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**CARLINK: A SMART CARSHARING SYSTEM—
A STUDY OF BEHAVIORAL ADAPTATION**

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ABSTRACT

Most trips in U.S. metropolitan regions are drive-alone car trips, an expensive and inefficient transportation form. A more efficient, but often less convenient, system allows drivers to share cars. Carsharing organizations are becoming common throughout Europe and North America. Shared-use vehicles offer a modal alternative that can make metropolitan regions more livable.

A shared-use system aims to reduce traffic by reducing the number of cars needed by households and encouraging commuters to walk, bike, and use transit, at least for part of their trips. Further, carsharing could help air quality by incorporating low-emission vehicles into shared-use fleets, further reducing traffic and vehicle miles traveled. For commuters, shared-use vehicles could offer a low-cost, low-hassle alternative to private vehicles.

This paper describes the CarLink study approach; presents market results from a longitudinal survey on the CarLink concept, conducted in 1998; and describes an early CarLink adopter profile for the East San Francisco Bay region. This study found that willingness to use CarLink was dependent on the amount and type of exposure. Specifically, participants who read only a CarLink brochure lost interest over time, while nearly 78% of those who read a brochure, watched a video, and participated in a drive clinic declared they would use CarLink.

Key Words: Carsharing, smart technology, market survey.

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The following scenario exemplifies the CarLink model (i.e., a commuter-based carsharing approach). While returning from work, Homeside Users pick up a shared-use vehicle upon arriving at a BART station close to home on their return from work. They drive the CarLink vehicle home, and perhaps to other places during the evening; then drop it off at the station in the morning. After riding BART for their morning commute, Workside Commuters pick up a CarLink vehicle at their destination station, drive a short distance to work. During the day, other workers (i.e., Day Users) employ the CarLink vehicles for tripmaking. At the end of the day, Workside Commuters use the vehicles to return to the BART station for their evening commute.

The field test was deployed in the Dublin/Pleasanton region (or the East San Francisco Bay area) from January to November 1999. Close to 50 program participants used the CarLink vehicles at several locations throughout the demonstration. Using advanced communication and reservation system technologies, vehicles were reserved in advance or rented automatically upon arrival at a CarLink lot.

Program components included: a fleet of twelve 1998 Honda compressed natural gas (CNG) vehicles, a smart key manager (i.e., INVERS' key dispenser and reservation system, called Car-sharing Organization and Communication System (COCOS)); a fleet management system (i.e., INVERS' software system, called COCOS Universal Communication Manager (CUCUM)); and contactless smart cards. Reservations were made via COCOS and an Internet web page operated at the LLNL, and vehicles were monitored using in-vehicle trip diaries. COCOS provided a two-way flow of information between a central control computer and the key manager.

Since carsharing is becoming more common throughout Europe and North America, it is important to understand the response to this emerging alternative in the U.S. This paper describes the CarLink research approach; presents results from the longitudinal survey, conducted in 1998; and describes an early adopter profile for the East San Francisco Bay region.

RESEARCH APPROACH

The CarLink study has three components. First, it included a review of relevant technical and institutional literature. Second, the study employed a longitudinal market survey of 302 individuals in the Bay Area, including focus groups with survey participants (approximately 40 individuals). Third, it included a ten-month field test of the CarLink system. Many field test participants were drawn from the longitudinal market survey. Both the survey and focus groups evaluated participants' willingness to participate and pay for these innovations. Study data were used to create and test a user-centered model of smart carsharing in the Bay Area. This paper focuses on results from the longitudinal survey.

Social learning and social marketing theories were used in this study to explain the processes by which travelers can and might accept or adapt to a transportation innovation. "An innovation is an idea perceived as new by those who are confronted with it as an option in choice...Reaction to an idea is quite different when one encounters it for the first time, than

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More traditional behavioral theorists have advocated a different learning framework. From the behavioral perspective, learning can only occur after an individual performs an activity and experiences its effects (i.e., trial-and-error learning) (Polley and Ven, 1996).

