Dynamic Ridesharing: Understanding the role of gender and technology

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A thesis submitted in conformity with the requirements for the degree of Master of Sciences

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1 Abstract

Using a case study approach, the thesis examines how dynamic ridesharing (DRS) has evolved through time, parallel with changes in information and communication technologies (ICTs). DRS is conceptually framed using a socio-ecological modeling approach, the goal being to develop hypotheses regarding factors likely influencing DRS use. This conceptual work forms the foundation for an empirical study of DRS use. Survey data were used in descriptive analysis and logistic regression modeling organized to identify who uses DRS and how. The study reveals that gender may be a central concept to understanding why and how DRS is used by certain segments of population more than others. With regard to technology, it is found that although technical competencies were enabling, in terms of facilitating rideshares, gender and perhaps related mobility constraints, emerged as a larger issues. The findings also caution against relying solely on technological advancement for the success of ridesharing programs.
2 Acknowledgements

I would like to sincerely thank my supervisor, Professor Ron Buliung, who has provided me with great insight, assistance, and guidance during my Masters theses. Without his guidance, support, and patience, this thesis would not have been possible.

The partnership with Drummond Gilbert, President of GoCarShare.com, was key to this thesis, and I am thankful for his help and support.

Finally, I would like to thank my father. He drove me to do this.
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Introduction

2.1 Background

Road transport systems today, in many parts of the world, face considerable pressure from rising travel demand. The upward trend of the post-war era toward increased automobile ownership and use, coupled with urban sprawl, has contributed to the current state of high automobile ownership, increased travel times, traffic congestion, and noise pollution (Litman, 2007). In the Canadian context, as of 2006, only 7.4% of workers commuted to work as passengers, 69.4% were drivers (Statistics Canada, 2009). Public transit mode share, nationally, between 1996 and 2006 increased only 1% (Statistics Canada, 2009). Commute distances have gradually risen over time; the median distance travelled by a Canadian worker increased by 7.9% between 1996 and 2006, which has created greater demand for travel (Statistics Canada, 2009). The percentage of workers who use cars decreased by 1.3%, but the added travel demand created by a 2.8 million increase in the labour force between 1996 and 2006 has put additional pressure on transportation infrastructure (Statistics Canada, 2009).

Looking to the United Kingdom (UK), the setting for this thesis, recent data from the Department for Transportation tell a similar story. The average trip length has increased by 50% since the early 1970’s; between 1997 and 2010, the average trip length increased by 9%. The average trip time has also increased by 12% during the same time period (Department for Transport, 2010). The automobile now accounts for 84% of all distance travelled, a 10% rise since 1970. Between 1970 and 2011, the proportion of distance travelled by public transport systems dropped from 24% to 14% (Department for Transport, 2010). During this period, the UK has seen a 48% rise in travel demand, 94% of which was serviced by cars, vans, and taxis (Department for Transport, 2011). The seemingly ever present conversation here and abroad about, “what to do about transport in our
cities” continues, some government agencies, some employers, and some members of the public continue to discuss and occasionally implement alternatives to auto-driver commuting.

Planning and ultimately government or employer response to the pressures exerted on transportation systems may include either creating more transportation facilities such as roads and highways, or managing the demand for motorized travel using Travel Demand Management (TDM) strategies, or some combination of these approaches (Table 2.1).

Building new roads is considered a short-term solution that comes at an economic cost that is not always feasible. In addition to this, building new roads may produce induced demand (short term capacity increase and improved flow are diminished by rising demand), resulting in the production of trips that would otherwise not exist and only do because the convenience of travel has increased (Leeming, 1969). Other TDM strategies such as encouraging carpooling have been slow to increase in mode share when compared to single occupancy vehicle use (SOVs). For example, U.S. carpool mode share in 2000 was 12% whereas SOVs accounted for 76% of trips (Pisarski, 2006).

New ideas to address increasing travel demand are being considered, and policy makers and planners are looking again, this is not new by any means, toward alternative modes of transport (Buliung et al., 2009). What is new is how modern information and communication technologies (ICTs) are facilitating and arguably reshaping development of dynamic ridesharing (DRS) processes on both the user and application ends. The very recent experimentation with DRS has meant that there are knowledge gaps that represent an opportunity to better understand the circumstance in which DRS can be a viable TDM strategy. This thesis is focused on discovering what the demographic, technical, and mobility-related characteristics are that influence an individual from being merely interested in utilizing the DRS mode choice, to actually attempting to use DRS to organize travel.
<table>
<thead>
<tr>
<th>TDM Strategy</th>
<th>Description</th>
<th>Cost/Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carpooling</td>
<td>Shared use of a car by a driver and one or more passengers.</td>
<td>Social cost to commuter as flexibility of car is given up. Economic benefit for the commuter.</td>
</tr>
<tr>
<td>Vanpooling</td>
<td>Similar to carpooling, but on a larger scale. Groups of people share a vehicle to and from the workplace.</td>
<td>Social cost to commuter as flexibility of car is given up. Economic benefit for the commuter.</td>
</tr>
<tr>
<td>Dynamic ridesharing</td>
<td>Derivative of carpooling, allows for rides to be formed on an ad-hoc basis.</td>
<td>Excellent means to fill unused capacity of vehicles, but relies heavily on fast relay of ride information.</td>
</tr>
<tr>
<td>Teleworking or Telecommuting</td>
<td>Employee works at a location different from the office, usually at home.</td>
<td>Dependent on whether employer or employee bears equipment cost. Generally, employer relinquishes some control over employee.</td>
</tr>
<tr>
<td>Public transit subsidies</td>
<td>The employer, government or another agency contributes towards the cost of using public transit.</td>
<td>Depending on whether employer or government is subsidizing the cost. Economic benefit for the commuter.</td>
</tr>
<tr>
<td>Compressed work-weeks</td>
<td>Employees work longer shifts for fewer days in a week. For example, instead of working an 8 hour day for 5 days, they work a 10 hour day for four days. In both cases, 40 hours are worked.</td>
<td>Cost-savings for employee as the number of trips is reduced; employee usually also enjoys longer weekends. Employer relinquishes a measure of control over business practices (e.g., schedule-making).</td>
</tr>
<tr>
<td>Flexible scheduling</td>
<td>Employees establish their own start and finish times for work; employers usually require employees to be at the office during core hours, e.g.: 11AM-2PM.</td>
<td>Employee saves time by travelling in off-peak hours. Employer relinquishes some flexibility in terms of scheduling and planning.</td>
</tr>
<tr>
<td>Employer-paid parking</td>
<td>Employer offers free parking, usually the de facto case in suburban areas. Employer may also subsidize parking in urban areas.</td>
<td>A cost to the employer and a benefit for the employee.</td>
</tr>
<tr>
<td>Customized ridematching</td>
<td>Service provided by an employer or a third-party organization that organizes and facilitates the creation of carpools.</td>
<td>Organization providing ridematching bears the administration cost.</td>
</tr>
<tr>
<td>Emergency ridesharing</td>
<td>Ridesharing occurring due to necessity rather than choice.</td>
<td>Depending on the situation, it could be an economic cost for the employer or an inconvenience for employee.</td>
</tr>
<tr>
<td>HOV lanes</td>
<td>Lane reserved for vehicles carrying two or more people.</td>
<td>A cost to the government for building the lanes; a benefit for high-occupancy vehicle (HOV) commuters.</td>
</tr>
<tr>
<td>Taxation of cars and fuels</td>
<td>The use of cars is taxed along with fuel consumption.</td>
<td>An economic cost to the commuter and an economic benefit for the public.</td>
</tr>
<tr>
<td>Road congestion pricing</td>
<td>Charging drivers for use of the transportation system during peak hours.</td>
<td>An economic cost to the commuter and an economic benefit for the public.</td>
</tr>
<tr>
<td>Public information campaigns</td>
<td>Dissemination of information pertaining to alternate commute options.</td>
<td>Organization or governmental agency funding the campaign bears cost.</td>
</tr>
<tr>
<td>Kilometer charging</td>
<td>Charging drivers based on the amount of kilometers travelled.</td>
<td>An economic cost to the commuter and an economic benefit for the public.</td>
</tr>
<tr>
<td>Prohibiting cars in certain areas</td>
<td>Outright prohibition of automobiles in selected areas.</td>
<td>Social cost to commuter as flexibility of car is given up.</td>
</tr>
</tbody>
</table>

Table 2.1: Popular Travel Demand Management Strategies
2.2 What is Dynamic Ridesharing?

Dynamic ridesharing is a derivative of regular carpooling; it enables the formation of carpools on an as-needed basis, usually on very short notice. It differs from regular carpooling and vanpooling in three ways. First, unlike a traditional ridesharing system, dynamic ridesharing does not rely on its users to have similar travel schedules at the origin or destination. Instead, it can accommodate users travelling to or from different, perhaps unrelated locations depending on the availability of rides along a route (including origins and destinations). Second, whereas traditional ridesharing largely relies on a ride being arranged well in advance of the travel, DRS eases this dependency by allowing users to arrange travel closer to the time of an activity or trip. Lastly, DRS may also differentiate from regular carpooling in terms of the technologies deployed in the search for rides. For example, traditional dynamic ridesharing can employ technologies such as intranet-based applications that assist in coordinating rides between employees of a company. DRS systems would use technology differently, and would need to adopt tools and technologies that facilitate instant notification and communication (e.g., smartphones, SMS).

2.3 A Brief History of DRS

Earliest implementations of DRS can be traced to 1993, when operator-based systems were used to relay ride information between passengers and drivers using pagers (Kowshik et al., 1995). Sponsored by various institutions including employers, schools and private companies, early DRS systems were limited by the capabilities of available communication technologies, technologies that produced slow and difficult communication. Early on, DRS struggled to be seen as a feasible Travel Demand Management (TDM) strategy. Between 1993–2011, advancement of ICTs, and the knowledge to program and manipulate them helped to improve the functional capability of DRS implementations. Valuable information could travel more quickly to potential matches. The evolution of DRS continued into the early 21st century, when mobile communication technology allowed for even faster and more accurate information delivery, including visual data on route and
destination location. The convergence of digital geography, mobile data and communications spawned sophisticated DRS systems that appear to have the necessary technological capabilities to facilitate activities and personal transport.

2.4 Research Objectives

Over the last two decades, advances in ICTs have altered the capabilities and opportunities for the development of DRS systems. The purpose of this thesis is twofold: first, the work will, through a descriptive analysis, identify the type of activities that are conducive to dynamic ridesharing; second, the thesis aims to identify the demographic, technical, and mobility-related factors that help advance an individual from being casually interested in DRS, to a DRS user. With regard to the second objective, the thesis will, through a regression analysis performed on survey data, examine the relationship between individual demographic characteristics and DRS use. The remainder of the thesis is organized into five sections. The next section is a Literature Review and DRS case study, which describes the origins of DRS and how it has evolved since the mid-1990s, with focus given to several example systems largely situated in North America. A Study Design section, organized to describe the empirical and theoretical structure of the thesis, follows the literature review. The Results section presents a descriptive study of the survey, and the estimations results from a logistic regression model of DRS use. Results are then contextualized using recent travel demand data from the UK and literature drawn from travel behavior and travel demand management and modeling research. The conclusion of the thesis summarizes the main findings, while clarifying the contribution of this work.

3 Literature Review

The purpose of this review section is to describe how DRS originated as a response to increasing travel demand, and how it has evolved since its introduction in the mid-1990’s. The review begins by situating DRS within the broader concept of travel demand management (TDM). The section traces the simultaneous evolution of shared
ride application and ICTs. A series of implementation case studies are then summarized. The case studies are then evaluated based on user response to the initiatives, use of available technology, and rides matched and executed. The review concludes with a discussion centered on lessons learned from the case studies, while looking ahead to emerging technologies and trends, and how they may influence DRS in the future.

3.1 Transportation Demand Management

TDM is the construction and application of strategies and policies to reduce travel demand, or to redistribute this demand in space or in time (Nelson, 2000). TDM is often cited as a response to the growing environmental concerns brought about because of an increase in automobile use (Rye, 1999; Garling and Schuitema, 2007). The earliest definitions of TDM had to do with the preservation of raw materials for war efforts (Ferguson, 1990), whereas over the last two decades, TDM has been seen as a means to improving the efficiency of existing transportation systems in the face of growing population (Meyer, 1999). TDM may also be described as a mechanism for reducing car-use by creating disincentives for single-occupancy vehicles (SOVs), and incentives for high-occupancy vehicles (HOVs) (Rutherford et al., 1994). In recent economic climate, TDM is viewed as a means to reduce the financial costs the growth of the automobile has exacted (Kasipillai and Chan, 2008). A list of popular TDM strategies and their benefits is shown in Table 2.1. These include carpooling, vanpooling, teleworking, compressed work-weeks and more. DRS is a strategy that also comes under the umbrella of TDM, as it aims to redistribute the demand of travel by utilizing the unused capacity of automobiles.

3.2 The DRS Niche

Unlike traditional ridesharing, with DRS, travelers are not required to plan their trips in advance and can communicate ride information closer to the actual time of travel; this is in sharp contrast to traditional ridesharing systems which provide match-lists well in advance of the start times of predetermined trips (Casey et al., 1996). A dynamic ridesharing system is a mechanism for delivering just-in-time mobility options for passengers seeking rides, and drivers looking to pick up passengers in to meet a wide range of needs including:
addressing environmental/social concerns, accumulate capital by charging for rides, creating flexible schedules, or save on travel time by gaining legitimate access to HOV lanes (Lefovsky and Greenberg, 2001). Due to its near temporally and spatially static nature, traditional carpooling is largely limited to home to work transportation and does not allow passengers to join a carpool in an ad-hoc manner, often resulting in unused vehicle capacity. Traditional ridesharing usually depends on commuting patterns being prescheduled and doesn’t accommodate uncertainty in travel, thus making them less applicable to a vast array of situations (Bandara and Dias, 2009).

DRS is viewed as an effective tool for reducing automobile use. It aims to decrease automobile use by utilizing the wasted carrying capacity of automobiles (i.e., increasing the average number of occupants per vehicle). This is seen as a viable strategy for combating congestion as vehicle capacity is inversely proportional to congestion. For example, a moderate increase of 4% in the number of vehicles carrying multiple passengers would have been enough to offset the increase in congestion for the year 1999 in the largest 68 urban areas in the U.S., where congestion cost over $78 billion (Dillenburg et al., 2002).

