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Framework for the Analysis of Grocery Teleshopping

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Household replenishment and consumer direct—two closely related and developing forms of teleshopping that are emerging as strategies within the broader realm of supply chain management—could have an impact on behavior related to grocery shopping trips, as well as on commercial development. In concept, household replenishment and consumer direct are the businesses of delivering groceries to households through various means. These grocery delivery systems have the potential to change household activity behavior, which could result in numerous changes throughout the transportation network. An examination of the relevant issues surrounding implementation of household replenishment and consumer direct, and an analysis of their potential impact on transportation systems planning, are provided. A conceptual framework for modeling changes in business and household behavior is also offered.

Supply chain management is a major trend sweeping the business world. At its root it involves the examination of all aspects of the supply chain by businesses in an effort to decrease total costs while simultaneously increasing product quality and customer service (*1–3*). The total costs of transportation, warehousing, purchasing, manufacturing, marketing, design, business partnerships and alliances, and the relationships and trade-offs between them are all considered. The analysis extends to all business partners up and down the supply chain.

A number of papers and books have been written on supply chain management; they provide numerous descriptions and examples of strategies employed by companies that embrace the concept. Many of the strategies associated with supply chain management could have numerous significant impacts on truck and passenger vehicle traffic. Household replenishment and consumer direct were chosen from among these strategies to provide an in-depth exploration and conceptual analysis of how supply chain management may impact transportation.

While household replenishment and consumer direct are different forms of the same basic concept—delivering groceries to households—they vary in their implementation and complexity. Consumer direct is a means by which consumers may electronically order and pay for groceries to be delivered in the near future (*4, 5*). Household replenishment is a service provided by a company to restock the household's pantry without the customer's involvement, freeing the customer from the burden of shopping (*3, 6*).

Together, consumer direct and household replenishment have the potential to alter the behavior of both consumers and suppliers. Depending on how these services are provided and how many people use them, trip rates, traffic volumes, vehicle miles traveled, and the spatio-temporal distribution of traffic could all be affected. In the long term, household replenishment and consumer direct could even affect land use.

To explore these concepts, several topics are discussed as follows: (*a*) a synopsis of the most recent research on market penetration of household replenishment and consumer direct is presented; (*b*) that research is then compared against past research on the adoption of various forms of teletravel; (*c*) the possible effects of household replenishment and consumer direct on the traffic network are discussed; (*d*) a detailed description of the methods used in providing household replenishment and consumer direct services is provided, including a discussion of the various factors most likely to influence both shoppers and businesses; (*e*) a methodology is suggested for modeling consumer and business behavior relevant to household shopping and consumer direct; and (*f*) in conclusion, a brief synopsis and suggested courses for future action and research are offered.

MARKET PENETRATION

Consumer direct is a growing industry in the United States. In some market areas, roughly 3 percent of the grocery market has already been penetrated by consumer direct and household replenishment companies (*7*). An extensive study involving interviews with 1,800 consumers nationwide was performed by the Consumer Direct Cooperative, a consortium of 31 companies and organizations led by Andersen Consulting and including members such as Coca-Cola and Nabisco. The study estimated that consumer direct shopping will capture 8 to 12 percent of the grocery business in major markets by 2007 (*4*, *8–10*). This translates to a $60 billion to $85 billion industry. The study also suggests that 50 percent of the average household's 17 monthly shopping trips to grocery stores and related outlets will eventually be replaced by consumer direct, and that roughly two-thirds of all grocery expenditures and 80 percent of all primary grocery shopping trips will eventually be captured by consumer direct. The study's findings are consistent with a separate article, which predicts that 50 percent of all shopping will be performed over the Internet by 2010 (*3*). This is in stark contrast to past studies performed on consumer attitudes toward teleshopping.

The concept of teleshopping has been explored in the past, along with telecommuting and other forms of travel substitution through telecommunications (generally referred to as *teletravel*). Most studies have suggested teleshopping will not find widespread use and will therefore have a negligible impact upon traffic (*11–13*). Several reasons have been offered to support this theory. Salomon conjectured that the shopping experience is a social and recreational one and therefore cannot be replaced by teleshopping (*12*). Koppelman et al. describe shopping as a two-stage process of information gathering and actual purchase; they suggest that teleshopping is unable to

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supplant other means of information gathering and will therefore not be chosen as the means of purchase (*13*). Finally, Gould reported that delivery requires customers to wait at home and would therefore not be an attractive alternative (*11*). These concerns, while valid in many instances of teleshopping, may break down when applied to household replenishment and consumer direct.