Cognitive theorists offer still another approach. They focus on rational processes and how individuals' preferences change as they undertake a course of action. For instance, once an individual has decided to adopt an innovation they often reinforce this decision and, in turn, become even more positive about this choice (Polley and Ven, 1996). Social learning integrates these perspectives and advocates that "the capacity to learn by observation enables people to acquire large, integrated patterns of behaviors without having to form them gradually by tedious trial and error" (Bandura, 1977, p. 12). Furthermore, social learning theory argues that as individuals gradually decide to adopt a new behavior, they do not implement it instantly. "Among other effects, this slow adaptation allows individuals to manage their anxiety in dealing with the newness of the new behavior" (Andreasen, 1995, p. 268). This study tests the validity of social learning methods in presenting informational media to CarLink study participants.

Social Marketing Theory

Social marketing offers the second important framework relevant to this study. It is the application of concepts and techniques used in business to social behaviors. Social marketing theory has been applied to health, family planning, childcare, and the environment (Kotler and Roberto, 1989; Andreasen, 1995). These techniques can also be applied to transportation, as researchers have done in the CarLink study.

Social marketing begins with targeted customers. It focuses on understanding a target audience's needs, wants, and perceptions and is directed at creating a "social" campaign or product (e.g., anti-smoking campaigns and carsharing) (Andreasen, 1995).

"Social marketing recognizes that influencing behavior—especially behavior change—cannot come about simply by promoting the benefits of some new course of action. Careful attention must be paid to the nature of the behavior to be promoted (the product), the ways in which it will be delivered (the place), and the costs that consumers perceive they will have to pay to undertake it (the price)" (Andreasen, 1995).

Other key features of social marketing include an emphasis on program cost effectiveness; the use of market research to design, pretest, and evaluate new programs; careful market segmentation; and a recognition of competition (e.g., traditional auto ownership and leasing are competition to carsharing).

Not surprisingly, social marketing builds upon other theoretical frameworks, including traditional education, persuasion, social influence, behavior modification, and social learning approaches by focusing on target adopters. Social marketing integrates and improves upon those other approaches by addressing many of their weaknesses and focusing on target adopters.

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ing, Bandura developed the social learning theory approach described earlier (Bandura, 1977). Social marketing builds upon and employs several social learning theory principles. For instance, media (e.g., modeling videos and articles) can be used to stimulate learning by targeted groups, and modeling can help develop an individual's sense that they can perform a new behavior. Nevertheless, the social marketing approach generally prefers in-person training (e.g., drive clinics) to media devices, such as videos and brochures.

Behavioral Adoption Process

Similar to social learning theory, social marketing supports a gradual or dynamic approach to behavioral adoption of a new product, concept, or service. Individuals move through definable stages in adopting a new product (Maibach and Cotton, 1995). There are four stages in Andreassen's social marketing behavioral adoption process: 1) precontemplation, 2) contemplation, 3) action, and 4) maintenance.

Precontemplation is the first stage in the behavioral adoption process during which a target population is introduced to the social product as a possible alternative to their current behavior. The goal of this stage is to generate awareness and interest in the target group. The appropriate tools for this phase are education and media.

In the second phase, contemplation, individuals consider adopting a social product. Individuals first consider the impacts of adopting the social product (e.g., reduced congestion time from using CarLink). This evaluation includes an assessment of the benefits and costs of adoption. Next, they consider what others (e.g., a spouse) might want them to do with respect to the new product. "Behavior change does not take place in a social vacuum. The broader society and its cultural norms and values have important roles to play, as do individual co-workers, friends, and family...Others are almost always involved, playing several roles—providing information about the potential benefits and cost of taking action, serving as role models, and bringing direct pressure to act in the desired way" (Andreassen, 1995, p. 253).

Target users typically evaluate potential satisfaction with a social product on a small subset of attributes. These attributes are important for researchers to understand, particularly in planning product development, communication, and promotion (Kotler and Roberto, 1989). In this study, two household members were invited to participate due to the influence these individuals are likely to have on each other, particularly in response to the CarLink innovation. Then, they contemplate whether or not they can adopt a new behavior. Clearly, if they want to develop an effective marketing program, marketers must document potential influences, including competing alternatives, on the target market's decision to adopt a social product (Andreassen, 1995).

