UCTC) is one of ten regional units mandated by Congress and established in Fall 1988 to support research, education, and training in surface transportation. The UC Center serves federal Region IX and is supported by matching grants from the U.S. Department of Transportation, the California State Department of Transportation (Caltrans), and the University.

Based on the Berkeley Campus, UCTC draws upon existing capabilities and resources of the Institutes of Transportation Studies at Berkeley, Davis, and Irvine; the Institute of Urban and Regional Development at Berkeley; the Graduate School of Architecture and Urban Planning at Los Angeles; and several academic departments at the Berkeley, Davis, Irvine, and Los Angeles campuses. Faculty and students on other University of California campuses may participate in Center activities. Researchers at other universities within the region also have opportunities to collaborate on selected studies. Currently faculty at California State University, Long Beach, and at Arizona State University, Tempe, are active participants.

UCTC’s educational and research programs are focused on strategic planning for improving metropolitan accessibility, with emphasis on the special conditions in Region IX. Particular attention is directed to strategies for using transportation as an instrument of economic development, while also accommodating to the region’s persistent expansion and while maintaining and enhancing the quality of life there.

The Center distributes reports on its research in working papers, monographs, and in reprints of published articles. For a list of publications in print, write to the address below.

University of California
Transportation Center

108 Naval Architecture Building
Berkeley, California 94720
Tel 415/643-7378
FAX 415/643-5456

Authors of papers reporting on UCTC-sponsored research are solely responsible for their content. This research was supported by the U.S. Department of Transportation and the California State Department of Transportation, neither of which assumes liability for its content or use.
The Effects of Transportation Services
On the Scale of Food Retailing

Youngbin Yim
Institute of Transportation Studies
University of California at Berkeley

Working Paper, No. 112

The University of California Transportation Center
University of California at Berkeley
THE EFFECTS OF TRANSPORTATION SERVICES ON THE SCALE OF FOOD RETAILING

Youngbin Yim

Institute of Transportation Studies
109 McLaughlin Hall
University of California
Berkeley, CA 94720
Telephone (510) 642-9216
Fax (510) 643-5456

July 1992

Abstract

Employment centers, residential locations, and home-to-work trips have traditionally been the focus of the urban transportation planning (UTP) process, while shopping and social/recreational trips have been largely neglected. This paper seeks to improve understanding of the relationships between transportation services and other urban activities; specifically, it examines the food retailing industry. How do transportation systems influence the scale economies of food retailing, and how then does food retailing generate new travel demands on shopping trips? We have investigated increases in automobile usage and improvements in urban roads to identify the effects of transportation services on food retailing. By tracing historical data at the national level, we were able to identify changes in transportation and retail activities. The study shows that transportation has a far-reaching effect on food retailing; it has introduced food stores to new technological formats. The reduced number and increased size of food stores suggest that, over time, traffic patterns relating to food shopping are significantly modified.
1. Introduction

When considering the capacity of urban freeways, arterials, and local streets, analysts typically view shopping trips as relatively insignificant. Conventional practice is to design facilities to meet peak work trip demands and the resulting facilities are then assumed to also satisfy other trip purposes (Institute of Transportation Engineers, 1987). Both observation and logic, however, suggest that practice would be improved by including shopping trips when demand is considered.

Shopping trips comprise up to 15 percent of afternoon peak-hour traffic (Sheppard, 1986). On a corridor operating near capacity, the shopping trip increment to traffic volume can mean the difference between free-flowing traffic and severe congestion. The ready availability and low cost of auto travel, coupled with improved urban arterials and highways, has made distant store locations more accessible to shoppers and has encouraged travelling farther to go shopping. Auto ownership has steadily increased since the mass production of automobiles began early in this century. By 1985, almost every person of driving age had access to a car (DOT Highway Statistics, 1985).

The travel behavior of urban consumers has changed as the size, function, and location of urban retail stores have changed. Cities have expanded outward. Retail industries have changed their technological formats, and improved management capabilities have contributed to more efficient marketing. Interacting with demand and travel, storeside changes have resulted in a reorganization of the spatial arrangement of retail activities and in altered patterns of shopping trips. This paper seeks to illuminate these interrelationships between changes in retail structure and transportation. At issue is how the retailing industry responds to changes in transportation systems and how transportation systems respond to changes in retailing.