The concept of shopping as a social and recreational experience that requires extensive information gathering activities largely breaks down for grocery shopping. Grocery shopping is generally considered to be an undesirable activity, a chore, a repetitive task, an obligatory and undesired maintenance activity, but not an enjoyable or social one (*4*, *9*, *14*). In a study of time use, it was found that grocery shopping rated lower in terms of desirability than other forms of shopping (*15*). Furthermore, because of the repetitive nature of grocery shopping and the fact that most grocery items are commodities, the amount of information that needs to be gathered for grocery shopping is small. It should also be noted that the Internet's hypertext and pictures, as well as modems with higher speeds, may overcome the inadequacies in information provision that characterized teleshopping perceptions in earlier shopping choice studies. Likewise, computers have become easier to use, leading to significant increases in computer ownership and Internet use. Finally, in emerging household replenishment and consumer direct services, consumers are not always required to stay at home to receive the delivery.

EFFECTS ON TRAFFIC

Four possible interactions between telecommunications and travel have been suggested in the literature (*14*, *16*). Substitution, described as a first-order interaction, refers to telecommunication replacing travel. Two second-order, or complementary, interactions are described as enhancement (telecommunication increasing travel) and operational efficiency (telecommunication making travel more efficient). Finally, a higher-order interaction postulates that telecommunication will in the long term effect land use patterns. First-order interactions are discussed in detail in this section, while potential second-order interactions and land use interactions are summarized. A more detailed description of second-order interactions and land use effects may be found in Marker and Goulias (*17*). A summary of first-order interactions, accompanied by sample calculations, is shown in Table 1.

Important to note is that while household replenishment and consumer direct could significantly alter the grocery business and grocery shopping behavior, their overall affects on traffic may still be minor. According to an analysis of the 1995 Nationwide Personal Transportation Survey, all forms of shopping trips totaled still account for fewer vehicle trips than commuting trips in the average American household—501 shopping trips annually compared to 553 commuting trips annually (*18*). Even considering that the percentage of trips devoted to shopping is increasing, it seems unlikely that grocery shopping will become a dominant influence on traffic patterns. Without activity behavior data that breaks shopping into more detailed categories, however, the true importance of grocery shopping cannot be ascertained.

First-Order Interactions

When examining only the number of trips made, grocery delivery should have a first-order replacement effect (*12*, *14*, *16*). When shopping trips made by passenger vehicles are replaced by delivery trucks making a chain of deliveries, a net reduction in actual trips can be expected in the most simple case, not considering load consolidation or truck capacity. Assuming there are n shoppers, shoppers require a maximum of $2n$ trips—each shopper making one trip to the store and one back to their residence. The delivery truck, however, requires only $n + 1$ trips—one to the first customer, one to the next customer, and so on to the nth customer, plus one additional trip back to the store or warehouse for reloading.

When truck capacity is considered, where a truck can no longer make n deliveries in one chain, a reduction in efficiency is observed because the truck must return to its origin periodically to reload and start another delivery chain. If a truck can carry only m deliveries, it will have to make n/m delivery chains of $m + 1$ trips, resulting in $(n/m) \cdot (m + 1)$ trips, or $n + n/m$ trips. Comparing $2n$ with $n + n/m$, so long as m is greater than 1, even if the delivery is made by a store employee in a passenger vehicle, there is a likely net reduction in trips made.

Truck capacity, however, is not the only driver of the number of delivery chains required. Trucks can also make delivery chains when not fully loaded in order to service customers within an acceptable time frame. This is especially likely when delivery customer density is low. If d is the average number of deliveries a truck carries, where $d < m$, it can be seen that the trucks require n/d delivery chains of $d + 1$ trips, resulting in $n + n/d$ trips. If one uses an average truck utilization factor (f) where $f = d/m$, multiplying m by f in the equations from the previous paragraph, $n + n/(f \times m)$ produce the same results.