The third stage is action. During this phase, individuals decide whether they can actually produce the new behavior (e.g., join CarLink). Related to this decision, potential customers evaluate the role of the environment (e.g., location of the carsharing system) and other individuals (e.g., a husband or wife) in adopting the new product and/or behavior. In the CarLink market study, the longitudinal survey stopped before the beginning of the action stage. How-

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households, for both the longitudinal survey and field test, included four groups: current BART commuters, individuals who might use BART when carsharing becomes available, people who do not usually take transit but could take it to work, and people who live in neighborhoods with substantial BART ridership. These groups represent potential CarLink participants.

In the longitudinal survey, the final sample population consisted of 207 experimental participants (154 households) and 95 control group participants (58 households). A total of 488 individuals (i.e., both experimental and control) received the initial questionnaire. Throughout this study, there were 186 dropouts (58 did not return the first questionnaire, and 128 individuals dropped out after returning the second questionnaire). To assist in evaluation and interpretation, researchers conducted four focus groups, consisting of three experimental groups with a total of 28 participants and one control group session with nine participants.

Several ways to explain CarLink were used: an informational brochure; a video; and an interactive drive clinic with the Honda Civics, smart cards, and the COCOS smart key manager kiosk. An experimental and control group was recruited for the study to evaluate the informational media.

At the drive clinic, held in September 1998, participants used a smart card to access a CarLink vehicle, release the immobilizer, which blocks unauthorized users from starting the car, and took a test drive, accompanied by a researcher who documented their observations, questions, and concerns. The drive clinic offered participants a chance to see and try these new technologies, as well as to interact with study researchers. Each participant completed a 20-minute exit interview with a researcher on his or her response to the CarLink system and willingness to participate in such a service. At the end of the clinic, participants received a final questionnaire and travel diary to take home and complete over the next several days, giving them time to reflect on their observations from the clinic and to answer questions about CarLink within the context of their own travel.

Dynamic Innovation Response Hypothesis Findings

To test and monitor participant response to the carsharing concept over time, researchers developed a question, administered in all three survey phases to measure this response. Essentially, "Do you think that you would use the CarLink system?" served as the dependent variable in the CarLink longitudinal survey. This paper presents the results to dynamic innovation response hypothesis and response/interest to participate in the CarLink field test. These data were used to create an early adopter profile.

In the first phase, researchers presented the carsharing concept in an informational brochure. Researchers asked respondents to review the brochure and complete a questionnaire. Approximately 58.2% of the experimental respondents said "Yes." It is interesting to note that 45.3% of the control group individuals responded "Yes." In the initial phase, a significant difference was found between the responses of the experimental and control groups ($\chi^2 = 5.38$, $p\text{-value} = .002$). See Figure 1 below.

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many participants from precontemplation into the contemplation phase and, for some, into the "action" phase of the behavioral adoption process.

During the final phase, researchers asked experimental participants to reflect on the clinic and complete a questionnaire. Again, respondents were asked whether or not they thought they would use CarLink. Nearly 78% of the experimental group said "Yes," whereas only 32.6% of the control responded positively (i.e., a 3.2 percentage point decrease from the previous phase). As mentioned, however, there was a significant decrease in the experimental group's positive response in the final phase. This change in response supports this assessment of the social desirability effect, indicating an overstated response from the clinic. During this phase, a significant difference was found between the responses of the experimental and control group ($\chi^2 = 58.65$, p -value = .000).

The overall data gathered from the longitudinal survey supports the study hypothesis and validates the behavioral adoption process. The only exception to this hypothesis is the drop in positive responses between the drive clinic and final phase for the experimental group. In contrast, the control group behaved as predicted. Over time, the control group became less positive toward CarLink use. Researchers attribute this effect to the lack of educational media and feedback needed to move an individual through the behavioral adoption process described by social marketing theorists.