3.3 The Evolution and Impact of ICTs on DRS

3.3.1 Communication

Dynamic ridesharing relies on accurate information being delivered in a time-sensitive manner. Information can become stale very quickly, for example, a driver who has just decided to leave for his destination in five minutes only has those five minutes to be able to offer, find, and confirm a ride. This makes dynamic ridesharing heavily dependent on efficient communication between participants, but this dependency when satisfied, has the potential to eliminate trips. Telecommunication is one of the keys to effective dynamic ridesharing and can shape the way travel occurs. This ideal relationship may not reduce the amount of travel, but can enhance it to be more efficient (Salomon, 1986). It can also be stated that the better and more efficient the underlying communications technology are, the better the chances of achieving success with dynamic ridesharing.
For a ride-seeker, a successful ride-match in a dynamic ridesharing system depends on four key factors. First, it must be known to the ride-seeker that someone is driving between the desired origin and destination at the designated time, and has room for a passenger. Second, the driver must be notified that there is a passenger seeking a ride. Third, the driver must be willing to offer a ride and will need to provide a positive response to a query posted by the potential passenger. Finally, the ride must be successfully completed following the driver meeting the passenger at an agreed-upon location (Hall and Qureshi, 1997). These are the technical steps in executing a rideshare arrangement; a successful rideshare from the perspective of the participants might also include an assessment of the qualitative dimensions of the experience such as social compatibility, safety, and prior knowledge of participants (Dueker and Bair, 1977).

The above described scenario represents a simplistic description of dynamic ridesharing. More complex dynamic ridesharing systems enable passenger pick up en route and calculate acceptable detours to facilitate passenger pick-up to fill unused capacity, while avoiding excessive penalties in terms of driver travel time (Dillenburg et al., 2002). In most cases examined, the tracking of vehicle location involved telephone communication, but advances in information technology have resulted in Geographic Positioning Systems (GPS) capable devices, which can relay the longitude and latitude of mobile devices to centralized management servers. As ridematching is highly sensitive to the space-time constraints of the participants, dynamic ridesharing systems must provide match information to drivers quickly in order to increase the chances of near-term contact and travel. In advanced ridesharing systems, the technical convergence of ICTs such as mobile phones and GPS hardware enables broader geographical and temporal coverage of the travel market in near real-time, a considerable advance over older modes of communication. Leveraging these technologies, information about potential drivers and passengers can be communicated in real-time, potentially producing higher match rates (Dailey et al., 1999).
The speed at which communication between participants occurs is vital to the success of the dynamic ridesharing model. The space-time gap that exists between drivers and riders is a major obstacle. Fortunately, the current generation of information and communications technologies appears to offer the perfect mix of digital geography, and instantaneous voice and data communication necessary to enable effective resolution of the “technical” challenges associated with DRS development and deployment. As we will see when reviewing DRS implementations, the technology to communicate necessary information has evolved from human operators working on analog phones, to pagers, telephones, websites and today to the use of 3G and 4G Internet-enabled hand-held devices or smartphones.

The creation of the internet, specifically the ability to transmit information in real-time across a wireless network, has had a significant impact on ridesharing. Table 3.1 shows a timeline of the technological milestones that contributed to wider use of information communication technologies (ICTs), and the eventual establishment of internet-based dynamic ridesharing systems.
<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1974</td>
<td>Motorola Pageboy created</td>
<td>First commercial pager introduced, by 1980 there were 3.2 million pager users.</td>
</tr>
<tr>
<td>1982</td>
<td>TCP/IP protocol standardized</td>
<td>Technical standard and technology used by the internet to send and receive data established.</td>
</tr>
<tr>
<td>1985</td>
<td>Motorola DynaTAC 8000x</td>
<td>First commercial mobile phone.</td>
</tr>
<tr>
<td>1993</td>
<td>Commercial deployment of SMS</td>
<td>Text-messaging for mobile phones possible, both phone-to-phone and phone-to-computer. As of 2008, 4.1 trillion text messages were sent.</td>
</tr>
<tr>
<td>1993</td>
<td>Mosaic, first web browser</td>
<td>Computer users could browser the internet using a graphical interface.</td>
</tr>
<tr>
<td>1996</td>
<td>Hotmail.com founded</td>
<td>First commercially successful web-based email service.</td>
</tr>
<tr>
<td>1999</td>
<td>Nokia 7110 released</td>
<td>First mobile phone with a web browser.</td>
</tr>
<tr>
<td>2000</td>
<td>President Bill Clinton orders unscrambling of GPS signal</td>
<td>Allows general public to receive same pin-point location as military.</td>
</tr>
<tr>
<td>2001</td>
<td>First 3G network developed</td>
<td>Faster data-transfers for mobile phones.</td>
</tr>
<tr>
<td>2002</td>
<td>Java Mobile Specification released</td>
<td>Java’s mobile specification released, developers could build Java applications for mobile devices.</td>
</tr>
<tr>
<td>2002</td>
<td>BlackBerry Smartphone released</td>
<td>Commercially successfully smartphone supporting push-email, web browsing, internet-faxing and more.</td>
</tr>
<tr>
<td>2007</td>
<td>First generation Apple iPhone</td>
<td>The iPhone’s software development kit encouraged developer to build application for mobile platforms.</td>
</tr>
</tbody>
</table>

Table 3.1: Significant technological milestones leading to the widespread adoption of ICTs.

The commercialization of all-purpose real-time communications was aided by three important developments. First, the feature-set of phones increase to cover functionality that was limited to desktop and laptop computers. For example, the BlackBerry smartphone revolutionized email by making it easily accessible anywhere, thus always keeping a person connected. Second, competitions in the mobile phone industry lead to a stabilization of hardware and service prices, which allowed greater market penetration. Third, mobile phone vendors enabled third-party software developers to create applications for their platforms. Through Apple’s iOS Developer Program, the company released a Software Development Kit (SDK) which allowed developers to build applications capable of using the phone’s internet connection, thus creating a new realm of possibilities.
Platforms such as BlackBerry, Google’s Android and Nokia’s Symbian did the same. In a classic instance of technological convergence, wireless networking, mobile phones and integrated application development complemented each other to make communication fast and powerful.

These developments have laid a foundation for innovation in the public and private realms, which have seen new ideas, come to the forefront. The rapid growth of the Internet and the increasing speed at which information exchange is taking place has enabled service providers to be more efficient, innovative, and provide greater consumer choice (Feldman, 2002). This rapid development of technology serves as an ideal backbone for the development of contemporary dynamic ridesharing systems, with many of the technical challenges essentially addressed, DRS may emerge as a more viable TDM strategy than in the past. DRS may even serve as a tool for planners who can view it as a means of providing flexible options for using the unused capacity of motor vehicles, and to overcome the often stringent restrictions of carpooling such as predetermined schedules.

Salomon (1986), classified the interactions between telecommunications and transportation into three different types: substitution, enhancement and complementarity. Substitution occurs when trips are eliminated because of the use of ICTs, enhancement occurs when trips are generated because of increased communication, and finally, complementarity refers to when the efficiency of existing travel is improved without a change in the number of trips being generated.

The use of ICTs in dynamic ridesharing falls into the third category, as the synergy between the two is an ideal example of how transportation systems can potentially become more efficient in terms of capital, operating, energy and pollution costs standards (Salomon, 1986). More specifically, as smartphones become more capable, their use will increase and they may be frequently consulted to communicate information and execute daily activities. Built-in GPS capabilities can allow them to be strongly interlinked with travel patterns and activity characteristics. Creative smartphone applications that utilize the capabilities of the device can provide information to the user which may influence mode choice and thus have an impact on vehicle
occupancy, and serve as a tool to relieve congestion alleviation. In short, the quick dissemination of location-sensitive ridesharing information through smartphones can increase the chances of matches in a ridesharing system (Srinivasan and Raghavender, 2006).

Potential barriers to ICTs influencing DRS are traffic laws which prohibit the use of ICTs while driving a vehicle. For example, the distracted driving law (Ontario Regulation 366/09, Highway Traffic act) passed in Ontario, Canada in 2009 prohibited drivers from using any kind of hand-held device while driving. Drivers may still use these devices in a hands-free manner. The impact of such laws on dynamic ridesharing is not known, but it can potentially have an impact on a person being unable to use a DRS system.

3.3.2 Implementation Case Studies
Several ridesharing case studies have been identified for review. Importantly, the cases span the years 1993 – 2011, a period of considerable innovation in ICTs, and so we are able to see parallel innovation in ICTs and the march of ridesharing systems toward being near real-time dynamic systems. The evolution of the process and technology as it relates to DRS is evident in the systems reviewed, and evaluative criteria such as registered users reflect the impact of communication technology. Other comparable attributes used as evaluative criteria include interested users, matches generated, rides completed, economic feasibility, and diversity of technology. The systems are reviewed with a summary of the results shown in Table 3.2 and discussed in the remainder of the section.
<table>
<thead>
<tr>
<th>Plan Name</th>
<th>Location</th>
<th>Period</th>
<th>Community</th>
<th>Impact</th>
<th>Technology</th>
<th>Sponsor</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bellevue Smart Traveler</strong></td>
<td>Bellevue, Washington</td>
<td>November 1993 – April 1994</td>
<td>Restricted to employees of Bellevue working in the downtown location.</td>
<td>Fifty-three people registered, 509 rides offered, 148 rides sought and 40 matches generated. Only six rides were reported as being completed.</td>
<td>Employees used a one-way pager to receive matches every hour. Trips were registered via phone.</td>
<td>The employer provided funding for the system. The cost of pagers was incurred by the employees.</td>
</tr>
<tr>
<td><strong>The Los Angeles Smart Traveler</strong></td>
<td>Los Angeles, California</td>
<td>July 1994 – September 1994</td>
<td>Open to all members of the public.</td>
<td>Thirty-four people per-week used the system. Data about matches and rides was not recorded.</td>
<td>Telephone used to input rides; matches conveyed using automated telephone messages.</td>
<td>Commuter Transportation Services, a non-profit company.</td>
</tr>
<tr>
<td><strong>Sacramento Rideshare Matching</strong></td>
<td>Sacramento, California</td>
<td>Late 1994 – Early 1995</td>
<td>Open to the general public in the Sacramento-area, targeted commuters who worked in downtown Sacramento.</td>
<td>A survey showed 5,000 people indicating interest, only 360 registered as drivers, 10 requests were made and only one match generated.</td>
<td>Users speak with an operator, who manually searches through database.</td>
<td>California Department of Transportation</td>
</tr>
<tr>
<td><strong>TransAction Network</strong></td>
<td>Coachella Valley, California</td>
<td>May 1994 – December 1994</td>
<td>Open to all members of the public; targeting Coachella Valley residents.</td>
<td>Approximately 250 people retrieved ride information; data regarding matches or rides completed is not available.</td>
<td>Kiosks providing ride information; deployed in retail and other high-pedestrian areas.</td>
<td>Commuter Transportation Services, a non-profit company.</td>
</tr>
<tr>
<td><strong>Smart Traveler Program</strong></td>
<td>Seattle, Washington</td>
<td>March 1996 - November 1996</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Restricted to faculty, staff and students at the University of Washington. Generated 150 potential matches with 51 rides successfully completed. A website collected ride information; matches were dispensed using email. The University of Washington.

<table>
<thead>
<tr>
<th><strong>LiftShare.com</strong></th>
<th><strong>United Kingdom</strong></th>
<th><strong>1998 - Present</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Community</strong></td>
<td>United Kingdom public. Special services provided to local authorities, schools, hospitals and communities.</td>
<td></td>
</tr>
<tr>
<td><strong>Impact</strong></td>
<td>Registered 300,000 members and matches 20,000 roundtrip rides per weekday. Has brought a 0.06% commute mode shift in the UK.</td>
<td></td>
</tr>
<tr>
<td><strong>Technology</strong></td>
<td>Web-based ridematching with matches distributed via email and real-time on the website.</td>
<td></td>
</tr>
<tr>
<td><strong>Sponsor</strong></td>
<td>LiftShare.com, a private company.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>M21-FahrPLUS</strong></th>
<th><strong>Stuttgart, Germany</strong></th>
<th><strong>September 1999 – September 2004</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Community</strong></td>
<td>Employees of Mercedez-Benz, approximately totaling 6000.</td>
<td></td>
</tr>
<tr>
<td><strong>Impact</strong></td>
<td>Approximately 10% of the workforce had registered and on any given day, there were 20-30 active users. Matches and completed rides were not tracked.</td>
<td></td>
</tr>
<tr>
<td><strong>Technology</strong></td>
<td>A web-based intranet service was used to collect ride information; matches were distributed via email and text-messaging with customer service available via phone.</td>
<td></td>
</tr>
<tr>
<td><strong>Sponsor</strong></td>
<td>Collaboration between Mercedez-Benz and Daimler Chrysler.</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Goose Express</strong></th>
<th><strong>Washington, USA</strong></th>
<th><strong>August 2007 - August 2008</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Community</strong></td>
<td>Open to the general public, but designed for commuters with irregular schedules. Conducted beta test with Microsoft employees in Seattle.</td>
<td></td>
</tr>
<tr>
<td><strong>Impact</strong></td>
<td>Not available. Service was discontinued due to lack of use.</td>
<td></td>
</tr>
<tr>
<td><strong>Technology</strong></td>
<td>Web interface collected ride information; Text-messaging was used to request rides and convey matches.</td>
<td></td>
</tr>
<tr>
<td><strong>Sponsor</strong></td>
<td>A collaboration between the state of Washington and the privately owned, Goose Networks.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>iCarpool</strong></th>
<th><strong>Issaquah, Washington</strong></th>
<th><strong>October 2006 - Present</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Community</strong></td>
<td>USA, Canada, Europe and Australia; focused in the state of Washington</td>
<td></td>
</tr>
<tr>
<td><strong>Impact</strong></td>
<td>10 million miles of driving saved; 50 clients using integrated services.</td>
<td></td>
</tr>
<tr>
<td><strong>Technology</strong></td>
<td>Entirely web-based system; matches distributed via email.</td>
<td></td>
</tr>
<tr>
<td><strong>Sponsor</strong></td>
<td>Privately owned by Interact Soft Inc.</td>
<td></td>
</tr>
</tbody>
</table>

| **Carticipate** | **San Francisco, California** | **August 2008 - Present** |
Employer-based dynamic ridesharing in Bellevue, Washington

The Bellevue Transportation Management Association developed the Bellevue Smart Traveler System which was designed to assist Bellevue employees working in their downtown location. In order to increase the chance of matches, the project divided employees into groups based on where they lived. This had the effect of having static origin and destination points for employees in a particular group and was counter to the theory that for maximum benefits; dynamic ride matching systems need to allow some variability for both locations and not restrict its users to only work-related trips (Dailey et al., 1997). When rides were offered or requested, a pager was used to send messages to the members of a particular group; these messages were transmitted every hour. The users also had an option to search for and enter ride information using a telephone (Haselkorn et al., 1995).