Within this context, the paper is aimed at expanding our knowledge of the evolution of urban activities by examining the relationships between transportation services and the scale of grocery stores. Among retail activities, food retailing was chosen because the scale, scope and locations of food stores changed greatly during the past few decades. There is also a wealth of information available to researchers of both production and consumption
in the food industry. The food industry has long been the largest sector of the U.S. economy and thus a significant amount of research has been done in wholesale and retail distribution of grocery products by major government agencies and food merchants. Furthermore, the grocery industry deals with homogeneous goods which makes a comparative analysis vastly simpler than would be for other retailing, such as comparison goods. Comparison goods are those items for which consumers compare prices at more than one store before purchasing.

The most important reason for examining the food retailing industry, however, is that we need to improve current land use and transportation models. Not only do today’s operationalized land use/transportation models neglect shopping trips, but those models are also based primarily on the concept of a static equilibrium of land use and transportation systems. This is perhaps due to the fact that the dynamic equilibrium is not well understood. Previously, the research focus had been on studies of the static properties of urban systems; only a few researchers have attempted to investigate the dynamic process of change in retail and transportation systems. This paper describes the process of change in the scale of food stores that are directly influenced by the deployment of transportation technologies. The scale effects were measured in the sizes of grocery stores and scale changes were analyzed by tracing historical data over the past 50 years. The time-series data used in this paper were aggregated at the national level from 1940 to 1988.

2. Trends of Shopping Trips

Today’s shopping trip patterns are vastly different from the patterns observed in the 1970s or even in the 1980s. New spatial patterns of retail locations emerged as urban consumers became able to travel farther while shopping for goods and services. Shopping centers grew not only in size but also in number (Figure 1a). The evolution of urban grocery retailing is exemplified by supermarkets in the 1940s, shopping centers in the 1950s, hypermarkets in the 1970s, convenience mini-marts in the 1980s, and discount megawarehouses in the 1990s. Over the past few decades, food stores increased in size while they shrank in number (Urban Land Institute, 1985; Food Marketing Institute, 1987; Figures 1b). Mini-marts, somewhat similar to the "mom-and-pop" stores of old, emerged in response to the demand for convenience created by the greater distances between
supermarkets (Progressive Grocer, 1989). Earlier, and extending through the 1920s and 1930s, there were many small family-operated, mom-and-pop grocery stores. The emergence of supermarkets in the 1940s made these smaller, less efficient grocery stores more difficult to sustain; thus, there was, until the late 1970s, a declining trend in small grocery stores.

Examples of changes in comparison-goods retailing include the demise of most neighborhood-level stores and the concentration of business in fewer, larger, and more dispersed stores, both freestanding and in shopping centers. (The industry divides retail services into two major categories -- comparison and convenience. Examples of comparison goods include furniture, clothing, and home appliances. Convenience goods are those items consumers buy after little or no store-to-store comparison shopping; examples include groceries and drugstore sundries.) These new retailing locations are almost always adjacent to urban freeways or major arterials. In general, new comparison goods retailing centers are more widely dispersed than new grocery stores.

The trends in retailing, for both comparison and convenience goods, probably resulted in longer and more frequent intra-urban shopping trips using vehicles. The increased number of automobiles per household accounts for more frequent vehicle trips. Despite the
loss of some comparison retailing at the neighborhood level, improvements in urban transportation make more stores accessible to consumers seeking the best value for their dollar. These opportunities encourage consumers to visit as many stores as practicable in search of the best value among comparable goods.

Similarly, there are fewer stores per capita carrying convenience goods such as groceries and drugstore items; this decrease requires consumers to make longer journeys for even routine shopping. Increased automobile holdings encourage single vehicle occupancy for shopping trips. Increased vehicle miles of travel (VMT) per household and decreased vehicle occupancy in shopping trips were precisely what was found in national travel surveys (DOT Personal Trips in the U.S., 1983). Longer journeys to the market and single vehicle occupancy result in more traffic on urban arterials and highways.