If trucks are fully loaded for deliveries, truck weight and volume constraints will determine what an average m is for a given truck

TABLE 1 First-Order Trip-Making Interactions

Factor	Equation	Assumed Variable Values	Number of Trips	Reduction in Trips	
				Unchained	Chained
Shopping Trips	2n	n = 100 (number of shopping actions)	200	(NA)	(NA)
Chained Shopping Trips	n + n * (1 - c)	c = 0.2 (percent of trips chained)	180	(NA)	(NA)
Delivery	n + 1	n = 100 (as above)	101	99	79
Capacitated Delivery	n + n / m	m = 10 (truck capacity)	110	90	70
Unutilized Capacity	n + n / (m * f)	f = 0.8 (average truck utilization)	112.5	87.5	67.5

(NA) No reduction in trips.

type, while time constraints such as loading time, delivery time, and travel time would determine the number of delivery chains a single truck could complete in 1 day. Unfortunately, actual operations of delivery trucks have not received a great deal of attention in literature concerning grocery delivery.

Load Consolidation

If a third-party logistics company (TPL) is operating delivery services for multiple businesses within a region, there may be opportunity for a further reduction in trips. Consider a household that buys items from multiple grocery stores. Even if each trip is replaced by a truck delivery chain, that household will still generate multiple trips, one delivery from each store. A TPL would be able to consolidate those deliveries into a single trip, further reducing the number of total trips made. Consolidation could also reduce the number of less-than-truck-load truck trips made, increasing delivery efficiency. Finally, consolidation allows opportunity for greater efficiency in delivery routing. The total potential effect of consolidation is unknown because it is a function of the number of stores the service is provided for, number of delivery customers for each store, number of delivery customers who teleshop from multiple stores using the TPL service, locations of stores and customers, and temporal distribution of orders.

Trip Chaining

A factor that must be considered when estimating replacement of shopping trips is trip chaining (*14*). If shopping trips are chained, the number of trips by which to reduce $2n$ is not accurate, as shopping trips could be part of various trip chains, including shopping store-to-store or stopping at a store on the way to work. As other trips of each chain would still be made, only one trip is eliminated instead of two. Consider a three-trip chain, home to work to store to home. If the shopping trip is eliminated, the home-to-work and work-to-home trips would still be made, resulting in only one trip being eliminated. To show this, instead of $2n$ shopping trips being replaced, there are $n + n \cdot (1 - c)$ shopping trips, with c the percentage of shopping trips made that are part of a trip chain. At worst case, if all shopping trips are part of trip chains, the total number of trips eliminated will be only n. The potential therefore exists for a net increase in the number of trips made.

A study of shopping trip generation in Toronto found that only 60 percent of all shopping trips are home-based, indicating the number of chained trips could be significant (*19*). Unfortunately, type of shopping was not addressed in the study, so the percentage of chained grocery shopping trips cannot be determined. To accurately quantify this factor, the percentage of chained grocery shopping trips likely to be replaced by truck delivery would have to be estimated along with truck capacity/utilization and the resulting number of required delivery chains. The issue is further complicated by the possibility of chains of shopping trips one store to the next, with an unknown number of trips in each chain replaced by truck delivery.

Vehicle Miles Traveled

Regardless of number of trips made, truck trip chains—determined by current truck route optimization techniques—should reduce the vehicle miles traveled (VMT) that are directly attributed to shopping (*12*). Load consolidation and truck capacity/utilization become important in this consideration as greater truck capacity and density of delivery locations increase the opportunity for reducing vehicle miles traveled as well as total trips made. The exact reduction in VMT achieved by replacing passenger vehicle trips to the store and back with truck delivery chains, however, is unknown. A geographic study of residential and grocery shopping locations, average trip lengths, and average delivery chain lengths (under various assumptions concerning truck capacity/utilization, market penetration, dispersion of residences using delivery, etc.) could be used to form a rough estimate of possible VMT savings. VMT of shifts in time use and associated travel demand from second-order interactions must be considered when evaluating the net change in VMT.

Second-Order Interactions

Replacement of shopping trips may be offset by various enhancement interactions. Convenience of delivery could lead to an undesirable increase in shopping trip frequency. Conversely, if cost of delivery is high enough, customers might batch grocery shopping to reduce the number of deliveries required. The average distance of shopping trips could increase as consumers would be able to order deliveries from more distant sources than they would be willing to shop at in person. Assuming teleshopping frees time once spent in stores for other uses, the manifestation of induced travel could lead to an increase in passenger vehicle trips. Finally, when considering truck trips in terms of operational effects on traffic flow, even a net reduction of trips could still lead to an increase in effective traffic volume. However, delivery could improve the operational efficiency of traffic by changing the spatial and temporal patterns of traffic, possibly smoothing peak demand periods and locations. Assuming a net reduction of effective traffic volumes, latent demand could become a factor, reducing or eliminating gains in traffic conditions.