The project ran from November 1993 to April 1994, and during this time 53 people were registered to form three ride groups (South, East and North of Bellevue), 509 rides were offered, and 148 rides were sought producing 40 potential matches. However, only six matches were logged. Since logging was not required, there is no way of reliably estimating a success rate. The ride seeking and matching statistics are limited to telephone
usage; since the project could not track how many times somebody looked at their pager, ride searching results could not be fully tracked (Haselkorn et al., 1995).

The results did, however, demonstrate that participants liked the project concept. Unfortunately there was a reluctance to seek rides which resulted in a low number of matches. The main reason for this result may have been the limitations posed by the pager’s interface. The 256-character limit was cited in the final report as a considerable barrier to effective participant communication. The lack of ride choices/options, due to the small size of the groups, uncertainty of obtaining a return trip, the short length of the project, and lack of incentives including limited HOV lanes (usually less-travelled lanes dedicated to vehicles with multiple occupants) were also cited as possible reasons for failure. The project also found that people were more likely to offer rides by inviting others into their car, instead of being a passenger in someone else’s car, thus creating an imbalance between those seeking and those offering rides (Haselkorn et al., 1995).

The process by which users viewed and selected potential ride matches was also inconvenient enough to deter system usage. Since the system did not actually do the matching but provided a list of available rides at the time, users were then required to locate a time match and coordinate the trip on their own, all using a pager’s limited interface. The evaluation report conducted at the end of the project suggested that an internet-based matching system would improve success by allowing participants to more easily obtain and respond to rideshare information (Haselkorn et al., 1995).

The system also provided traffic reports and transit information, these features were accessed a total of 150 times. This general information was provided over the phone and did not require a user to be registered with the system; registration was only required to use the ride-matching features (Haselkorn et al., 1995).

**Phone-based dynamic ridesharing in Los Angeles, California**
The Los Angeles Smart Traveler project was sponsored by Commuter Transportation Services, a non-profit private company dedicated to promoting commute alternatives, in order to alleviate traffic after the 1994 Northridge earthquake. Using a toll-free number, users would register with the system by speaking with an operator. Once registered, an automated system allowed them to enter their origin, destination, travel time and whether they were seeking or providing a ride, using a telephone’s touch-tone interface. Ride matches were provided over the phone after the system automatically queried the database. The system provided users with a match-list and then required the users to call the individuals on their own, or have a computer send an automated message (Golob and Giuliano, 1996).

The program operated from July 1994 to September 1994; a later evaluation showed that an average of 34 people per week used the system. The system was unable to track how many matches were made since the phone interface did not provide any such options and logging was not required. The evaluation done after the project’s completion found that participants were hesitant to use the system due to safety concerns. The limitations of the telephone’s interface posed barriers as well. Entering ride information using a telephone proved to be a tedious task that was not guaranteed to meet with success; so many users opted to call friends for rides if their normal mode of travel was not available (Golob and Giuliano, 1996).

Operator-based dynamic ridesharing, Sacramento, California

The California Department of Transportation tested an operator-based ridesharing program in Sacramento between late 1994 and early 1995. It was not an automated system and required users to speak with an operator and answer questions regarding, origin, destination, time of travel, and purpose of trip. The operator would sort the database based on zip code and provide matches based on geographical proximity and start trip times. Of the 5,000 people who had shown an interest in carpooling, 360 registered as drivers willing to offer rides. Ten requests were made for rides and only one match was made, and there is no confirmation whether a
ride actually occurred. These data suggest that the project was a dismal failure attributable to poor marketing, lack of HOV-lane incentives, and security concerns about taking trips with strangers (Kowshik et al., 1995).

**CTS’ TransAction Network, Southern California**

The Commuter Transportation Services developed the TransAction Network (TAN) as a dynamic ridesharing initiative aimed at providing match-lists in the Coachella Valley area in Southern California. TAN deployed a system of kiosks in locations with retail activities and high pedestrian flows. The system allowed users to enter, query and view match-lists based on their desired trip. The kiosks also served other purposes such as distributing local transit schedules via a printer. Between May 1994 and December 1994, 21,150 people accessed the kiosk system and one-third accessed information on ridesharing. Of the 3,200 printouts, only 8% were related to ridesharing. As seems to be the general trend with dynamic ridesharing systems, actual ridematching metrics were not available (Commuter Transportation Services, 1995).

The failure of the system was attributed to low usage and a very high capital cost ($550,000), which was deemed unfeasible for implementations in regions with smaller budgets. The kiosk’s printer statistics pointed to a lack of interest, and CTS decided not to fund TAN beyond the test phase (Commuter Transportation Services, 1995).

**Smart Traveler Program, Seattle, Washington**

Based at the University of Washington, the Seattle Smart Traveler Program was one of the first dynamic ridesharing systems to utilize the Internet as the primary means of collecting user data. It utilized a website to build its database of users who provided information such as origin, destination, trip start time and expected duration. It used email to deliver ride matches and required users to have a valid email address. Faculty and staff comprised 68% of the users with students comprising the remaining 32%. The system ran from March
1996 to November 1996 and generated 150 potential matches with 51 rides successfully completed. Reporting of rides was optional so it is possible that more than just 51 rides were completed (Dailey et al., 1999).

An interesting finding by the program evaluation report was that there was little overlap between traditional carpoolers and those using the dynamic ridesharing system. More than 80% of the system usage occurred during normal business hours which are when traditional carpoolers are at work (Dailey et al., 1999). The success of the system was attributed to it being restricted to university staff and students, which meant that fears about security were likely partially alleviated, since people are hesitant to share rides with complete strangers (Tao and Wu, 2008). The university’s strict parking regulations also encouraged users to carpool, and having a common origin or destination for each trip also increased the chances of matches (Dailey et al., 1999). So, in other words, the system was not really set up as a dynamic ridesharing system, it was set up as a ridesharing system that predominantly serviced trips between fixed origins and a single destination. The target population of the system were known to have highly variable schedules which was expected to increase their interest in the initiative. In addition, there existed a direct financial incentive to participants in the form of saved parking costs.

LiftShare.com, UK-based online ridematching service

Liftshare is a private company based in the UK that uses a website (www.Liftshare.com) to connect people who are making similar journeys. Although usable by anyone, Liftshare serves the 61 million population of the UK where it has expanded to provide lift-sharing schemes to hundreds of businesses and communities. LiftShare.com has registered 300,000 members and matches 20,000 roundtrip rides per weekday (Raney, 2009). Liftshare requires that a user be registered with the website (registration is free) before searching for rides. Users enter their origin, destination, the days the trip will be made, time of departure and the flexibility in departure time. The system then attempts to find matches based on these trip characteristics and if none are found, the trip is stored in the database and the user is notified if and when a match is made. Liftshare does not
ask the user whether they are driving or looking for a ride, and leaves the users to decide on who is driving, pick-up time, vehicle, and any other costs (e.g., fuel). Liftshare has brought about a 0.06% commute mode shift in the UK; this is very significant as the dynamic ride sharing as a whole has accounted for much less than a 0.01% mode shift (Raney, 2009).

**M21-FahrPLUS, Stuttgart, Germany**

M21-FahrPLUS was the dynamic-carpooling component of the M21 project, a public-private partnership which tested a package of mobility services aimed at decreasing traffic congestion. Developed by Daimler Chrysler, the pilot-test of the project was held at the Mercedez-Benz plant in Stuttgart where approximately 6000 employees worked. Users would supply ride information using a web-based Intranet and matches were distributed electronically. In addition, customer service support was available via phone (Holzwarth et al., 2001).

As of July 2000, approximately 500 employees had registered and on any given day there were 20-30 active users. Information about matches and completed rides was not tracked as users handled communications on their own. The project encountered various technological problems and the usability of the system hampered its growth. The project was discontinued in September 2004 (Steger-Vonmetz and Bregenz, 2005).

**Goose Express, Washington, USA**

In August 2007, Goose Networks, a private company dedicated to developing solutions to the challenges of transportation, launched Goose Express, a carpool network designed for commuters with irregular schedules. Users had the option to use text messaging (SMS) or an online web interface to enter ride information and request a driver or a passenger. If a match was found, the system would direct both parties to a neutral meeting spot for pick-up arrangements. Goose Express also integrated a billing system designed to split fuel costs (Zimmermann and Stempfel, 2009).
The biggest challenge faced by Goose Express was getting their users to return with regularity to the website to manage their rides. The character limitations and minimalistic user interface of SMS did not attract users as entering ride information was too cumbersome, and did not guarantee an immediate response. In August 2008, Goose Networks discontinued support for Goose Express and instead focused its efforts towards helping organizations influence employee travel habits (Raney, 2009).

iCarpool.com, Washington-based online ridematching service

A state-of-the-art web-based ridematching system, iCarpool.com caters to users interested in traditional and dynamic ridesharing. Founded in 2006, the company promoted traditional carpooling by focusing its efforts on commute trip reduction (CTR) programs through partnerships with local employers and governmental agencies. Since then it has expanded into the area of dynamic ridesharing by providing their users the option to search for rides and passengers in real-time. In total, the system classifies trips in four categories: recurring, one-time one-way trips, one-time round-trips and real-time trips.

Unlike other systems at the time, iCarpool.com has privacy-protection options where users can restrict their trip visibility to users of a particular network; a network is pre-defined by system administrators and can represent members of a community, students of educational institutions, employees of firms, nurses at a particular hospital, and more. The ability to search globally and within a set of users makes iCarpool.com popular within organizations resulting in over 50 such partnerships.

iCarpool.com requires that users specify exact origin and destination addresses so that it can accurately search for matches. In addition to this, the dynamic ridesharing component of the system provides users with an option to specify any flexibility in their trips for up to three hours. In order to convey as much information to would-be travel partners, the system optionally asks for trip purpose and allowable waiting times.
The system also approximates the savings associated with ridesharing including: number of miles saved, carbon dioxide emissions prevented, gasoline saved and money saved. It claims to have saved 10 million miles of driving and 10 million pounds of carbon dioxide.

**Carticipate, Apple iPhone-based dynamic ridesharing**

Carticipate, Inc., was created by Steffen Frost, a San Francisco-based Software Engineer in May 2008. The first dynamic ridesharing application for the Apple iPhone platform, Carticipate is described by its founder as a "location-aware social network" (S. Frost, personal communication, August 14, 2010) which matches drivers and passengers travelling similar routes in real-time. When it is launched using an iPhone, the location-aware application automatically detects the location of the user and presents them with all rides originating from their current location. Users have the ability to add schedules which consist of trip origin, trip destination, departure time, role (driver, passenger or either), and will instantly receive matches. Once a match is presented, a user may contact the passenger or driver using email or text-messaging, with both these options available from within the application. In order to use the ridematching features, a user must be registered with a valid phone number and email address (S. Frost, personal communication, August 14, 2010).

Since its launch in August 2008, Carticipate has been downloaded over 30,000 times from the Apple App Store, which is available in 88 countries. The application is available in English, French, German, Italian, Spanish and Dutch. Although it can be downloaded in many countries, the application can only function in areas where Google Maps, Google’s online mapping software, is available. Over 3000 users have registered with Carticipate and approximately 375 of those users can be considered active. Metrics for actual rides completed via Carticipate are not available; the recent trend indicates that 10% of downloads generate registrations, and 10% of registrations result in active users (S. Frost, personal communication, August 14, 2010).

Future versions of Carticipate plan to address security and trust concerns by integrating with online social networks such as Facebook, and by allowing users to restrict the visibility of their schedules to people in a
defined network. At the time of writing, Carticipate is developing mobile applications for platforms other than the Apple iPhone, including Google’s Android platform. The company is also working on integrating the application with service providers such as 511.org, which is a transportation information resource serving the San Francisco Bay Area. This would provide users of Carticipate access to up-to-the-minute transportation information including traffic reports, road conditions and more (S. Frost, personal communication, August 14, 2010).

**goCarShare.com, Facebook-user driven ridesharing**

The web-based application goCarShare.com, attempts to ease the security and trust concerns of its users by ensuring that all users have Facebook accounts. Launched in May 2010, goCarShare.com is not a pure dynamic sharing application, as it does not factor in the current time when matching trips, instead asking only for the trip origin, trip destination, role (passenger or driver), and day of travel. It uses Google Maps for a visual display of routes can only be used in areas serviced by Google Maps (Gilbert, 2010).

Drivers can use the website to create trips and search for passengers, and passengers can search for drivers. In the case of a match, users are notified using goCarShare.com’s internal messaging system. Due to the project being in its early stages, there are no reliable statistics regarding registration, matches or executed rides. There are presently 607 members in the goCarShare Facebook group, however, these do not represent registrations (Gilbert, 2010).

**Theoretical and Miscellaneous Systems**

The systems described reflect the transition in technology used to facilitate dynamic ridesharing. There are numerous other systems which provide very similar services, some targeting a particular type of traveler while others choosing to stay more general. PickupPal (iPhone ridesharing), Carpool Zone (employer-driven ridesharing), Zimride (school-focused), findcarpool.ca (Canadian-focused), Carpool World, carpool.ca,
erideshare.com are only a few of the web-based systems that connect people interested in ridesharing. The concept and technology behind these systems is similar, however, there have been ideas that are a departure from the common form of web-based carpooling.

Raney (2009), presented a concept for a dynamic ridesharing system which was aimed to service the San Francisco Bay Area commuters who work in Silicon Valley. Instead of attempting to deliver end-to-end trips, the proposed system utilizes existing public transportation stops as “transfer hubs” so that there is greater interaction between driver and potential passengers, thus increasing the chances of matches. The project focuses on a particular industry, information technology, and is designed to cater to the flexible schedules of workers in the industry. As is expected, the role of smartphones, internet-enabled mobile devices, is central to the operations.