3. Research Needs

For many decades researchers have attempted to develop large-scale models to forecast travel patterns and to evaluate land use policies. During that time, however, many researchers and practitioners questioned the efficacy of these models. Among the major criticisms were: the absence of a theoretical framework to integrate individual models into a comprehensive frame, the unreliability of the output produced by the models without a proper coordination between the land use and the transportation models, and an unrealistic view of the models based primarily on home-to-work trips for all trip purpose estimates in urban highway and arterial design. Difficulties in the early models of the Chicago (CATS) and Penn-Jersey (P-J) area studies unfortunately led to a decline in interest and development of large scale models (Boyce, 1988). The skepticism about large-scale models (Lee, 1973) in the 1970s reoriented research efforts to mostly theory-based studies, with the expectation of strengthening the foundation of future models.

However, recent and remarkable improvements in analytical methods have encouraged renewed interest in large scale models in urban transportation planning (Boyce, 1988; Akinc, 1988; and Anseline and Griffith, 1988). Even so, this work has focused mainly on analyzing the home-to-work trip, and the analysis of social-recreational-shopping travel and related land use has been neglected. Webster (1988) stressed the need for improvements in the analytical methods for the studies of land use and transportation activities. Boyce (1988) emphasized ways in which land use and transportation submodels could be
integrated. Meyer (1984) advocated the forecasting of transportation demand based on knowledge of spatial distribution of economic activities and of people for all facets of urban activities.

According to Garrison (1987) the number of behavior-based and theory-based studies of transportation and land use increased sharply about 1960. Planning analysis models incorporated the results of these studies and the models then focused on aggregate behaviors, mainly, the locations of work places and residences within zones and the resulting trip patterns. Such models aided decisions about the location and capacity of freeway-type facilities in the 1960s and early 1970s. To strengthen the knowledge base, behavioral- and theory-based work is needed, and this paper aligns with that need.

In order to improve the analytical techniques presently available for large scale transportation models, the study seeks to understand the structures and processes of change in urban activities by examining food retail activities. A better understanding of the spatial and structural behavior of retail business will lead to an improvement in UTP analysis techniques and to a better critique of transportation policies.

4. Previous Studies

Studies in transportation and retail activities can be classified in three groups of basic research: the impact of transportation services on the structure and spatial organization of urban retail activities, shopping trip demand and retail locations, and dynamic properties of urban retail activities (Inventory of previous research is shown in Figure 2).

1) Impact of transportation services

The early work of Garrison (1959) and Horwood (1959) pioneered the study of the effects of new highway services on the location of retail business. The study of Marysville, Washington, (Garrison, 1959) found that the pattern of retail locations changed significantly after the construction of the Interstate 5 freeway. Stores were positioned close to freeway access points to take advantage of the service provided by the facility. A study of urban highway plans in the 1950s suggested that both radial routes and ring roads would shift demand for development from one sector of the city to another without any net economic benefits to the city at large (Horwood, 1959).
Related studies by Berry (1967), Potter (1982), Morrill (1987), and Berry and Parr (1988) examined whether intra-urban locations of retail and wholesale activities (such as those treated by Vance, 1970) conform to the basic tenets of central place theory. Berry (1967) examined the hierarchy of retail locations and retail center sizes. His later work (1988) elaborates on the structural arrangement of retail centers with respect to center size and location. Potter’s extensive study (1982) of urban retailing structure in Stockport, England, and Morrill’s study (1987) of the structure of shopping in Seattle further confirm the hierarchical organization of retail centers.
2) **Shopping trip demand models**

Shopping trip demand models generally fall into three categories: families of activity interaction models (Reilly, 1931; Voorhees, et al., 1955; Huff, 1959; Applebaum, 1968; Wilson, 1974; Dawson, 1980; Hallefjord, 1986; Wills, 1986), logit or probit type choice models (Bucklin, 1967; Ben-Akiva, 1985; Dows and McCulloch, 1974; Brand, 1976; Sobel, 1980; Vickerman and Barmby, 1984; Hazel, 1988), and intervening opportunity models (Curry, 1970). These models are used in cross-section static fashion. Studies using time-series data and dynamic ideas are sparse.