Effects on Land Use

It has been suggested that the replacement of travel by telecommunications would allow people to locate even farther away from activity centers because of the decreased need to travel to them (*14*, *16*). To date, telecommuting studies have not shown a significant increase in dispersion, leading to the hypothesis that household replenishment and consumer direct are also unlikely to increase dispersion because they would replace fewer trips than telecommuting would (*20*). However, the possible interaction between various forms of teletravel could result in significant cumulative effects. While one who does not need to shop in town but has to work there or vice versa might not be sufficiently motivated to relocate, one who teleshops and telecommutes might have a greater liberty to move and might therefore choose to do so.

That consumer direct and household replenishment may cause major shifts in business development patterns must also be considered. Over time, "big box" developments could become obsolete, as a 4 percent loss of market share would reduce profits by roughly 50 percent, and an 8 percent loss of market share would render conventional supermarkets unprofitable (*4*). As the consumer direct and household replenishment penetrate the grocery market, grocery retailers will be faced with a number of choices. Three responses have been postulated: abandon retail stores and deliver from warehouses, abandon large retail stores and adopt a boutique strategy, and maintain large retail stores and compete on price (*9*, *10*). The first two response strategies could lead to significant changes in commercial development.

FORMS OF DELIVERY

Seven key factors defining the logistics of delivery were identified for the various forms, or models, of delivery that businesses might adopt. These variables are as follows:

1. Business type,
2. Scope of services,
3. Ordering,
4. Automation,
5. Delivery reception,
6. Delivery mode, and
7. Pick location.

A synopsis of these variables is provided in Table 2. A more detailed discussion of these factors and how they could have an impact on the decisions of businesses and consumers may be found in Marker and Goulias (*17*).

Business Type

A variety of different businesses may choose to enter the delivery market. Existing grocery chains, Internet startups, and manufacturers may all become active in home delivery (*4*, *21*). Profitability and feasibility are key concerns for businesses when considering the delivery market. Other important considerations include defending market share, not falling behind, and gaining control of consumer purchasing information. For consumers, brand name recognition and trust may have the most influence in determining acceptance and choice of delivery services (*7*, *8*).

Scope of Services

Businesses engaged in delivery may do so alone or with varying degrees of cooperation and partnership, leading to differences in scope among delivery services offered. The scope may be isolated (delivery from a single store or manufacturer), consolidated (delivery from multiple stores or manufacturers, including different industries), and bundled (items and services—such as house cleaning, for example—delivered together) (*3*, *5*, *8*). Greater scope requires greater organization—including strategic alliances among businesses and TPL—and could be difficult to achieve or manage. Businesses may also be reluctant to consolidate deliveries and services with competitors. However, consolidation of deliveries holds the possibility of monetary savings through increased efficiency and economies of scale. Customers may value the increased variety of options and services offered by consolidated and bundled delivery, especially those who regularly shop at multiple grocery stores (*9*).

TABLE 2 Key Variables of Delivery

	Customer Issues	Business Issues
Business type		
Grocery chain	name recognition	defend market share
Internet startup	trust	scale, profitability
Manufacturer	name recognition	complexity
Ordering		
Telephone	time, catalogue	cost of labor, time
Facsimile	time, catalogue, access to fax	cost of labor, time
Internet	access to Internet, trust, complexity	expertise, startup, cost, maintenance
Delivery reception		
Personal	time waiting at home	delivery timing
Infrastructural	security, cost	box management
Residential	privacy, trust	key management
Pick location		
Store pick	cost	scale, cost, efficiency
Warehouse pick	cost	scale, cost, efficiency, location
Scope of services		
Isolated	range of items	efficiency
Consolidated	range of stores	efficiency, 3pl, competition
Bundled	range of services	complexity, alliances, 3pl
Automation		
Minimal	time	order reception
Moderate	time, privacy	information management
Complete	time, privacy, control, trust	forecasting, pattern recognition
Delivery mode		
Passenger vehicle, van/delivery truck, single-unit truck	disturbance caused by delivery	market, size, efficiency, cost, expertise
Express mail	brand recognition	market type, cost
TPL	brand recognition, disturbance	bundling, expertise, cost

Ordering

In systems where customers are required to initiate orders, businesses offer several means by which to send them. Generally customers may order by telephone, fax, or the Internet (*4*). Telephone and fax orders are far less cost-efficient, but Internet ordering systems require greater technical expertise and startup costs (*10*). Telephone and fax systems also require additional time to prepare and distribute catalogues. This must be balanced against the cost of computer ownership and Internet use, as well as computer familiarity and trust in the security and reliability of online transactions (*9*).