Whereas Raney (2009), focuses on a particular industry and a specific commuter corridor, Dillenburg et al. (2002), offers to create an “Intelligent Travel Assistant” that can offer dynamic ridesharing options, traffic reports, air quality information, route-finding ability, and event information. The contrast in scope of the two projects is significant, the latter attempts to bundle every conceivable feature inside a smartphone for general public usage, while the other services a specific segment of the population using a distinct technique.

The concept of using existing transportation resources to facilitate ridesharing is not a new one. A self-organizing form of hitchhiking in the late 1990’s had drivers hovering around bus stops in order to pick up enough passengers to qualify them to use HOV-lanes for travel into downtown areas (Spielberg and Shapiro, 2001). The use of transportation resources for purposes other than what they were built for can cause conflict between the transit authorities who manage them, and the people who take advantage of them, arguably more efficiently. The congestion caused by such usage can also result in confusion for bus drivers who cannot tell which passengers are there for a bus and which are waiting around for a driver to pick them up. The economic impact of such a movement on local transit authorities cannot be discounted, as each passenger lost to this form
of DRS has an associated cost. Although controversial, this phenomenon does merit further research with a view to how organized hitchhiking can be formalized and integrated into existing transportation schemes (Spielberg and Shapiro, 2001).

One of the most advanced dynamic ridesharing concepts came from Austria in the form of WIGeoPOOL. The web-based software boasted connectivity with virtually every kind of mobile device while a GIS-based, intelligent searching algorithm matched drivers with passengers, not only from end-to-end, but also partial trips where minimal detours were needed on part of the driver. The technology was branded as a “quantum leap in the development of carpooling software” (Steger-Vonmetz and Bregenz, 2005, p. 995), but the prototypes developed were not well-received. This was due to the project’s focus being primarily on technology, and not on the creation of incentives and the promotion of the culture of ridesharing (C. Steger-Vonmetz, personal communication, August 17th, 2010). The project was similar in its technical nature to the theoretical Smart Para-Transit in New York City which proposed using ICTs “to group and optimize existing trips” (Gorton, 2008, p. 3).

3.3.3 Case Study Assessment

Most of the projects reviewed were discontinued with reasons ranging from cost inefficiencies such as high initial investment and steep operational costs, lack of use, level of service, usability, and technological limitations. The main measure of success for these case-studies is the number of rides matched and executed, i.e., the number of trips completed after a match between driver and passenger was made. Of the systems reviewed, the success stories appear to be the more recent examples of LiftShare.com and iCarpool.com, which have grasped a stronghold on the ridesharing market by attracting users through an efficient and easy-to-use website, while reaching out to local and regional institutions, both public and private.

These data, then, suggest that indeed, the most recent period in the evolution of ICTs appears to associate with the development and deployment of relatively more successful systems. Both these companies have integrated their services with major employers by providing customized solutions, including the ability to
share rides within social networks such as groups of friends or work colleagues. Other examples of such networks would be hospital workers finishing their shift at the same time, or students at a particular university attending classes starting at the same time. Instead of relying solely on social marketing such as advertising campaigns, successful ridesharing companies have focused on building relationships with organizations that directly influence people’s mode of travel. These organizations have to be willing to engage and educate their workforce about commute alternatives and provide incentives for users to participate in ridesharing schemes. Although both icarpool.com and Liftshare.com have achieved success by working closely with organizations, they do provide a DRS component which allows for immediate trip ride searching.

These ridesharing systems provide feature-rich services like location-aware searching, route-finding, en route matches and instant notifications, all delivered through web-based and mobile applications. The system developers do assume user familiarity and comfort with diverse graphical user interfaces. From early systems where users struggled with technical interfaces such as kiosks and pagers, current users of ridesharing systems come equipped with the knowledge of how to utilize mobile phones, web-browsers, text-messaging and other communication means to make the process of ridesharing easier and efficient. The conceptual difference between the software developer and end-user is reduced because of the latter’s increasing technical literacy. The technical profile of the potential ridesharing user has evolved to the point where ridesharing systems can offer a multitude of service options through varying information and communication technologies, while remaining confident that the user will be able to use the system without difficulty.

Mobile phones have penetrated Canadian households with astonishing success. In 2008, 74.3% of Canadian households had at least one mobile phone (Statistics Canada, 2008). Despite this success, access to advanced dynamic ridesharing tools will be limited to persons who can afford the technology and have an intermediate knowledge of how to use it. These requirements will naturally exclude a segment of the
population. It is possible that competition in the ICT industry will make the technology more affordable, and that the usefulness of the smartphone will attract even non-technical persons to adopt ICTs.

As evidenced by the case studies, this implicit level of comfort would not have been possible during the early days of dynamic ridesharing because the technology did not exist and neither was there a focus on producing quality interfaces. This was due to lack of standardized interface development processes, missing dedication to user-centered design, and an inconsistency in interface development primarily caused by a lack of collaboration amongst vendors and usability experts. It also was not until 2000 that U.S. President Bill Clinton called for the unscrambling of GPS signals, thus allowing GPS-enabled devices to receive and produce exact locations.

Human-Computer Interaction and usability standards, developed between 1985 and 2000, dictated a consistency in design by providing guidance and outlining principles key to producing quality interfaces. Standards were created for key user-interface elements such as icons, cursor controls, window behaviour, gesture recognition, dialogue interaction and visual display terminals. Conformity to these standards has meant that users can leverage their tacit knowledge of computers and apply it to new applications. In particular, the standards created paid specific attention to the limited capability of mobile screens (Bevan, 2001) (Myers, 1998). The major standards included:


The benchmark for sophisticated mobile interfaces was set by Research in Motion and Apple Inc., the latter setting the standard for high-performance touch-interfaces, and the former pioneering full-keyboard (QWERTY-style) mobile phones.
These companies have done more than just design phones; they have created platforms that facilitate rapid development of mobile applications that shape the way consumers use mobile devices. These innovations have come during a period where consumers were already fast-adopting internet and mobile access as a major means of communication. Between 1997 and 2004, Canadian households increased their expenditure on cellular phones by 253%, and on internet access by 600% (Statistics Canada, 2006). These data point to an increasing familiarity and acceptance of internet-enabled mobile technology, a key to developing applications for widespread use. Companies such as GoCarShare.com and Carticipate are assuming this trend will continue so that they may capture the ridesharing market-share.

A consequence of the relative infancy of dynamic ridesharing is the limited amount of literature and implementations to review in this thesis. This paucity of reference information, combined with the disparity between the number of failed and successful implementations of DRS make it difficult to construct an evaluative framework from within which implementations can be examined for factors influencing success or failure. Therefore, data collection strategies for any research, including this thesis, are difficult to construct and are exploratory in nature. As dynamic ridesharing matures, the expectancy is that the associated literature will expand, with data sets becoming fuller in diversity and volume, paving the way for more focused research.

The case studies described in this thesis have also been primarily focused on the technological aspect of the implementations. The acknowledgement of the social and economic context within which these systems have been implemented is limited. This may be understandable due to the newness of technology and the curiosity it emanates, but it is problematic because, as we see from the literature on carpooling - another form of ridesharing - social and economic context, the spatial organization of economy, along with the organization of labour at the workplace (e.g., horizontal versus vertical/hierarchical structures), and work scheduling, can influence shared mobility in ways that are perhaps more critical than technical concerns (Buliung et al. 2009; Buliung et al. 2010; Buliung et al. 2012).
3.4 Discussion

The literature provides an incomplete technical profile of a DRS user, mostly because the technologies associated with DRS are changing at a rapid pace and due to interest in DRS being generally low. As discovered in the case studies, in the mid 1990’s, DRS users responded well to technology such as pagers as a method of ride communication (Haselkorn et al., 1995). Although the number of matched rides was not high, it was due to the functional limitations of a pager, not the incompetence of the user. Massaro, et al. (2009) reviewed the success of PickupPal.com, a web and mobile-based DRS system, concluding that users interested in DRS are able to use mobile devices without difficulty. DRS system authors see technological advances as enablers for shifting DRS efforts to the mobile landscape, and the product of this wave of innovation has given rise to mobile-based DRS systems such as Carticipate, Avego, Energetix and others (Niels, et al., 2010). In the U.S, 63 million people access the internet on their mobile devices (Lardinois, 2009). The fervor of developing new DRS systems, and increasing internet use paints a picture of a well-informed target user, who if not already comfortable with mobile technologies, is expected to be. Dailey et al., 1999, and Raney, 2009, have also illustrated that DRS users were very familiar and comfortable using web-based internet applications to manage their rides, although with limited success rates.

As the implementations of dynamic ridesharing are reviewed, a trend of adopting ICTs and improving information technology can be seen. From early operator-based ridesharing services in the mid-1990’s, to real-time database driven technologies of today, the implementations of dynamic ridesharing have undergone a reengineering process that has seen them become more efficient by leveraging the advancements in information technology and communication over the last two decades. While earlier arcane systems were usable by only a specific group of people with access to a particular technology, newer systems use the internet as the primary medium of communication which, as indicated by soaring expenditures on cellphones, handheld text messaging and internet access, indicates that the technology is more readily accessible (Statistics Canada, 2009b). The information-distribution to the masses can provide a platform for the advancement of DRS.
The focus of new dynamic ridesharing systems is shifting towards understanding how to use the new tools at their disposal in order to implement a ridesharing system which can gain a substantial market share, thus making it useful, e.g., LiftShare.com which brought about a 0.06% commute mode shift in the UK. The critical mass needed for a successful implementation is rarely achieved, and initial capital investments for prototype projects can be large as seen in the case of M21-FahrPLUS and TransAction network. Instead of implementing a solution and then learning the lessons through failure, efforts are being made to understand, in advance, what exactly a successful dynamic ridesharing system would entail, both in terms of logistics and planning, and technology. Defining and evaluating the concept of operations of a yet to be constructed system has two main benefits: It can save significant economic costs, and through better planning can allow for early detection of pitfalls.

Since these systems have not all been realized, it is difficult to define what the most promising approach is; however, it is possible to outline the priorities one must take in the approach in order to achieve wider adoption. Based on extensive surveying, Chaube et al., (2010), identified three core issues key to increasing user participation in DRS systems: trust, convenience and incentives. This supports the findings of the previous section, namely, dynamic ridesharing systems have faltered because of lack of use, and concerns regarding safety. It can be inferred that the reason for lack of use is because of factors such as safety and convenience.

The convenience factor is closely related to how usable and accessible a system is, and how easy it is to pick someone without significant deviation from the original route. For the systems reviewed, the interfaces have often been seen as barriers rather than conveniences. This is not surprising as the usability concerns of a system are usually harder to address and implement than the functional requirements, and quite often, not enough detail is paid to them (Nichols and Twidale, 2003). All the ridesharing systems discussed operate under the same conceptual model of providing on-demand ride information to users closer to the time of travel, it is
the level to which the implementations can alleviate security concerns and provide a pleasant and useful experience, all the while remaining cost-effective for both parties, that the difference in success and failure lies.

Improving the accessibility of dynamic ridesharing systems while focusing on reducing their external complexity is a fundamentally sound method of increasing user-friendliness which might lead to wider adoption. Overwhelming riders with excessive options and sophisticated interfaces can hinder their desire to use the system; the comfort level in the human-computer interaction is decreased every time a user encounters a usability hurdle, eventually leading to avoidance.

The safety risks and social discomfort associated with sharing private spaces such as cars must also be addressed (Resnick, 2004). Shared mobility, whether by car or transit, is not merely a technical experience, it is a human experience – an opportunity for the projection and intersection of value and discourses that may indeed conflict with one another, or mesh quite nicely. Dynamic ridesharing systems must provide the facility to alleviate the security concerns of the user. This can be achieved by providing verified information such as name, age, gender and occupation about the participants, well before the trip is consummated. In order for this information to be meaningful, the reputation of the users of the system needs to be maintained and, ideally, peer-reviewed by other members of the system. This peer assessment concept is similar to the one proposed by Walbridge (1995), for the conceptually specified Wireless Access Ridesharing (WAR) system. It called for drivers and passengers to be thoroughly screened prior to using the system, with any transgressing behaviour being recorded in the system. It acknowledges that building the trust and confidence of its users would be a “difficult and crucial challenge” (Walbridge, 1995, p. 491). More recent dynamic ridesharing services such as SideCar rely on a more direct approach for establishing trust; the San Francisco-based service requires background checks of potential users, and conducts a five-minute interview with each potential driver, before making a decision as to whether they are eligible to drive other users around (SideCar 2012).
Internet social networking has redefined the concept of trust, confidence and familiarity, and this should be leveraged in any future ridesharing solution (Chaube et al., 2010). For example, Carticipate’s plans to leverage the critical mass carrying social network, Facebook, to address security concerns is seen as a “logical next step” (S. Frost, personal communication, August 14, 2010) which is cost-effective and reliable. The embryonic goCarShare.com has heeded this advice and has mandated that all its users already be part of Facebook. Although this is not a solution to verifying user identity, it can alleviate concerns by providing information about user activity and interactions on Facebook, which savvy users can detect as being valid or not. Zimride also, though optionally, provides Facebook as a mechanism for establishing trust. The concept of “crowdsourcing”, loosely defined as the outsourcing of tasks to a large group of people, must be leveraged as technology propagates to the masses. In goCarShare.com’s case, it is counting on the “crowd” to provide enough information about a user so that they can be verified. As users become more comfortable using the technology and have their security concerns addressed, it is then up to the underlying system to serve the willing user. How efficiently and accurately it is able to provide the user with the necessary information will determine whether the system can be successful in promoting ridesharing as a commute alternative (Dueker and Bair, 1977).

Automobile manufacturers are responding to the wave of technological change by becoming increasingly telematic. Leading global manufacturers such as Nissan, BMW, Ford and Toyota already offer social networking through in-car dashboards, without the need to install additional hardware. The car itself is becoming an ICT, and depending on the execution of the technology, has the potential to impact travel patterns and influence the likelihood of ridesharing. Location-based social networks such as Foursquare, GoWalla and Facebook Places, which allow users to easily share location information are gaining popularity at breakneck pace, paving the way for intelligent applications which leverage this data to enhance ridesharing. Spurred on by an eager community of software developers utilizing the programming interfaces provided by these companies,
the applications in this ecosystem are sure to grow in both number and quality. In a twist of irony, it could be that the car, as it evolves technologically, will lend a helping hand in providing commute alternatives.