(a) **Activity interaction models:** In the early 1930s, Reilly made the first effort to develop a model for estimating shopping travel demand. His model, called the "Law of Retail Gravitation," was widely applied in practice and later modified and refined by many researchers. Voorhees' method (1955) predicts the destination and frequency of shopping trips based on Reilly’s gravity model. As in the gravity model, his method relies on travel time as the distance measure and the floor area of retail space as the measurement of facility size and attractiveness. From surveys of several American cities, Voorhees concluded that "the number of shopping trips generated from any residential area is directly related to automobile ownership" and "the movement of shoppers in an urban area is largely controlled by the competitive relationships of shopping areas."

Following Voorhees' work, Huff (1959) transformed Reilly’s deterministic model to a probabilistic model with spatial interaction parameters. Applebaum (1968) subsequently attempted to estimate food store trade areas using the gravity model, but he found estimation extremely difficult, especially in metropolitan areas. The difficulty arose from the complex forms of competition among stores where consumer driving times were barely distinguishable, even though distances to stores varied significantly.

The activity interaction models have been scrutinized by many researchers, including Dawson (1980), for their practical application to urban shopping trip estimates. But the models do have shortcomings. Activity interaction models have very weak theoretical bases, although there have been attempts to improve these models, especially by Niedercom and Bechdolt (1969) using utility maximization principles, by Harris (1964) using an intervening opportunities approach, and by Wilson (1967) using an entropy maximizing approach. These models are limited to short-term applications because they are designed for a static equilibrium without consideration of the dynamic of change. Moreover, models
deal only with the supply side of interaction. Many factors, such as consumer responses to the size and accessibility of retail centers, are excluded in the models. They do not have standardized elements which can respond to changes in travel and retail behavior and are thus limited when extrapolations are made based on existing behavioral patterns. The consensus is that spatial interaction models do not provide a comprehensive framework for the analysis and prediction of retail location because they are allocational in nature (Coelho and Wilson, 1976).

(b) Shopping destination choice models: One of the early experimental studies of the shopping behavior of consumers was performed by Bucklin (1967) for the metropolitan Oakland, California, area. His study showed that traditional choice models cannot effectively define intra-urban trading boundaries because the propensity to visit shopping areas is positively related to income and social standing. However, Daws' (1974) travel diary survey of the Watford area of Hertfordshire, England, suggests that patterns of shopping trip behavior are somewhat regular from week to week. Extensive work was done by Ben-Akiva, et al., on the use of logit models for shopping trip generation estimates, but his work largely treated plausible model formulations.

Vickerman and Barmby (1984) later attempted to add a socio-economic determinant (shopping expenditure) to the shopping location choice model by assuming that destination choices depend on both accessibility and attractiveness of retail locations. They found that increased income has little effect on the level of trip making although expenditures increased per shopping trip, in the case of comparison goods. In shopping for convenience goods, increased income did not matter in either expenditure or level of trip making. In more recent years, Barnard (1987) and Hazel (1988) further developed a trip generation model using a multinomial logit form for food store locations. These models seek to predict the location of food retail destination choices; Barnard and Hazel's works are also directed to plausible model formulations.

(c) Intervening opportunities models: The intervening opportunities models are used as an alternate approach to the gravity model. Stouffer's model (1940), the original intervening opportunities model, assumed the number of trips from an origin is proportional to the opportunities at the destination zone but is inversely proportional to the number of
intervening opportunities (Wilson, 1974). Subsequent studies include Harris (1964, mentioned earlier), Wilson (1967), and others involved in the Chicago Area Transportation Study (Curry, 1970). There has been little literature on this subject. The reasons may be that the models require a calibration technique which is inconvenient to use.

3) Dynamic properties of urban retail activities

Until the late 1970's, the focus of research was on static situations. Lately, a few researchers have attempted to describe non-equilibrium states of complex urban systems by using differential equations or probability theory (Allen, 1981; Beaumont and Clarke, 1981; Allen, et. al., 1981; Harris and Wilson, 1978; Harris, et. al., 1982; Arthur, 1988). Their studies are mostly theoretical and, on the whole, there has been limited experience in using dynamic models for describing the self-organization processes of urban retail systems (Oppenheim, 1986; Wilson, 1987).