Automation

Various degrees of automation may be offered in the order-generation process. Automation levels may range from minimal (calling the business with a list of item numbers and quantities or shopping over the Internet by picking items desired for delivery) to moderate (shopping over the Internet by altering an automatically generated suggested list) to complete (automatic order generation performed by the business) (*3*, *6*, *10*, *22*). For any automation level, businesses have to maintain records of each household's past purchasing history and brand preferences in order to develop an expert system or forecast model for accurately predicting consumer needs (*22*). While greater automation leads to less shopping time spent by the customer, it also requires the sacrifice of privacy and control (*7*, *9*).

Delivery Reception

Businesses and consumers have several options for completing the final transfer of goods. Forms of delivery reception range from personal (a member of the household at home to receive the delivery) to infrastructural (deliverer placing items into a secured and probably refrigerated box or receptacle on the household's property or inside the house itself) to residential (deliverer placing items in the household's refrigerator, kitchen, and pantry) (*3*, *5*). Personal delivery limits when delivery may occur, infrastructural delivery requires businesses to provide and manage delivery box arrangements with customers, and residential delivery requires managing access to the house. Only personal delivery ties the customer to the home, yet infrastructural delivery will most likely require some initial investment, or deposit, for the delivery box; and residential delivery requires both trust and a loss of privacy (*9*).

Delivery Mode

Various modes may be used for delivery. Businesses may use passenger vehicles (similar to a pizza delivery service), delivery vans or trucks (like those of UPS, FedEx, or floral delivery services), or heavier trucks. Businesses may also choose to use express mail delivery services or depend upon a TPL to handle all delivery activities (*3*, *4*, *21*). The cost and efficiency of delivery services, market size, and whether a business has the expertise to operate such a service all affect business attitudes toward which delivery mode to employ. Other factors, such as whether the business sells perishable items and whether other services will be offered, may also influence business delivery mode decisions. Customer concerns can also play a role, as customers or their neighbors might disapprove of the use of larger trucks in their neighborhoods.

Pick Location

Ordered items picked out of storage for loading onto the delivery truck is yet another logistical issue. Businesses may choose to pick items from an existing store or from a warehouse (*4*, *5*, *8*). Warehouse pick systems are more efficient and more cost-effective to build, maintain, and operate (*5*, *7*). While the method of picking orders will mean little, directly, to customers, it could indirectly influence customers depending on their sensitivity to cost (*9*).

MODELING METHODOLOGY

Past Experiences in Modeling Teletravel

Transportation researchers have already made several attempts to model the complementary and substitutive elements between travel and telecommunication. While only some of these aspects apply specifically to teleshopping, all are instructive as examples for possible means of study. Stated preference discrete choice models have been used for modeling both telecommuting and teleshopping behavior (*13*, *23*, *24*). It should be noted that the survey data and methodology of Mokhtarian and Salomon (*24*) extend beyond the usual stated preference model, thereby blurring the distinction between stated and revealed preference discrete choice models. Although the usefulness of stated preference studies has recently been questioned because of their relative inaccuracy due primarily to differences between stated and revealed preferences, their methods and findings are nevertheless useful and noteworthy. Other methods involve simple trend analysis [Gould (*11*)], longitudinal studies of activity diaries [Pendyala et al. (*25*)], and the synthetic metaanalytic assembly of other studies for comprehensive modeling [performed by Mokhtarian (*26*)].

Because teleshopping involves the joint actions of businesses deciding to provide delivery services and customers deciding to use them, it is appropriate to model these choices together to capturing their relationships. Several studies have been performed to model telecommuting in this manner, including stated preference discrete choice models by Bernardino and Ben-Akiva (*27*), Yen and Mahmassani (*28*), and Brewer and Hensher (*29*). In addition, the relationship between telecommunications and travel is mediated by many factors, as illustrated in U.S. Department of Energy's *Energy, Emissions, and Social Consequences of Telecommuting* (*30*, p. 53). Model frameworks accounting for the various business and consumer actions involved in delivery are also starting to appear, as in Sullivan et al. (*31*). These studies may be used as blueprints for modeling the use and development of grocery delivery services.