4 Study Design

The study attempts to identify activities conducive to DRS, and describe the technological and demographic factors that transition a user interested in DRS to executing an arrangement. Dynamic ridesharing is framed within the socio-ecological model in order to develop a conceptual understanding of what influences DRS use. Descriptive analysis of survey data is followed by an exercise in explanatory modeling, where logistic regression analysis is used to identify factors that could influence who a user who has shown an interest in DRS to actually execute an arrangement. In order to meet the objectives of this thesis, data regarding travel patterns and activities of DRS users was needed. The research was assisted by GoCarShare.com, a private company based in Edinburgh, U.K, which provides a publicly available web-based DRS system which can be used to search for, and offer, rides on a real-time basis. The study design consists of four main parts: (1) on-line activity-travel survey of GCS database registrants; (2) development of a framework for understanding DRS use by applying a socio-ecological theoretical modeling approach; (3) descriptive analysis of survey data; and (4) logistic regression analysis of DRS use, with model specification informed by the conceptual work from part 2 of the study design.

The GoCarShare.com website is available globally and can be used by anyone with access to an internet connection. However, GCS’s marketing campaigns are primarily focused in Edinburgh, U.K and the impact of their operations is felt most in the areas surrounding Edinburgh. Edinburgh has a population of 460,000, with the city undergoing rapid economic growth leading to an employment and housing imbalance. This has created a shift in the commute geography of the city with workers tending to commute to Edinburgh from surrounding areas. Over 70% Edinburgh commuters use automobiles, with 55% of city residents also opting to use the automobile as a primary means of work travel (Scottish Executive, 2003). Over 115,000 people work in the
Edinburgh city centre which has caused increased competition for limited parking spaces (Gaunt et al., 2007). Although bus and train service is provided, commuters have shown a preference towards automobiles.

Edinburgh is famous for its festivals, namely the Edinburgh Festival, which is a series of festivals that run during the summer months. Festivals include the Comedy Festival, International Film Festival, Edge Festival, and the International Science Festival. Edinburgh also hosts Scotland’s five National Galleries and a host of visual arts, music, theatre and film events which attract travelers to the city every year. Over 1 million overseas visitors travel to Edinburgh annually to attend these events and festivals; this is in addition to the thousands making their way from regions within England and Scotland.

Edinburgh is a tourist destination where group travel is common, and GCS endeavors to provide a service which encourages DRS by providing a very easy-to-use and effective way to find ride partners. Although GCS does not limit its services to event-based travel, the geography of its marketing efforts and head offices naturally incline itself to servicing local travel needs, thus catering frequently to event-based travel. Edinburgh is also home to four major universities with an estimated student population of 100,000.

Like most cities, Edinburgh’s travel needs are diverse. GCS has recognized the opportunity to facilitate this travel through a DRS system built upon Google Maps, a public mapping service and technology provided by Google Inc., which is free for non-commercial use.

In association with GoCarShare.com (GCS), this thesis will explore survey data providing insight to the preferences of individuals interested in dynamic ridesharing. The DRPS (Appendix B) was conducted by GCS and canvassed the preferences of existing users of GCS. The web-based survey tool, SurveyMonkey.com, was used to administer the survey to GCS users, who received the hyperlink to the survey in two ways: via email due to them being subscribed to the GCS email list, and via the GCS Facebook page, a webpage created on the social networking site, Facebook, which users interested in the services GCS has to offer can “Like” and then receive updates from.
By signing up for the newsletter and Facebook page, these users have already shown an interest in DRS and are looking to seek rides through the system; their opinion and preferences are understood to be reflective of a DRS user, and provide excellent insight to their mindset, psyche and preferences. The survey was administered to 750 users, resulting in 260 responses; a rate of 35% (Table 4.1).

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Used DRS</td>
<td>109</td>
<td>35</td>
<td>144</td>
</tr>
<tr>
<td>Did not use DRS</td>
<td>107</td>
<td>9</td>
<td>116</td>
</tr>
<tr>
<td>Total</td>
<td>216</td>
<td>44</td>
<td>260</td>
</tr>
</tbody>
</table>

Table 4.1: Survey respondents by gender and DRS use (n = 260)

The survey asked respondents about their demographic information, existing travel habits, technological maturity, motivations for using DRS systems, activities for which they preferred to use DRS systems, their preferences for travel partners, role in a DRS setting (driver or passenger), and information about their last ridesharing activity. As an incentive to respond to the survey, the random giveaway of an Apple iPad2 was promoted, with a winner randomly selected at the end of the survey data collection stage.

4.1 Theoretical Framework: Ecological Theory and Dynamic Ridesharing

This thesis uses the socio-ecological model to conceptually describe the dynamic ridesharing process. This section begins with a description of dynamic ridesharing before specifying, in general terms, how the socio-ecological model can provide insight into understanding decisions about DRS. An adaptation of the theory is identified as being a potentially useful approach for understanding, conceptually, dynamic ridesharing processes. In the remainder of the section, dynamic ridesharing is framed using the SEM approach. This conceptual model is gradually translated into an operational logistic regression specification through an exercise in mapping survey data to the various levels of influence afforded by the adapted socio-ecological modeling approach. The section begins with an attempt to describe, using broad terms, the dynamic rideshare process, as a process that includes both planning and execution phases.
Identifying and planning an activity, irrespective of travel mode, is the earliest stage of executing an activity (e.g., a doctor’s appointment at noon; a concert at 7 pm with friends). Activity planning and travel planning (e.g., mode choice, route, etc.) could occur sequentially or simultaneously, and revisions over time and across space may also occur. Within this context, dynamic ridesharing (DRS) is a transportation mode available for individuals requiring near-immediate travel that have the abilities/capabilities and tools that enable participation in this mode. DRS is a derivative of regular carpooling, enabling the formation of carpools on an as-needed basis, usually on short notice. The process of dynamic ridesharing starts when it is considered as a possible travel mode for a particular activity, and ends at the conclusion of the trip executed to conduct the activity. The socio-ecological model can arguably help to provide an understanding of the decision making process an individual undertakes that leads to participation in dynamic ridesharing. The socio-ecological model does this by helping to deconstruct the varied factors that hypothetically shape the decision to use dynamic ridesharing into well-defined categories of influence.

When an individual decides to use dynamic ridesharing as the travel mode to complete a particular activity, it is conceptualized that the DRS process consists of two sub-processes for the individual: 1) selecting a dynamic ridesharing arrangement, 2) executing the selected DRS arrangement. The environments and influences for DRS selection are conceptualized here as being different from those encountered during execution. The two types of participants in a dynamic ridesharing activity are the driver and the passenger, and both have different experiences in either sub-process. In the selection process, a passenger may use the internet to find a suitable ride depending on his/her route and travel preferences, for example the type of vehicle desired and the cost of the trip. A passenger may contact trusted friends and family first to see if safe travel arrangements can be made, as they may be more apprehensive about sharing a ride with someone they do not know. In the selection process, a driver may use the internet to search for passengers who are within an acceptable driving distance. A driver may also be looking for passengers who are willing to share travel costs, and can respect the rules set by the driver (e.g., no smoking or eating). For both types of participants, the selection process would usually be
happening outside of a vehicle (e.g., home, workplace) before the trip starts. While there are some commonalities between the experiences of the driver and passenger in the selection stage (e.g., using the internet to search for a ride), the execution of a DRS arrangement is distinctly different for the driver and passenger. For the driver, this can mean waiting in a vehicle for a passenger, operating the vehicle, and obeying traffic laws. For the passenger, it could involve travelling to a designated meeting spot, waiting in a physical environment for a driver, modifying personal preferences/behaviours during the ride to accommodate the perceived or actual preferred norms of the driver (e.g., not smoking), or simply resting during the journey.

A holistic view of DRS should consider the selection and execution environments in both distinct and related terms, as the resources and skills available when selecting an arrangement can determine the quality of the execution. For example, a passenger could find him/herself participating in a longer journey than anticipated because they did not have access to key information such as the exact trip route in advance. A negative experience could potentially be attributed to the selection process, as it failed to yield the critical information that the individual needed to adequately forecast the quality of the arrangement. To facilitate a holistic analysis that accounts for such influences, this thesis applies the socio-ecological theory to DRS.

The adaptation of McLeroy et al. (1988) of the socio-ecological theory of Bronfenbrenner (1979) is used as a basis for conceptualizing an individual’s interaction with the dynamic ridesharing mode. The observations of Sallis et al. (2008) are also used to gain an understanding of the dynamics of interactions across various dimensions of the socio-ecological model. Specifically, it is hypothesized that interrelations between an individual and her/his environment can influence a mode choice decision that includes the dynamic ridesharing alternative. The general concept behind ecological models is that intrapersonal biological and social qualities and various types of environmental factors can influence the behaviour of an individual (Wicker, 1979). For example, influences can originate from intrapersonal biological traits such as age and sex; organizational settings such as the workplace; regulatory practices such as local laws; cultural factors such as language, religion, and
customs. Influences can be innate or acquired, and when accumulated, can affect certain choices while
discouraging others; the tendencies and decisions of an individual become a function of their environments,
personal circumstances/intrapersonal traits, and applicable policies.

The act of an individual executing a dynamic ridesharing activity is arguably influenced by a multitude of
factors spanning different levels of influence. Given a person’s environment, their propensity to use dynamic
ridesharing could differ depending on their value systems, the behaviour of their peers, the institutions they
belong to, the communities that house them, and the public policies that, while established at a macro level,
may limit or enable individual behaviours. Numerous ways of conceptualizing behavioural influences have been
developed; once such conceptualization, McLeroy et al. (1988), identify several categories of determinants of
behaviour, which are listed in Table 4.2.
### Table 4.2: Determinants of Behaviour, Source: McLeroy et al., 1988, pp. 355

<table>
<thead>
<tr>
<th>Factor Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intrapersonal</td>
<td>Characteristics of the individual such as knowledge, attitudes, behaviour, self-concept, skills, etc. This includes the developmental history of the individual.</td>
</tr>
<tr>
<td>Interpersonal processes and primary groups</td>
<td>Formal and informal social network and social support systems, including the family, work group, and friendship networks.</td>
</tr>
<tr>
<td>Institutional</td>
<td>Social institutions with organizational characteristics, and formal (and informal) rules and regulations for operation.</td>
</tr>
<tr>
<td>Community</td>
<td>Relationships among organizations, institutions, and informal networks within defined boundaries.</td>
</tr>
<tr>
<td>Public policy</td>
<td>Local, state, and national laws and policies.</td>
</tr>
</tbody>
</table>

Sallis et al. (2008) later described additional properties for these categories of determinants: 1) that behaviours interact across the levels; 2) that relevant influences must be identified at each level; and 3) that multi-level interventions are more effective in changing behaviour than single-level interventions. For example, if a transportation planning organization is to take actions aimed at increasing carpooling, the actions should span multiple spheres of influence such as imposing tolls (a public policy influence), providing ridesharing networks (a community-level influence), and employer-based initiatives (an institutional-level influence) (Dahlgren, 1998). Classifying the influencing factors into the spheres identified by the SEM creates a framework for research that considers a possibly more complete set of determinants that may cause an individual to consider dynamic ridesharing. This work is not causal in nature, however, and the best that can be hoped for is to gain new insights into factors that associate with DRS decisions and use.

Framing dynamic ridesharing within the socio-ecological model can potentially yield an understanding of existing usage patterns by bringing to light the key determinants that drive behaviour in both selection and execution stages. It may also provide some guidance in terms of the development of enabling policies and technologies (e.g., public policies, organizational incentives) developed to support both the selection and execution phases. Table 4.3 presents a conceptual framing of dynamic ridesharing, cast within the socio-
ecological model presented by McLeroy et al. (1988), and serves as the first step in the process of relating DRS influences to a socio-ecological model.
<table>
<thead>
<tr>
<th>Intrapersonal Factors</th>
<th>Interpersonal Factors</th>
<th>Institutional Factors</th>
<th>Community Factors</th>
<th>Public Policy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Selection</strong></td>
<td><strong>Household Structure:</strong> The composition of the household can limit/influence the travel options of an individual</td>
<td><strong>Employment/School:</strong> The location can lend itself to convenience by potentially creating shorter trips and/or encouraging group travel (e.g., school, work, concert)</td>
<td><strong>Safety:</strong> The extent to which society protects participants of a rideshare (e.g., panic buttons)</td>
<td><strong>Incentives:</strong> Whether there are incentives to choosing a DRS arrangement over another mode of travel (e.g., tax credits, faster travel through HOV lanes)</td>
</tr>
<tr>
<td>Need: The need or desire for mobility, required to take part in an activity</td>
<td>Sense of Responsibility: The individual’s desire to help the environment</td>
<td><strong>Social/Environmental Benefits:</strong> DRS may be seen as having a distinct social benefit</td>
<td><strong>Values:</strong> The manner and extent to which a community communicates, promotes, and rewards a particular travel mode can arguably influence how it is perceived and used in the community</td>
<td></td>
</tr>
<tr>
<td><strong>Affordability:</strong> DRS could be one of the limited options due to lack of fiscal resources for individuals in need of transportation, particularly the transport disadvantaged which typically includes females and the elderly.</td>
<td><strong>Technical Skill to find DRS:</strong> The skill to find a matching ride must exist (e.g., accessing a website, using a mobile phone), when a technological method for DRS selection presents itself.</td>
<td><strong>Institutional Policies:</strong> Employer-sponsored policies can provide incentives for shared travel, affecting mode choice</td>
<td><strong>Infrastructure:</strong> The infrastructure should be conducive to DRS (e.g., HOV lanes, easy pick-up)</td>
<td></td>
</tr>
<tr>
<td><strong>Affordability:</strong> DRS could be one of the limited options due to lack of fiscal resources for individuals in need of transportation, particularly the transport disadvantaged which typically includes females and the elderly.</td>
<td><strong>Ride Pool:</strong> Available networks which can be accessed to find a ride</td>
<td><strong>Incentives:</strong> Whether there are incentives to choosing a DRS arrangement over another mode of travel (e.g., tax credits, faster travel through HOV lanes)</td>
<td><strong>Traffic Laws:</strong> Speed limits, planned road closures, road restrictions (e.g., no access between a certain time), will have direct influences on the timing of the trip, making them factors when choosing travel modes</td>
<td></td>
</tr>
<tr>
<td><strong>Institutional Factors</strong></td>
<td><strong>Employment/School:</strong> The location can lend itself to convenience by potentially creating shorter trips and/or encouraging group travel (e.g., school, work, concert)</td>
<td><strong>Incentives:</strong> Whether there are incentives to choosing a DRS arrangement over another mode of travel (e.g., tax credits, faster travel through HOV lanes)</td>
<td><strong>Traffic Laws:</strong> Speed limits, planned road closures, road restrictions (e.g., no access between a certain time), will have direct influences on the timing of the trip, making them factors when choosing travel modes</td>
<td></td>
</tr>
<tr>
<td><strong>Community Factors</strong></td>
<td><strong>Safety:</strong> The psychological comfort-level and physical safety felt when sharing a ride with another individual</td>
<td><strong>Values:</strong> The manner and extent to which a community communicates, promotes, and rewards a particular travel mode can arguably influence how it is perceived and used in the community</td>
<td><strong>Infrastructure:</strong> The infrastructure should be conducive to DRS (e.g., HOV lanes, easy pick-up)</td>
<td></td>
</tr>
<tr>
<td><strong>Values:</strong> The manner and extent to which a community communicates, promotes, and rewards a particular travel mode can arguably influence how it is perceived and used in the community</td>
<td><strong>Incentives:</strong> Whether there are incentives to choosing a DRS arrangement over another mode of travel (e.g., tax credits, faster travel through HOV lanes)</td>
<td><strong>Traffic Laws:</strong> Speed limits, planned road closures, road restrictions (e.g., no access between a certain time), will have direct influences on the timing of the trip, making them factors when choosing travel modes</td>
<td></td>
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</tr>
<tr>
<td><strong>Infrastructure:</strong> The infrastructure should be conducive to DRS (e.g., HOV lanes, easy pick-up)</td>
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</tbody>
</table>