Two approaches to land use and transportation studies might be thought of as classical. The first involves normative studies of location -- optimal facility location and transportation cost analysis. Taking this approach, optimal store and market sizes can be examined using efficiency criteria. An example of an optimization problem is minimization of the sum of customer travel and store operating costs. The second approach is choice analysis. Although several studies have developed choice models for transportation modes and trip distribution, little work has been done on consumer choices among food store locations. Store choice studies require origin and destination surveys of patrons' household locations, the frequency of their visits, and the amount of money they typically spend.

To complement available studies and approaches, this paper is broad in scope. The elements of the relationships considered in this study are shown in Figure 3. The underlying assumption is that increases in real income triggered the improvement of transportation services and brought about changes in consumer demand. Increased real income also allowed consumers to purchase more goods in general and encouraged them to rely on a greater use of automobiles. At the same time, improved transportation services enabled retail firms to increase economies of scale and scope, resulting in increases in store size and increases in distances travelled to and from stores within expanded trading areas. The effect of the automobile technology are the transformation of food distribution activities in the scale of stores, mix of products offered, location patterns of food stores and
spatial competition, and mix of firm ownerships such as chains versus independent stores. In this paper, the relationships are analyzed primarily from the supply side point of view, as shown with a dotted line in Figure 3.

Figure 3. Relationships between Transportation Services and Food Retail Activities

5. Consumer Shopping Patterns

Whether consumers altered their shopping habits is an important factor to be considered in analyzing relationships between transportation services and food retailing. Several surveys conducted nationwide indicate that the food consumption and shopping habits of American households have not changed greatly over the past several decades (Yankelovich, Skelly and White, Inc., survey series). One might speculate that the number of store visits would correlate with distance travelled. However, a national survey conducted by the Supermarket Institute from 1971-87 indicated that the frequency of store visits was not directly associated with the distance travelled. Despite the increase in travel distance, frequency of food shopping has remained relatively constant over the past 50 years.
than one half of all shoppers (54 percent) in 1987 still visited supermarkets just once a week. As expected, consumers over the age of 65 tend to visit supermarkets less often than do families with children.

Shopping patterns by day of week and time of day have also remained relatively constant in spite of the increased number of women in the workforce. Consumers generally prefer to shop during the latter part of the week, Thursday through Saturday. Households with one working spouse prefer shopping in the morning and households with two working spouses prefer shopping in the early evening. American households still believe that food shopping is a woman's responsibility. Nearly 70 percent of households surveyed identified the woman as being responsible for food shopping.

Although there is a growing tendency among shoppers to shop at regional discount food stores, 98 percent of grocery shopping is still done weekly at typical supermarkets (Progressive Grocer, 1989). Among supermarket shoppers, 40 percent also patronize convenience stores at least once a week, 30 percent visit specialty food stores weekly, and 14 percent visit other food stores each week. The amount of time spent in supermarkets on each visit has grown slightly as store size has increased. In 1985, the average time spent in supermarkets was about 46 minutes but in 1988 the average time was 50 minutes.

Consistent with the patterns described, not only do consumers spend considerably more for grocery products in supermarkets than in other outlets, the majority of customers are quite loyal to their primary grocery store. A large portion of grocery expenditure (69 percent in 1985; 71 percent in 1989) goes to consumers' primary stores (Progressive Grocer, 1988). Loyalty to primary stores notwithstanding, the national survey shows that many consumers shop at two stores -- 46 percent in 1985 and 47 percent in 1988. Increasingly fewer consumers shop regularly at only one store -- 27 percent in 1985 and 25 percent in 1988.

While expenditures on food items have grown over the years, the per capita quantity of food consumption has not changed greatly (Figure 4a). This may mean that people are consuming higher quality food at higher prices. Consumers are also highly receptive to packaged goods and will pay higher prices for convenience. On the other hand, as disposable personal income has risen, the proportion spent for food items has decreased (Figure 4b). At the same time, food prices have increased at a rate below the inflation level for several decades. Even so, consumers are highly price conscious.
Figure 4a. Food Consumption per Capita
United States, in constant 1982 dollars

Figure 4b. Food and Transportation
Personal Consumption Expenditures
United States

Besides the price of food items, amenities such as the cleanliness of the store, the variety of store items, and the service department are also important to shoppers (Progressive Grocer, 1989).