Person-Based Models

To predict the effect of household replenishment and consumer direct on transportation, it will be necessary to create models for how individuals will behave and react toward various grocery delivery services. For services operating exclusively through the Internet, computer ownership and Internet usage in households will have to be modeled. Within the limitations of delivery types available to individuals, mode choice models will need to be developed to predict which means of shopping will be used. For those who choose to use ordering and delivery services (moderate or complete automation and infrastructural or residential delivery) that free up time for other activities, activity models for task scheduling, activity participation, and

activity/trip chaining are required to model changes in travel demand. In the long term, the influence of grocery delivery on residential relocation may also need to be examined. A summary of proposed person and business models is presented in Table 3.

Computer and Internet Usage

Similar to vehicle ownership and its relationship to travel, computer ownership and Internet usage are the gate keepers of household replenishment and consumer direct. While other forms of ordering are available, the use of the Internet to send and receive orders is quickly becoming the dominant practice. Thus households without Internet capabilities will not be participants in grocery delivery services, or at least will use services different from those catering to households connected to the Internet. It is therefore important to know both the number and distribution of households connected to the Internet in the future form spatial, attitudinal, and demographic perspectives.

While computer industry projections and trend analysis may be sufficient for gross estimates of Internet usage in the future, other options are available. Surveys could be used to determine which characteristics of households and individuals are related to Internet usage. Revealed choice surveys of households and individuals just connected to the Internet could be useful to model this choice, as could longitudinal studies of households to study stages in market penetration and uses of the Internet. In these surveys, economic and demographic characteristics—particularly income, education, and age—in addition to technology usage attitudes would appear appropriate for study as possible covariates with Internet usage.

Shopping Mode Choice

Once household characteristics (including Internet usage) and the forms of grocery delivery available to the region are known, shopping mode choice models may be developed. Although revealed preference models are preferred, until the grocery delivery market has matured such studies are cannot be relied on. Therefore hypothetical scenarios surveys and some form of discrete choice models must be used. Again, the interactive nature of shopping mode choice and business sales strategy must be accounted for.

In performing the study, several key elements must be included. In addition to survey questions on demographic characteristics and current shopping practices, attitudinal characteristics must be measured. By rating on an ordinal scale, questions must determine how shoppers feel about such factors as service, price, convenience, business trustworthiness, information privacy and control, brand recognition, computer usage, and computer purchasing. Questions must then be provided to allow respondents to express their likely choice of mode usage by rating the various modes on a scale. All the various modes of grocery shopping (supermarket, convenience store, etc.), in addition to the various means by which grocery delivery may be accomplished, should be included in this section. From these data, an attempt may be made to model mode choice in terms of social and demographic data as well as attitudinal characteristics.

Time Allocation

To quantify the effects of time displacement, a before-and-after longitudinal study of time use and activity patterns for individuals in households using grocery delivery services appears to be the best choice. Similar studies have already been performed to measure the effects of telecommuting on an activity basis in time and space (*25*).

In a partnership formed with a grocery delivery service, potential subscribers to the service could be identified and contacted. Joint advertisement for the study and for the delivery service, as well as some compensation for survey participants and possibly for the delivery business, may be necessary to ensure a large enough sample size, adequate respondent participation, and business cooperation. A second group of people not intending to use the delivery service must also be identified and contacted for study purposes to serve as a control group. Once the participant study group and control group are identified, they must be surveyed before study participants use the delivery service. A survey consisting of a detailed activity diary and questions related to respondent demographics would be necessary. Attitudinal factors could also be collected for use in other data analysis. After data from this first survey are collected and a sufficient amount of time for grocery delivery service usage among the study group has passed, the same survey may be readministered to both groups. Detailed longitudinal spatial-temporal analysis of the study and control groups, including daily (if applicable) diary entries and waves, will then be necessary to determine if significant changes in activity behavior are induced by the use of the delivery service in the study group.