| **Execution** | **Physical Comfort:** The type of vehicle being used can have a bearing on the desirability of a ridesharing arrangement. For example, the opportunity to travel in a luxury vehicle may influence whether one repeats the arrangement | **Human Interaction:** Is the interaction during an arrangement deemed acceptable and repeatable to the individual? | **Safety:** The safety of the DRS participants is partly dependent on the quality of the driver, and the interactions in the vehicle that may distract the driver | **Driving Conditions:** The quality of roads, population density, and policing influence the quality of the trip |
| **Physical Comfort:** The type of vehicle being used can have a bearing on the desirability of a ridesharing arrangement. For example, the opportunity to travel in a luxury vehicle may influence whether one repeats the arrangement | **Human Interaction:** Is the interaction during an arrangement deemed acceptable and repeatable to the individual? | **Safety:** The safety of the DRS participants is partly dependent on the quality of the driver, and the interactions in the vehicle that may distract the driver | **Driving Conditions:** The quality of roads, population density, and policing influence the quality of the trip |
| **Driving Skill:** Having the ability to legally operate a vehicle while being a passenger may be attractive to a driver who is looking to share driving responsibilities | **Shared Values:** The degree to which DRS participants share beliefs, opinions, and values, could increase interest in and/or adherence to a DRS arrangement. | **Driving Conditions:** The quality of roads, population density, and policing influence the quality of the trip |

Table 4.3: DRS: Levels of Influence and Associated Factors (non-exhaustive)
Sallis et al. (2008) propose that the interaction of influences can affect the way variables relate to each other, which is at the nexus of understanding what individual and environmental characteristics produce dynamic ridesharing choices. For example, younger, technologically advanced students without access to an automobile could be more likely to seek DRS arrangements, than middle-aged, full-time workers with better access to an automobile. Intrapersonal variables such as age, technical skill, and employment status, can interact differently with interpersonal factors such as household composition, and access to automobiles, depending on the individual’s psychological and social influences.

A key hypotheses tested by the research is that by possessing greater technological literacy such as the ability to use smartphones and degree of exposure to internet, an individual can improve her/his chance of successfully organizing and executing a shared ride. As technological advances have shifted some of the search processes for DRS arrangements online, the skills required to find rides has changed (Section 1). When examining the shift of required skill in the framework of a SEM, the technical ability of a potential DRS user becomes a key intrapersonal factor; the ability to acquire this technical skill is also influenced by the financial, educational, and social resources available to the individual, thus making an individual’s technical ability a function of multiple. Respecting the key principle of multiple levels influencing behaviour presented by Sallis et al. (2008), the research also takes into account factors from different levels, such as household structure (interpersonal factors), and employment or school (institutional factors), amongst others. Including these factors allows for cross-sections of influences to be observed, and conclusions to be contextualized with respect to the categories of influences.

The factors that are hypothesized to have some influence on DRS participation include: age, gender, primary mode of travel, household structure, access to automobiles, preferred role in a DRS activity, employment status, and education level. These factors have been identified as having some influence over carpooling and ridesharing (Section 3), and will be further tested for relevance in dynamic
ridesharing. Data describing respondents along these dimensions were acquired from the Dynamic Ridesharing Preferences Survey, conducted between June 21 and July 13, 2011. The survey was designed by the author and informed by the conceptualization of DRS in the socio-ecological model. The factors that relate to the DRS process are organized in Table 4.4 according to the determinant categories proposed in McLeroy et al. (1988). Once the nature of how a factor relates to a determinant category is described, it becomes evident that most factors are influenced by multiple categories. This is consistent with the observation of Sallis et al. (2008) that behaviours interact across different levels in the SEM. This classification enables DRS use to be conceptually viewed through a wider lens, potentially enabling design of effective interventions aimed at increasing DRS use to be deduced.

While conceptually, DRS is composed of the selection and execution phases, the modeling exercise is specific to the execution phase, as it examines whether or not someone had participated in DRS at the time of survey. The definition of participating in a DRS is described in the survey question as “sharing of car journeys for one-off travel for any purpose and may be organized in any manner”. Therefore, it is important to note that the definition of participating in a DRS trip includes travel to a wide range of activities, ranging from going to a movie with friends after organizing the trip through text-messaging, to arranging a home-bound trip with a work colleague through face-to-face communication. The logistic model described in the next section models the factors that are believed to influence dynamic ridesharing as independent variables. These variables, as seen in Table 4.4, belong to varying spheres of influence and will be tested for having a bearing on DRS use.
<table>
<thead>
<tr>
<th>Intrapersonal</th>
<th>Interpersonal</th>
<th>Institutional</th>
<th>Community</th>
<th>Public Policy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
<td>Biological trait</td>
<td>Members of the same age group may associate with each other and partake in social activities (e.g., high school friends going to concerts)</td>
<td>Age often influences the organizations a person belongs to (e.g., high school, college)</td>
<td>Members of the same age group can form communities that may partake in joint activities and transport (e.g., senior citizen clubs)</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td>The biological and the social</td>
<td>Patriarchal households can impose restrictions on women’s activity-travel options</td>
<td>Spatial, social, and political organization of the economy contribute to different employment outcomes for males and females, affecting abilities to produce &amp; consume</td>
<td>Residential segregation can restrict mobility and impose boundaries on travel</td>
</tr>
<tr>
<td><strong>Primary Mode of Travel to School or Work</strong></td>
<td>Financial state can have a bearing on mode of travel</td>
<td>Influenced by family structure</td>
<td>Cars may be provided by employers</td>
<td>Community resources can determine availability of travel options</td>
</tr>
<tr>
<td><strong>Cars in Household</strong></td>
<td>An individual’s income influences how many cars they can afford</td>
<td>Influenced by family structure</td>
<td>Need for employment and education can be determined by state of household</td>
<td>Usually results in inclusion in an institution such as a company</td>
</tr>
<tr>
<td><strong>Employment</strong></td>
<td>Dependent on individual’s skill and ability</td>
<td>Cars may be provided by employers</td>
<td>Can result in inclusion in an institution such as a school</td>
<td></td>
</tr>
<tr>
<td><strong>Highest Education Level</strong></td>
<td>Acquired by an individual</td>
<td>Can result in inclusion in an institution such as a school</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong># of People Currently Living With</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong># of Licensed Drivers Currently Living With</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Used Smartphone to Plan Activity</strong></td>
<td>Individual skill</td>
<td>Can be dependent on circle of friends, and social networks</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Used Smartphone to Plan Travel to Activity</strong></td>
<td>Individual skill</td>
<td>Can be dependent on circle of friends, and social networks</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Ability to Operate Technological Devices</strong></td>
<td>Individual skill</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Internet Use</strong></td>
<td>Individual skill</td>
<td>The internet provides means to access friends and social networks</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4.4: Influence Level of Dependent Variables
5  Results

5.1  Descriptive Analysis

This section summarizes the results of the survey through a descriptive analysis that is informed by the broader literature on carpooling, gender and transport. The section is organized around ten themes: 1) demographics; 2) primary mode of travel to work or school; 3) technological characteristics; 4) activities conducive to DRS; 5) time, planning and frequency of travel; 6) role in a DRS arrangement; 7) motivation to use DRS; 8) organization of rides; 9) comfort-level when sharing rides; and 10) free-form respondent feedback. In order to view the differences in travel behaviour and preferences across males and females, the analysis controls for gender when presenting results, while contrasting respondents who had used DRS at the time of the survey, and those had not.

5.1.1  Demographics

A significantly higher number of males (83%) responded to the survey than females (17%). The three largest age groups were 20-29 (43%), 13-19 (18%), and 30-39 (17%). Figure 5.1 and Figure 5.2 show the gender and age distribution for all respondents. Respondents were asked whether they had used DRS in some capacity, 55% said that they had. A significantly higher proportion of females (80%) indicated that they had used DRS than males (51%) (Figure 5.3). The greatest proportion of DRS use was among 50-59 year olds (67%), followed by 13-19 year olds (65%) (Figure 5.4).
Figure 5.1: All Respondents – By gender

Figure 5.2: All Respondents - Age
Figure 5.3: All Respondents - DRS use by gender

Figure 5.4: All Respondents - DRS use by age
Males in the 20-29 age group accounted for 45% of all respondents, followed by females in the same age group (32%). In the 30-39 age category, females (23%) outnumbered males (16%). Approximately 42% of users who engaged in DRS travel were between 20-29 years old; the percentage declined sharply into the 30-39 age group (15%). The second-most popular age group for DRS was 13-19 (23%). Age appeared to not factor into DRS execution. Figure 5.5 shows respondent age groups. As suggested by the socio-ecological model, which classifies gender and age as influencing factors across all spheres of influence, it is not surprising that both factors have a strong bearing on travel behaviour: females tended to use DRS more frequently than males.

![Figure 5.5: All Respondents - Age Groups](image)

Almost half of all respondents were full-time workers (49%), 35% were full-time students. Part-time workers had participated significantly more in DRS (82%) than full-time workers (49%).
Employment is conceptualized as an influencing factor in the socio-ecological model, and as the descriptive analysis of the survey data shows, the hypothesis is supported through the finding that the nature of part-time employment translated to higher DRS rates. It could be hypothesized that the lack of regular hours aligns with the space-time flexibility afforded by DRS services. Full-time students (56%) were found to be more likely to use DRS than full-time workers; the latter were found to be mostly in the 30-39 age group (87%). For the 20-29 age group, 44% indicated going to school full-time, and 35% indicated working full-time. A higher number of female respondents (32%) worked part-time than men (9%), while more men (52%) worked full-time than women (39%). Figure 5.6 shows employment, education status, and gender of respondents who participated in DRS. The education level specified by 66% of respondents was that of a Bachelor’s Degree (or in the process of achieving one) or higher. Males indicated a higher education level than females (Figure 5.7). Overall, then, the responding sample was comprised of relatively highly educated, young adult males and females, who were either full-time students, or working full-time or part-time (in the case of females).
A higher percentage (62%) of respondents who had either completed, or were pursuing, undergraduate studies had participated in DRS, whereas only 52% of high school and 37% of post-
graduate students had done so. Of all respondents, 43% had completed their undergraduate studies, or were in the process of doing so. Of the respondents who had utilized DRS and had at least this education level, 66% were males and 54% of females, while of those respondents who had not used DRS and had the specified education level, 70% were males and 44% were females. This indicates that although male respondents were more educated, it did not translate to a higher DRS rate. Respondents in the 20-29 age group who had completed their undergraduate studies, or were in the process of doing so, were the most likely to use DRS.

5.1.2 Primary Mode of Travel

Public transit (34%) was the leading primary mode of travel for work or school, followed by car-as-driver (30%) and walking (22%). A greater proportion of females drove a car as their primary mode of travel, whereas men (35%) took public transit more than females (29%) (Figure 5.8). Females were also more likely to be auto-passengers than males. Respondents whose primary mode of travel was associated with an automobile in any capacity showed a higher tendency to use DRS. In contrast, public transit users were the least likely to use DRS. Figure 5.9 and Figure 5.10 show the primary mode of travel for work or school for DRS users and non-users by gender.
Figure 5.8: All Respondents - Primary mode of travel for work or school, and gender
Figure 5.9: DRS Users - Primary mode of travel to work or school, by gender

Figure 5.10: Non-DRS Users - Primary mode of travel to work or school, by gender
Of those respondents who did not use DRS, the following was observed: 1) females (44%) utilized the car-as-driver mode more than males (26%), 2) more males (42%) used public transit than females (22%). Generally, males used more public transit than females, and females were more likely to drive a car than males.

The distribution of automobiles across respondents was: zero (19%), one (32%), and two or more (49%). A greater proportion of female respondents (23%) indicated that they did not have any car in their household than males (18%). Respondents in the 20-29 age category who belonged to two-car households were the most populous group, followed by single-car households in the same age group (Figure 5.11 and Figure 5.12). The data suggest that DRS users were generally coming from households with relatively higher levels of auto-ownership than non-DRS users.