As the competition with fast food restaurants heightens, many supermarkets, especially large ones, are adding deli cases, in-store bakeries, and additional specialty items to ensure customer loyalty (Progressive Grocer, 1988). To increase productivity, many supermarkets now operate with automated checkouts, personal computers, and specialized receiving systems. Supermarkets now strive more than ever to increase store size and to stock more items to hold an existing market share or to capture a larger market share. Because it is increasingly cheaper to remodel than to build anew, the average age of supermarkets has grown substantially in recent years.

6. Relationships between Store Size and Automobiles

Since the 1920s, automobile transportation has become widespread and food stores have grown to serve larger market areas. The supermarket is a product of innovation in food retailing and of advanced technologies in other sectors of the economy (Muller and Garoian, 1961). The cumulative effects of improved transportation, advanced
communication, and refrigeration have undoubtedly influenced today's food retail supply systems and consumer shopping habits.

As mentioned earlier, the two major stimuli which probably have brought about the increases in store size are the widespread availability of automobiles and the increased demand from consumers for more varied products and choices. Automobiles provided opportunities for stores to reach out to larger market areas. Increased GNP and growth in personal disposable income made it possible to purchase higher quality foods and to demand a greater variety of goods. There has been no marked difference in food consumption per capita in tonnage, but personal expenditure on food items has increased even though the percent of disposable income spent on food items has dropped.

The dynamic of the relationships has an equilibrating character as travel and store characteristics adjust to each other. Over the long term, there is a trend toward ever larger stores and travel distances. Figure 5 presents an example of one relationship, the chronology of change in the store system (measured in median size of new stores) responding to change in the transportation systems (measured in the average number of automobiles per household). In addition to the observed annual values, a straight line relationship is shown.

The relationship is not well represented by the straight line, so it might be helpful to spell out some of the factors involved in the situation. The events and consequences stressed in the literature are expressed succinctly below:

1. Automobiles became available at lower and lower real prices beginning at about 1910. Local and arterial street systems were improved and expanded; urban areas grew rapidly.
2. Home refrigerators enabled middle-class households to purchase larger amounts of food per trip (mid-1920s).
3. One-stop, one-store, self-service shopping became more common (mid-1930s).
4. Store sizes increased (mid-1940s through late 1950s).
5. Improvements continued to be made on city and suburban roads and highways (mid-1950s through mid-1970s). Urban freeways were introduced in the late 1950s and in the 1960s.
6. Greater availability of automobiles and improved road conditions provided easy access to stores. Improved roads allowed consumers to cover greater areas in the same travel time. Thus, consumers were willing to drive longer distances for food shopping.
7. Consumers bought more items per shopping trip and the number of shoppers per store increased. As the sales volume of stores increased (in the 1960s) the marginal cost of store operation decreased. Consequently consumers could get better value for the same price.
8. Larger stores captured a larger market share at the expense of small stores (beginning early 1960s).
9. Competition heightened as trading areas expanded. Enlarged market areas encroached on competitors' trading areas (mid-1960s).
10. Larger stores allowed retailers to increase their productivity, thus offering better prices for similar goods (late 1960s).
11. For efficiency and productivity, chains consolidated their stores and adopted new communication and inventory management techniques. It became increasingly difficult for independent grocers and small chains to stay in business (early 1970s).
12. Large chains acquired sites with good automobile accessibility and expansion capability (1970s). Cheap land in urban neighborhoods became scarce. Thus, the larger supermarkets were built in outlying areas.

Figure 5. Store Size and Automobiles per Household 1940-1987
As noted previously, the hypothesis is that store sizes are directly correlated with automobile use and with improved highways and arterials. To investigate the relationships between transportation services and store size, we used regression. To explain causal relationships, we drew conclusions from observations of historical events. Accessibility to the automobile and the highway system is at issue when store size is considered, so the study examined the relationships between:

1. Store sizes \( (S_s) \) and the average number of automobiles per household \( (V_h) \):
   \[ S_s = f(V_h) \]
2. Store size and the percent of households owning automobiles \( (V_o) \):
   \[ S_s = f(V_o) \]
3. Store size and women drivers as a percent of total drivers \( (W_d) \):
   \[ S_s = f(W_d) \]

As mentioned earlier, women are still the primary shoppers for grocery items. Using data aggregated at the national level, setting store size as the dependent variable and using the transportation measures just listed as independent variables, data were plotted for the years 1940 to 1987. In addition, regressions were made relating store size to transportation variables \( V_h, V_o, \) and \( W_d \). Separate regressions were run for each independent variable because the independent variables are highly correlated.