TABLE 3 Summary of Proposed Behavioral Models

Model	Data Collection	Quantitative Data	Attitudinal Data	Statistical Model
Internet Usage	Revealed Preference Survey	Sociodemographic	Technology Usage	Discrete Choice
Shopping Mode	Stated Preference Survey	Sociodemographic	Store Shopping and Computer Shopping	Discrete Choice
Time Allocation	Longitudinal Travel Diary, Survey	Sociodemographic, Activity Diary	Intentions to Use Time Differently	Longitudinal Analysis, Spatio-Temporal Analysis
Competition Strategy	Stated Preference Survey	Business Financial Data, Business Demographics	Future Trends and Competition, Customers' Desires	Discrete Choice
Delivery Mode	Stated Preference Survey	Business Financial Data, Business Demographics	Future Trends and Competition, Customers' Desires	Discrete Choice

Business Adoption Models

An noted earlier, characteristics of available grocery delivery services will impact individual behavior. For forecasting purposes it will be necessary to predict what types of delivery services will be available and which businesses will be offering them. Toward this end, business behavior should be modeled—perhaps using techniques similar to that for individuals. The overall strategy of businesses—whether, for example, to compete on delivery and other convenience services or on price and selection, or whether to provide enjoyable boutique-like shopping experiences—will need to be predicted. For those businesses choosing to compete through delivery, the characteristics of their delivery service will need to be predicted.

Competition Strategy Choice

Many factors, not all of which can be quantified, influence competitive strategy-based business decisions. However, businesses generally act rationally, and so it should be possible to model businesses as rational decision makers using techniques already developed within transportation planning. It would therefore seem appropriate to use discrete choice models for business behavior based upon data from surveys using hypothetical scenarios. Businesses may be quantitatively measured by such factors as fixed and current assets; sales; cost of goods sold; expenses; return on net worth; number, size, and location of facilities; and number of employees. These data could provide some indication as to how efficient and flexible a business is and how easily it will change. Personal preferences of management may be captured by attitudinal surveys, perhaps focusing upon their beliefs concerning such areas such as Internet commerce optimism, competition from new delivery startups, familiarity with logistics network optimization, ability to quickly catch up with new trends, customer service, and enjoyment of the shopping experience. Again, some form of interaction model between business and consumer decisions is also required.

Delivery Method Choice

For businesses choosing to pursue grocery delivery, the precise means, or methods, must be predicted. As seen above, a wide variety of methods are available. Again, data from revealed preference studies, responses to hypothetical scenarios, and attitudinal measures could be necessary to predict business decision making behavior. In particular, the physical infrastructure and resources the business already has in place—particularly stores, warehouses, private fleets, and in-house optimization and logistics expertise—seem likely to play a major role in shaping its delivery service. Again, competing services may have an effect, as will decision maker perceptions pertaining to customer desires. Attitudes concerning the use of TPL and business partnerships could also have a major impact on the decisions of businesses. Again, some form of discrete choice modeling will be needed to model these choices. Care must be taken to capture the relationship between the various delivery factors, as each decision could impact the others.

CONCLUSIONS

Household replenishment and consumer direct appear to be viable phenomena, developing channels for retail grocery distribution and offering the potential to radically change the grocery business. Potential changes in the grocery business may have a strong effect on traffic resulting from changing grocery shopping trip-making behavior that can potentially alter (*a*) activity patterns, (*b*) the mix of vehicles in traffic, and (*c*) the spatial and temporal distribution of traffic. The exact nature and magnitude of these changes are currently unknown yet certainly hold the potential to impair traffic flow. While grocery shopping generates only a small portion of all traffic, its potential changes should nevertheless be studied and understood.

A great deal of study will be required to accurately forecast the net effect on traffic. Models must be developed to forecast grocery delivery service usage by households. This will require modeling of household Internet usage as well as future business actions and delivery services offered by different grocery industries. Furthermore, as household replenishment and consumer direct develop, studies should be undertaken to measure their effects on the traffic network. Time use and activity-based travel analyses may be required to determine (*a*) how the time freed from grocery shopping changes will be used, (*b*) whether grocery delivery will create more travel, and (*c*) whether grocery delivery will change activity patterns spatially or temporally. Analytical studies may be needed to determine the traffic network effects of delivery services in terms of trip rates, VMT, and traffic volumes, as well as to quantify the effect of trip chaining and load consolidation. These studies must be conducted soon if they are to be included in current long-range transportation planning and traffic forecasting efforts.

Finally, some attention should be given to transportation policy that could affect the development, adoption, and practice of household replenishment and consumer direct. If the cumulative impact of household replenishment and consumer direct is negative, an examination of transportation and land use policy, as well as a determination of available methods and tools and how they could be used to shape or redirect this business trend, would also be important.

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