Figure 5.11: DRS Users - Cars in household by gender
5.1.3 Technological Characteristics of DRS Users

Respondents who had used DRS (71%) showed a greater tendency to use smartphones to plan daily activities than those who had not used DRS (60%). A slightly greater proportion of males used smartphones to plan activities than females (Figure 5.13). The same held true for respondents who indicated that they used smartphones to plan the travel related to their daily activities. Respondents who use smartphones to plan travel were more likely to use DRS than those who did not.
The use of a smartphone to plan activities and travel to activities is conceptualized in the socio-ecological model as influencing mobility. Day-to-day usage of smartphones was gender-neutral for both, planning daily activities, and for the planning of travel related to those activities. Almost 73% of respondents indicated that they were able to use various types of devices (smartphones, laptops, tablets, GPS) at the very least, adequately. Over 94% felt they could use laptop and desktop computers easily, and 77% felt the same about smartphones (Figure 5.14). The degree of familiarity and comfort using these devices did not appear to influence whether a user had utilized DRS. Respondents who planned activities and travel using smartphones showed a higher chance of using DRS; technical competency on its own did not appear to correlate with DRS use for males or females.
DRS users displayed a slightly greater tendency to utilize the internet both at home and away from home. More respondents (60%) reported low internet usage away from home (Figure 5.15) than at home (20%) (Figure 5.16). High home internet use corresponded to a greater chance of using DRS for males. Low internet use away from home corresponded to a lower chance of using DRS for females (Figure 5.17, Figure 5.18).
Figure 5.15: DRS Users - Away internet use by gender

Figure 5.16: DRS Users - Home internet use by gender
Figure 5.17: Non-DRS Users - Home internet use by gender

Figure 5.18: Non-DRS Users - Away internet use by gender
5.1.4 Activities Conducive to DRS

The DRPS asked respondents to state what type of activities they are most likely to use DRS for, and what category their last DRS activity was classified as. Respondents could select from a pre-defined activity typology: 1) work, 2) recreation and leisure, 3) personal, 4) major shopping, 5) minor shopping, and 6) other. Responses for both questions reflected a heavy tendency to use DRS for activities concerning recreation and leisure, for example, concerts, parties, and restaurants. Sixty-four percent of respondents indicated that they were likely to use DRS for leisure activities, whereas 66% denoted that their last DRS activity was related to leisure. Leisure activities are often enjoyed by groups of friends, possibly in similar age groups, and individuals belonging to the same institution or community (e.g., college, interest circles) can form groups which partake in leisure activities at the same time. This can create a need for mobility for clusters of individuals, who might use dynamic ridesharing since group travel activities are likely to have the same destination.

Respondents were asked to state the type of activity they would generally prefer to use DRS for, and the type of activity that their most recent DRS arrangement facilitated. The general preference to use DRS for leisure activities was indicated in similar proportions by males (65%) and females (71%) (Figure 5.19). Females were more likely to indicated DRS use for shopping (19%) than males (5%). Males (20%) used DRS for work more than females (6%). When asked about the last DRS arrangement executed, 71% of males said that it was related to recreation and leisure, 52% of females answered similarly. The last DRS activity for 21% percent of females was shopping, whereas only 4% of males indicated the same. While the specific type of shopping (beyond major or minor) was not specified, the gendered nature of DRS-enabled shopping activities may potentially speak to gender-differentiated household roles and responsibilities.
5.1.5 Time, Planning and Frequency of DRS Travel

The time of the activity, day (51%) or evening (49%), was not a factor for users who participated in a DRS activity related to leisure. Only 14% stated that their last DRS activity was work-related, with such travel occurring more in the day (60%) than evening (40%). Shopping-related DRS travel mostly took place during the day.

The majority of the organization and planning associated with DRS travel happened at a user’s home (67%) rather than work (23%). There were no cases of travel being planned in real-time (e.g., public transit vehicles). The primary location of users prior to embarking on their DRS travel was also found to be their home (78%) (Figure 5.20 and Figure 5.21). The average time it took to travel to a DRS activity was 45 minutes, and the median travel time was 30 minutes.
Respondents were asked to select DRS frequency from a pre-defined typology: 1) everyday, 2) a few times a week, 3) about once a month, and 4) less than once a month. The frequency of DRS use
was: once a month (39%), a few times a week (38%), and less than once a month (21%) (Figure 5.22). The two major response categories for both males and females were “a few times a week”, and “about once a month”. Females chose each of these options 36% of the time, whereas males chose them 39% and 41% of the time, respectively. The data appear to indicate that while females were more likely to have used DRS at least once, males tend to use it more regularly.

5.1.6 Role in DRS Arrangement

Of respondents who provided information about their last ridesharing activity, 59% had access to a motorized vehicle, and 37% did not. Amongst the former group, 62% played the role of driver. Of the latter group, 93% played the role of passenger. Therefore, those had access to an automobile drove, and those that did not, were passengers. The preference for being a driver or passenger was even across the survey population, although females appeared for likely to prefer being a passenger, and males appeared to prefer the driving role (Figure 5.23) (Figure 5.23).
More females (73%) indicated riding as a passenger than males (56%). More males drove (44%) than females (27%). The role preference of passenger was more often satisfied (89%) than the role preference of driver (69%). Respondents who did not indicate a preference for either role found themselves as passengers (58%) more often than drivers (42%). Males had a greater chance of achieving their preferred driving role than females. Levin (1982) studied the preferred role of men and women in a traditional carpool setting. He found that women least preferred the option to drive in a carpool, while men least preferred to ride as passengers. These findings perhaps speak to issues of control, or power asymmetry in a mobility setting – reflecting who it is that actually possesses the car used to execute the carpool, or as is the case here, the DRS arrangement.

Figure 5.23: DRS Users - Role preference by gender

5.1.7 Motivation for DRS
The three leading motivating factors for using DRS were: 1) savings on vehicle operating costs, 2) convenience through time-savings, and 3) a desire to help the environment (Figure 5.24). While males and females appeared to have similar motivations (Figure 5.25), there were two noteworthy differences: more females cited environmental concerns (55%) than men (40%); more males cited expanding their social circle (28%) than women (16%).

Figure 5.24: DRS Users - Motivations for ridesharing (check all that apply)
5.1.8 Organization of Rides

The majority of respondents (68%) organized their last DRS activity using a mobile device, whereas fewer individuals used face-to-face communication (32%) and email from a computer (21%) (Figure 5.26). The majority of males (73%) used mobile phones to organize DRS activities, whereas 50% of women did the same (Figure 5.27). Females preferred using face-to-face communication more than males (39% to 30%). Females (26%) used third-party DRS organization tools such as websites more than men (9%) (Figure 5.28, Figure 5.29).
Figure 5.26: DRS Users - Communication means when organizing rides

Figure 5.27: DRS Users - Communication means when organized last DRS activity, by gender
Figure 5.28: DRS Users - Communication preference for DRS

Figure 5.29: DRS Users - Communication preference for DRS by gender
5.1.9 Comfort Level in Sharing Rides

Respondents were asked to categorize how comfortable they were sharing rides with household members, work colleagues, friends, someone they have met online, and someone they have never met. The choices to specify the level of comfort were: 1) not comfortable, 2) somewhat comfortable, and 3) very comfortable. The number of respondents who stated they were very comfortable sharing a ride with a household member (93%) was significantly greater than those who indicated the same with a work colleague (57%), or online acquaintances (5%). For the latter, 52% indicated some level of comfort while 43% stated that they were not comfortable. The majority of respondents (70%) were not comfortable sharing rides with someone they had never met (Figure 5.30).

![Figure 5.30: DRS Users - Comfort-level when sharing rides](image-url)
Sharing rides with household members, work colleagues, and friends, in that order, were indicated as the most comfortable scenarios for both genders. The types of people that DRS users felt comfortable sharing rides with were similar across genders. The only notable differences were that more females (61%) were very comfortable sharing rides with co-workers than males (54%), and that every female DRS user stated that they were very comfortable sharing rides with household members, whereas 91% of men did the same. Compared to males (Figure 5.31), females (Figure 5.32) indicated a slight apprehension when sharing rides with someone they had only met online. The concerns for security and need for safety when sharing rides is well-recognized (Tao and Wu, 2008) and gender (conceptualized as a strong influencing factor in the socio-ecological model) is a potentially key determinant in how comfortable a person is when sharing rides and with whom.

Figure 5.31: DRS Users - Comfort-level sharing rides for males
Respondents commented on what they liked and disliked about their last DRS activity. The positive responses highlighted the cost-effective nature of DRS, while indicating that DRS was a social activity as well. Users were aware of the environmental consequences of SOV-use, one respondent even deeming it as “plain wrong”. Time-savings were also cited as a positive, especially when compared to public transit. There was an underlying social conscience amongst the respondents, who saw DRS as a means towards expanding their social circle, helping others, saving on time and cost, and doing their part in improving the environment.

The negative characteristics of DRS cited included dependency on others, hygiene issues, restricted travel times, relinquishing control, apprehensiveness regarding travel with strangers, and not getting along with others in the automobile. The most cited concern was the problems resulting from the dependency on others. Respondents felt that the lack of DRS options required them to accept departure times that were not ideal. There was also considerable frustration when arranged rideshares
fell through due to other party not showing for pick-ups. Agreeing on a car environment (e.g., music, air conditioning levels) was also seen as a challenge. One of the more prevalent complaints about DRS was that it was hard to organize due to the complicated travel schedules produced due to ever-changing plans.

5.1.11 Summary of Descriptive Analysis

The main findings of the descriptive results include: females were more likely to use DRS than males; respondents were more likely to use DRS for leisure-based activities; males and females have different motivations when using DRS, with males expressing an interest in social network expansion and more females indicating environmental concern; respondents were most comfortable sharing rides with household members, and females were less comfortable with strangers; planning associated with DRS travel happened primarily at home; females preferred riding as passengers more than males; respondents who had used DRS were also more likely to use smartphones to plan activities or travel, than those who had not used DRS; part-time employment translated to higher DRS use. The next section explores, in greater detail, some of the demographic, technological, and mobility-related factors that were shown to be relevant in the descriptive analysis, but in a multivariate context.

5.2 Logistic Regression Analysis and Results

This section starts by identifying a statistical model in which to analyze the results of the DRPS. The relationship between the statistical model and the socio-ecological model is explained, and the elements of the statistical model are described, with particular focus on their relevance to the research question of what factors influence an individual’s participation in dynamic ridesharing.

5.2.1 Statistical Model

A logistic regression model is constructed to study the relationship between DRS use and its influencing factors. The model does not explicitly look at planning and execution as conceptualized earlier, rather, it
is specified with a view to identifying correlates of DRS participation (respondent use or not of DRS at the time of survey). The linear logistic regression model is a commonly used technique for describing the relationship between a binary-form dependent variable (e.g., survival or death from heart disease) and a set of explanatory categorical variables (e.g., high, medium, or low cholesterol level). The model takes the form of:

\[ y = \alpha + \beta_1 x_1 + \ldots + \beta_n x_n + \varepsilon \]

In the above equation, \( y \) represents the dependent variable; \( x_1 \ldots x_n \) represent the set of explanatory variables; \( \beta_1 \ldots \beta_n \) are the regression coefficients; and \( \varepsilon \) is the error term which signifies factors other than the explanatory variables that influence the dependent variable. The dependent variable in this model is the binary representation of whether an individual has used dynamic ridesharing or not at the time of the survey. The factors that influence this decision are the explanatory variables, and relate to the factors placed in the socio-ecological framework developed in the previous section. Although the factors in the socio-ecological framework are closely mapped to the explanatory variables in the regression model, the mapping is not a direct one (i.e., one SEM factor to one explanatory variable) due to certain interactions and statistical relations between the explanatory variables.

Logistic regression models that are estimated with too many independent variables can result in regression coefficients being biased in both directions. In order to avoid such pitfalls, the understanding of the events per variable (EPV) concept is important. EPV is the ratio of the number of cases in the category of the dependent variable with the smallest number of cases, to the number of independent variables in the model. Peduzzi et al. (1996) recommended that a minimum of 10 events per independent variable be present in order to avoid biased coefficients. In the binary logistic regression model that is described in this study, there are 112 cases where survey respondents indicated an answer
of ‘no’ to whether they have used DRS or not. As recommended by Peduzzi et al. (1996), of an allowable 11, there are 10 independent variables used in this study.

**Gender**

The DRPS asked each respondent to report their gender. Although the issue of diversity with regard to gender and sexual orientation is acknowledged, the survey limited the categories to male and female. The variable values were represented in binary form, males were encoded as 0, and females were encoded as 1. A significant amount of research has been conducted on gender and travel behaviour. Most of the research has focused on commuting, with attention given to housing choices, distances, household composition, socioeconomic characteristics, mode choice, and activity travel patterns. Key findings have included the discovery that women tend to pair their commute with household responsibilities, thus making their travel patterns more complex (Novaco and Collier, 1994). Research has centered on the recognition that the mobility behaviour of women is changing at a faster rate than men, and that a general increase in travel demand for women over the last three decades has produced, at both ends of the income gradient, some convergence in travel outcomes (Crane, 2007). While gender has been studied in relation to carpooling – less is currently known about female/male experimentation with DRS. Gender is represented in the socio-ecological model as having influences across the five spheres of influences, and is included in the regression model as a single binary variable (see Table 4.4).

**Age**

The DRPS asks the respondent their age by category. The categories are condensed in the statistical model and are represented as three binary variables: 13-19, 20-39, and 40 or more. For each variable, a 1 represents a respondent within the age range, and 0 outside it. The 13-19 range is a representation of youth, the age group of 20-39 represents an individual’s most productive years, and over 40 is used as a referent in the model. Age is also viewed as a factor that influences DRS use in the socio-ecological
framework, with research indicating it to have a bearing on mode choice, number of trips, and trip
duration (Newbold et al., 2005). It is also expected that younger people are more likely than older
people to engage in novel experiments which might involve higher risk (Han et al., 2010). The tendency
of a person’s age to influence his/her travel behaviour warrants the variable’s inclusion in the socio-
ecological and statistical models, where it is represented as a single factor and variable, respectively (see
Table 4.4).

**Household Size**

The size of the household is represented as a continuous variable indicating the number of persons
living in the respondent’s household. The survey asks the respondent to provide household person
counts in three different age categories, but for the purposes of the model they have been condensed
into a single variable. The socio-economic represents household size a single influencing interpersonal
factor.

**Access to automobiles**

The access to automobiles is modeled here as the ratio of number of household vehicles to licensed
drivers. It is expected that people with greater access to automobiles will be less likely to use ridesharing
options (Buliung, et al., 2009). The socio-ecological model includes the number of household vehicles
and the number of licensed drivers as separate factors because they belong to varying spheres of
influence. In the statistical model, the two factors are combined to form one continuous variable which
indicates an individual’s access to automobiles (see Table 4.4).