Some of the regression results were to be expected. Store size increased from the 1930s and the numbers, uses, and users of automobiles also increased. Relatively high correlation coefficients were expected and obtained. However, as Figure 5 shows, the notion that a linear relation describes the process is inappropriate. Technically, the deviations of the observed values of \( S_s \) from the regression line are not identically or independently distributed. At any rate, the plot of the relationship is suggestive of three regimes; unstable, stable, and highly unstable, and those regimes are time related. The values of the variables have increased with time and the positioning of increases is indicated by the years of observations noted in Figure 5.

Automobile ownership has followed a product adoption or diffusion type curve, an S-curve (Figure 6a). If the relation of store size to the availability of the automobile had followed in a direct fashion, then store size would be expected to follow a similar curve.
That hardly seems to be the case (Figure 6b). Instead, the store size curve shows a large variation from the automobile product diffusion type curve. Even though store sizes do not adhere very well to the S-shaped curve for the years 1955 through 1970, one could argue that the overall curve is S-shaped or that there are two S-shaped curves, one running to about 1965 and another beginning at about that time and ending at about today. The latter argument would seem superior, for it is clear that a regression obeying two (S-curves) regimes would fit the data quite well. For that reason, investigations were made of the relations that might be at work.

Looking at regimes in more detail, the plot of store size with respect to time can be thought of as representing three process regimes (Figure 7). The first regime involves the growth of store size from roughly 7,000 to 20,000 square feet. This regime probably began in the early 1930s and continued on until the late 1950s. During the second regime, continuing for about a decade, store size changed little. In the mid 1970s, a new regime emerged, a move toward an even larger scale of store size. The rates of increase in store size during the 1970s and the 1950s are similar.
The availability of the automobile created an opportunity for increased store size and that retailers began to grasp that opportunity during the 1930s when reliable, all-weather vehicles created market niches. Although from a product and service point of view, these larger stores were more than "larger corner stores," the larger stores may be thought of as a scale-up of existing store technologies. After a period of gestation (the second regime), a transformation or new combinations process followed. That is, store operators learned that increased store size enabled them to do new things in new ways. In turn, this energized a second round of store size increases.

The discussion now turns to an overview of historical data bearing on the remarks just made. The strategy followed is that of sorting through variables affecting the dynamic of store size changes.
7. Reasoning with Historical Data

The store size data series begins in 1940 with the post World War II period being characterized by increased store size. At the end of the war, and after several transition years, this phenomenon, caused by increased automobile holdings, accelerated (Figure 8a). Wartime savings, family formation, and other factors created a prosperous housing market, especially in the suburbs; the growth of suburban homes created a high demand for automobiles. In 1946, the American auto industry produced thirty times as many automobiles (2.1 million) as were produced in 1945 (67,532). In 1947, 3.5 million vehicles were on the road and, in 1948, 3.9 million. Consequently, vehicle registration increased by 22 percent (from 30.6 million vehicles in wartime to 37.4 million post-war vehicles) in the late 1940s, and highway travel speed increased by 6 percent annually for the decades following the end of wartime rationing and emergency speed controls (DOT, America’s Highways, 1976).

Only about half of all households owned cars before World War II but nearly 70 percent of households owned a car by 1955, and 80 percent by 1960. Automobile holdings increased sharply around 1948. About five years later, store size began to increase sharply. The simplest explanation for the lag is learning time. It took several years for this opportunity for larger store size to be recognized and acted on. About five years after retailers began to seize the opportunity (about 1957), store size growth leveled off. The trends in population, economic growth (gross national product and expendable income), and in transportation factors, such as improvements of city streets, had less impact on food retail activities than did automobile holdings. The growth curves shown by these variables after the war indicate a monotonic increase in variable levels.