In summary, control group participants did not receive the information and feedback needed to move from precontemplation into the contemplation phase. In contrast, the experimental group received educational media throughout, which allowed them to assess the benefits and costs of CarLink for their lifestyle and fostered a positive response among many toward this transportation alternative. In fact, many indicated in their final questionnaire that they would be interested in joining the CarLink field test (i.e., 77.9% of the experimental group in contrast to 32.6% of the control).

CarLink Early Adopter Profile

In the final questionnaire, researchers also asked participants if they would be interested in joining the CarLink field test in the Dublin/Pleasanton region. The field test provides an opportunity for individuals who participated in the longitudinal survey to move from the contemplation phase of the behavioral adoption process into the "action" stage.

In the final phase of the longitudinal survey, 77.9% of experimental ($n=161$) and 32.6% of control respondents ($n=31$) said they would use the CarLink system. In contrast, only 53.6% of experimental ($n=111$) and 17.8% of control participants ($n=17$) indicated that they would be interested in participating in the CarLink field test. Not surprisingly, the number interested in joining the field test was lower than that reflected by this study's main dependent variable.

After the survey was completed, researchers contacted individuals who indicated they were interested. If they had a match with one or more of the program groups, individuals were able to enroll in CarLink:

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- The majority of participants (i.e., approximately 90%) are between the ages of 24 to 64. About 56% percent are 24 to 40 years of age, and 39% are between 41 to 64.
- Approximately 60% of those interested in CarLink participation have a Bachelor's or Master's degree.
- Approximately 50% of those interested in CarLink participation live in a large- or medium-sized city. (A large city is greater than 250,000 individuals and a medium city is greater than 50,000, but less than 250,000 individuals.)
- The majority of the individuals interested in CarLink participation (i.e., approximately 60%) have a household income over \$50,000 per year.
- Approximately 20% of participants interested in the CarLink program are currently dissatisfied with their current transportation modes. This result is contrary to what researchers would have expected. Researchers thought more would be dissatisfied with their current modes.
- Approximately 60% of individuals interested in CarLink participation agree or strongly agree that vehicle maintenance is a hassle.
- As expected, 20% of the participants interested in the CarLink program strongly agree or agree that vehicles are enjoyable.
- Approximately 60% of those interested in the CarLink program strongly agree or agree that congestion is a serious problem.
- Approximately 50% of those interested in CarLink participation agree or strongly agree that the environment is a concern.
- Approximately 80% of those interested in CarLink participation agree or strongly agree that they like to experiment with new ways of doing things.

It is interesting to note that many of the above profile characteristics are comparable to those of early carsharing adopters in Europe. Differences are reflected in the areas of gender, income, and land use. In Europe, there are more male participants than women. The overall profile results indicate an equal interest among men and women. However, in the CarLink field test this same relationship holds. It will be interesting to observe U.S. carsharing organizations over time to determine whether or not this initial trend, found in the CarLink field test, continues.

CONCLUSION

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Workside Commuter group categories. The next phase of the CarLink study includes an evaluation of the field test, participant usage patterns over time, and feedback from members on how to improve the program.

Next, researchers developed a CarLink early adopter profile. It is interesting to note that many of the above profile characteristics are comparable to those of early carsharing adopters in Europe. Differences are reflected in the areas of gender, income, and land use. In Europe, there are more male participants than women. The overall profile results indicate an equal interest among men and women. However, in the CarLink field test this same relationship holds. It will be interesting to observe U.S. carsharing organizations over time to determine whether or not this initial trend, found in the CarLink field test, continues.

Second, in Europe, participants tend to have lower incomes, which is typically explained by the lower average age of carsharing members. In this study, a majority of the households earn over \$50,000 a year. This difference can be explained by the region of California in which the study is conducted, as well as the interest of older individuals. Another difference is related to land use. In Europe, carsharing is primarily an urban phenomenon. In this study, CarLink was tested in a medium to large-size city. This model was established to support "reverse" commute travel patterns. Hence, it is difficult to contrast community patterns in this study to those common in Europe.

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