During the second regime new store sizes stabilized at about 20,000 square feet. Stabilization suggests that food stores reached an optimal store size. Interestingly, during this time an extensive highway expansion program was underway. A store trend worth noting is that the number of supermarkets continued to decline.

Changes in population composition and household numbers had some effect on the slowdown of food store expansion in the 1960s. Although the growth rate of population has been relatively constant during the study period, the makeup of age groups has changed significantly over time. In 1960, the youth population under age 25 comprised 45 percent of the total population. Through the early 1970s, the households were smaller
and younger. In the 1970s, a large portion of this population formed new households. These new households needed small appliances and other household goods. The increased number of those in the older population also needed changes in supermarket supplies.

The third regime suggests new growth forces emerged as even larger stores sought locations and markets. The changes in transportation variables (automobile holdings and urban road improvements) during this period suggest that factors other than transportation led to store size growth (Figures 8b). Highway expansion was achieved as improvements were made gradually over several decades, although the most extensive efforts were made following the Highway Act of 1956. By 1970, the Gross National Product in the U.S. came to around one trillion in real current dollars. The disposable income per capita also increased. As the proportion spent on food items decreased, discretionary income could be channeled to luxury living items and higher quality food. This required new product lines and new ways of carrying and presenting a variety of store items.

It is, however, mildly plausible that retail stores were able to expand and transform during this third regime due to improvements in road capacities through geometric design.
and improved traffic control devices. Another factor contributing to store size increase might be the extended service hours. Increasing store capacity by extending service hours could yield a more efficient use of floor space per customer. These aspects of transportation improvements and store operations were not examined in this paper.

8. Summary and Conclusions

The intent of this paper was to examine the effects of transportation services on the scale of food retail distribution activities as determined by store size.

The study suggests that transportation improvements have played a significant role in the food industries and have provided opportunities for food retailing to establish new scale and scope economies over time. In reviewing the historical data on the food industry over the past 50 years, three growth and development regimes were identified. The diffusion curves of transportation technologies suggest how these different regimes were produced with respect to transportation services. They suggest that increased automobile holdings in the 1950s brought scaled-up effects of existing food store technology (first regime). After a period of gestation (second regime in the 1960s), transportation services transformed food retail activities into a new technological regime (third regime). If changes in transportation services and food retail store sizes were simply correlated, store size increases would have followed the automobile diffusion or market penetration curve. Instead, the store size increases showed a large variation from the automobile diffusion curve.

When this research began we assumed that changes in transportation services and food retail distribution activities would be simply correlated. Considerable time-series data were available on transportation and food distribution. Literature that could be applied to retail location studies was available from urban economics and regional science. Interaction between transportation services and food retail distribution activities was presumed to be a straightforward one. Therefore, we assumed that the findings of the study could be generalized, and based on the findings, models could be developed to assist urban transportation planning.

While the above was true to some extent, it was found that the relations were not that simple. Transportation services had far-reaching and complex impacts on food retail distribution activities. Continued change creates complications and difficulties in
generalizing our findings. The study opened up puzzles, and it suggests that continued work needs to be done to understand the relationships between transportation series and the distribution patterns of urban activities.

In this paper, we explored a limited number of topics, and research was restricted to transportation and food retail activities. The study suggests that highway availability and automobile holdings have now stabilized. But food store behavior has not stabilized. It is still evolving, with continually larger store sizes. Because this relationship is not straightforward, it is difficult to generalize as to how change occurs in retail distribution activities. The cumulative effects of new technology in transportation, product specialization, communication (television and other advertising channels) and refrigeration on food retail distribution were not discussed in this paper. Studies of other sectors in relation to transportation improvements may help provide answers to the growth and development puzzle.

Acknowledgement
This work was supported by the University of California Transportation Center and the Institute of Transportation Studies at the University of California, Berkeley. The author wishes to acknowledge Professors William Garrison, Randolph Hall, and Mark Hansen for their contributions to and advice on this research.
References


Food Marketing Institute, Facts About New Supermarkets, Annual Reports, Chicago, 1953-87.