**Travel Planning Using Smartphones**

The model represents the planning of travel related to activities using smartphones by encoding a
respondent ever having planned travel to an activity as 1, and not having done so as 0. The Travel
Planning Using Smartphones variable, along with Activity Planning Using Smartphones is a strong indicator of the affordance offered by the technology, especially as an enabler of activity and travel planning. A Chi-square correlation test was performed between both variables, and the two were found to be correlated, as dynamic ridesharing is a travel arrangement driven by activity demand. The socio-ecological model represents both variables as distinct factor belonging to multiple spheres of influence. However, the Activity Planning Using Smartphones variable is not present in the statistical model due to the aforementioned correlation. To reflect smartphone use for travel planning in the regression model, only the Travel Planning Using Smartphones is used (see Table 4.4).

Technical Competence

The technical competence is a measure of how adept a user is at using ICTs. These data are extracted from the DRPS through a Likert scale question which asks the respondent to grade their ability to use smartphones, desktop and laptop computers, tablet computers, and automobile or GPS navigational devices. Respondents are asked to grade their ability to use these devices in terms of ‘Easily’, ‘Adequately’, ‘Cannot Operate’, and whether they own or use the device. This is an assessment-based metric that gauges technical competence by canvassing the respondent’s evaluation of his/her technical competence; this approach is different than a performance-driven metric where a respondent would be tested on their ability. The statistical model represents technical competence as a binary variable, where a value of 1 represents respondents who have rated their ability higher than average for all respondents, and 0 as those who have indicated their ability to be below the average for all respondents.

This variable is derived by assigning a value of 0, 1, and 2, to ‘Cannot Operate’, ‘Adequately’, and ‘Easily’ for all devices, respectively. If a respondent has indicated that they do not use the device, it is also reflected as a value of zero. The average rating for all devices is calculated per respondent; this is
then divided by the average rating across all devices for all respondents, resulting in a value that indicates a respondent’s relative competence to the sample size. A value greater than 1 is modeled as a 1 in the statistical model, and a value less than 1 is modeled as a 0.

Although smartphone use has been rising at a rapid pace throughout the world (International Telecommunications Union, 2011), and gaining on traditional desktop use, and high use of modern technology such as smartphones is raising the bar for an individual to be termed as having high technical competence, this study does not ascribe a weight to the devices when assigning competency scores. This is done in order to avoid making assumptions regarding the manner of device use and complexity, as the proliferation of smartphones, tablets, GPS devices, and laptops, have resulted in an innumerable amount of varying interfaces which differ in ease of use. In general, the expectation is that more technically advanced users will have perceived such technologies as being useful, and would thus acquire access to the technologies, creating a cyclical relationship that incrementally builds technical skills (Park and Chen, 2007). For example, a person interested in dynamic ridesharing would have recognized the value of having access to real-time, location-sensitive ridesharing information, and would invest in such devices; the continual use of the devices would build their technical competence, and would result in them rating their ability higher in the survey.

The socio-ecological model represents technical competence as an intrapersonal factor by relating it to the skill of an individual. The statistical model also uses a single variable, with the key difference being that, whereas the socio-ecological model assumes competence to be proven, the statistical model determines the skill using an assessment-based approach (see Table 4.4).

**Internet Use**

In addition to technical competence, internet usage is also considered in the statistical model. The survey asks respondents to state the range of time they use the internet at home, and away from home.
The ranges available for selection are 0-10, 11-20, and more than 20 hours. They correspond to low, medium, and high use, respectively. The responses to these two questions are modeled as a single binary variable in the regression model. A 1 indicates respondents two indicated high internet use both at home, and away from home, while a 0 indicates all other responses. Internet use is modeled a single intrapersonal factor in the socio-ecological model.

**Primary Mode of Travel to School or Work**

A respondent’s primary mode of travel can be an indicator of their reliance on automobiles; this is especially the case when their primary mode of travel is being a driver in an automobile. In order to model the impact of having “car as driver” as the primary mode of travel, the study models primary mode of travel as a binary variable. A 1 indicates the “car as driver” travel mode, and 0 indicates all other models of travel. To remove the endogeneity that would result in having car-sharing modes such as “car-sharing as driver” and “car-sharing as passenger” predict dynamic ridesharing, cases where respondents selected those modes were removed from the model. In total, 18 cases were removed. The primary mode of travel is also stated as an influencing factor spanning three spheres in the socio-ecological framework. It is included in the statistical model to test the effect of travel mode on DRS use (see Table 4.4).

**Full-time Employment Status**

Fixed schedules tend to correspond to fixed travel patterns (Lee and McNally, 2003). The survey attempts to determine the impact of fixed schedules on DRS by asking the user to state their work and involvement (part-time or full-time). An indication of a full-time status for work is modeled as a 1, and indication of a part-time status is modeled as a 0. The work status of an individual to work is listed as a factor in the socio-ecological model because it can affect their schedule and transportation needs; the regression model accounts for this information in a similar manner, i.e., viewing the full-time as the key
indicator. A Chi-square test indicated that education levels were closely interrelated with full-time work status: higher education levels indicated a full-time employment status, and therefore education levels were removed from the model. However, in the socio-ecological model, education level remains an influencing factor belonging to the intrapersonal and institutional spheres of influence (see Table 4.4).

5.2.2 Results of Unadjusted and Adjusted Correlations

This section presents the results of the logistic regression analysis. Unadjusted correlations between the dependent variable (respondent used DRS) and each independent variable are presented, with emphasis given to variables that are statistically significant. Results of the logistic regression model are then presented. The results of the unadjusted correlation analysis are reexamined in light of the results of the regression model, and the significance of the independent variables to DRS use is presented.

Unadjusted Models

The unadjusted correlation of a dependent variable and an independent variable is simply a linear logistic regression model with one independent variable. It takes the form of:

\[ y = \alpha + \beta_1 x_1 + \varepsilon \]

In the above equation, \( y \) represents the dependent variable; \( x_1 \) is the sole independent variable, and \( \varepsilon \) is the error term which signifies factors other than the explanatory variable that influence the dependent variable. Table 5.1 contains the unadjusted correlations for the nine independent variables.
The unadjusted correlations reveal that gender is correlated with DRS use while other variables were not. Demographic variables such as age, employment status, and household size, which have been strong predictors of travel behaviour in other studies, did not emerge as correlates of DRS use here. The same holds true for the mobility-related variables of primary mode of travel, and access to automobiles. Although technical skill is required to access services that facilitate DRS arrangements, presence of the skill is not in itself an indicator of having used DRS at the time of survey. The familiarity and ability to operate ICTs, travel planning with smartphones, and internet use were not found to be correlated with the DRS use at the time of survey.

### Adjusted Models

The results of the adjusted logistic regression model are presented in Table 5.2. Unlike the unadjusted correlations which consider a single variable’s relationship with the dependent variable, the adjusted
correlations demonstrate how the effect of any one variable changes with the introduction of others into the model.

<table>
<thead>
<tr>
<th>Fixed Effect</th>
<th>B</th>
<th>p-Value</th>
<th>OR</th>
<th>OR ± 95% CI Lower</th>
<th>OR ± 95% CI Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-1.085</td>
<td>.108</td>
<td>.338</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Demographics</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender (reference: male)</td>
<td>1.398</td>
<td>.001</td>
<td>4.46</td>
<td>1.788</td>
<td>9.156</td>
</tr>
<tr>
<td>Age 13-19 (reference: 40 and over)</td>
<td>.460</td>
<td>.381</td>
<td>1.584</td>
<td>.566</td>
<td>4.430</td>
</tr>
<tr>
<td>Age 20-39 (reference: 40 and over)</td>
<td>.381</td>
<td>.312</td>
<td>1.464</td>
<td>.699</td>
<td>3.069</td>
</tr>
<tr>
<td>Working Full Time</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(reference: not working full-time)</td>
<td>-3.66</td>
<td>.263</td>
<td>.694</td>
<td>.561</td>
<td>1.469</td>
</tr>
<tr>
<td>Household Size</td>
<td>.123</td>
<td>.156</td>
<td>1.131</td>
<td>.954</td>
<td>1.341</td>
</tr>
<tr>
<td>Mobility</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary Mode of Travel</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(reference: car-as-driver)</td>
<td>.541</td>
<td>.100</td>
<td>.694</td>
<td>.366</td>
<td>1.316</td>
</tr>
<tr>
<td>Access to Automobiles</td>
<td>-.097</td>
<td>.694</td>
<td>.908</td>
<td>.561</td>
<td>1.469</td>
</tr>
<tr>
<td>Technology Profile</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technical Competence</td>
<td>.009</td>
<td>.976</td>
<td>4.046</td>
<td>1.788</td>
<td>9.156</td>
</tr>
<tr>
<td>Smartphone used for travel</td>
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<td>.215</td>
<td>1.471</td>
<td>.799</td>
<td>2.707</td>
</tr>
<tr>
<td>High Internet Use</td>
<td>.307</td>
<td>.517</td>
<td>1.360</td>
<td>.536</td>
<td>3.449</td>
</tr>
</tbody>
</table>

Table 5.2: Logistic Regression Results of DRS Use (n=240)

The adjusted correlations again demonstrate a strong gender effect, compared to other variables that, with the exception of primary travel mode to work/school, show little statistical evidence of an association with DRS use at the time of survey. Primary travel mode to work or school was marginally significant and positive (p ≤ .10). Males were the referent category for gender, and they were found to be significantly less likely to execute DRS arrangements than women. Specifically, 78% of females were able to execute a DRS arrangement, whereas only 48% of men did the same.
6 Discussion

In this thesis a socio-ecological framework was developed to first conceptualize the DRS process. This was followed by empirical analysis of activity-travel data collected from a sample drawn from a specialized population; individuals registered in a DRS application database. Survey data were mapped to influencing factors using the socio-ecological specification, and then, where possible, used in logistic regression analysis of DRS use. The descriptive analyses of the data provided a view to the activities, travel preferences, and behaviour captured within the sample. From the outset, gender emerged as an important concept in affecting DRS use. The regression model reinforced the importance of gender in DRS use, females were significantly more likely to execute DRS arrangements than males, and suggested that, controlling for other mobility and technology factors, gender – as both a sociological construct and was the most significant correlate of DRS use.

The use and knowledge of ICTs was hypothesized as being significant to DRS use but analyses revealed a relatively homogenous picture of ICT-use and technical competence. The overwhelming significance of the gender suggests that within a specialized group of technologically enabled individuals interested in dynamic ridesharing, the influence of technology and ICT competence is limited when compared with who people are, and how – who they are, affects their mobility experience. At the time of survey, female users had executed a larger share of DRS rides than males. This result may suggest that DRS is another example of the gendered nature of mobility.

Understanding the gender effect found here requires some social and cultural contextualization. Specifically, individuals must be viewed as being embedded in entities such as household, neighborhood, and regions in order for an understanding of why gender influences mobility to be developed (Hanson, 2010). In addition, how an individual views their own role in society in terms of ascribed or prescribed responsibilities, accepted behavioural norms, and social and cultural
expectations, is central to their degree of mobility and may dictate mobility options. Whether an individual’s mobility options and preferences are the results of a choice or constraint may also produce the sort of outcome seen here. For example, DRS may be seen as a less desirable mode of travel due to the dependency on others, and only when an individual is constrained in their mobility choice, would they choose a less preferred option. This is especially the case for females, who have historically experience greater mobility constraints.

Female rise in labour force participation, in conjunction with sustained household responsibilities has produced temporal and spatial travel constraints. For example, women’s labour force participation in Canada rose from 70% in 1986 to 81% in 2005 (Statistics Canada, 1985; Statistics Canada, 2005). During this period, the time women spent at work has also increased by 0.7 hours (a greater increase than men) (Statistics Canada, 1985; Statistics Canada, 2005). This larger workplace role has not coincided with any decrease in household responsibility. Although more men are contributing to unpaid household work (a rise from 72% to 79%), women have maintained their rate of performing household work at 90% during this period (Statistics Canada, 1985; Statistics Canada, 2005). The trend in the U.K is similar: female participation in the labour market increased by 7% between 1984 and 2002. This increase has coincided with women continuing to perform more unpaid household work than men, although men are contributing more time to household work than before. On average, women spend four hours 40 minutes on domestic responsibilities, whereas men spend two hours and 28 minutes (Office for National Statistics, 2011). Domestic responsibilities for females can generate travel demand (e.g., children’s activities), while the increase in work commitments has the potential to do the same.

It is important to make the distinction that it is not an individual’s biological sex that influences that mobility, but the way gender shapes access to key resources such as skills, technology, activities, and social networks that influence travel activity and behaviour (Law, 1999). A manifestation of this
thinking can be seen in the survey data collected, where females had a positive correlation to access with automobiles (automobiles per licensed drivers in households), but were still left to rely on creative options such as DRS to fulfill their travel needs. In other words, although a vehicle may have been available in the household for the DRS activity, females were either less likely to choose to use it, or were unable to use it due to some constraint (e.g., licensing, partner or spouse using the vehicle). Although other factors such as driver licensing and desire to drive can impact an individual’s decision to use DRS in favor of driving, it is interesting to observe this relationship between gender and alternative transport in the presence of self-reported access to automobiles.

In the U.K., females make 5% more trips than males, but for the car-sharing as passenger mode, females make a staggering 62% more trips than males (Department for Transport, 2010). In addition, although difference between male and female licensing is in decline, with the gap halved in the last 15 years, as of 2010, 21% more men had driver licenses than women (Department for Transport, 2010). The high percentage of DRS rates amongst females in the Edinburgh study area may also be explained by gendered access to automobiles. In U.K. households, there are more females without access to automobiles than males, which can drive the need to seek alternate travel options such as dynamic ridesharing. For households with automobiles, men were found to be the primary drivers of vehicles (Department for Transport, 2010). When males and females share an automobile, it is the male that has greater access to the automobile. The determinants of this access have been the subject of significant research (Cristaldi, 2005; Polk, 2003; Root, 2000), which has observed that females have generally less access to mobility options while arguably having a greater need for mobility.

The regression analysis found the primary mode of travel to be significant ($p \leq .10$). With auto driver as the referent category, the result indicates interest in DRS from the part of the traveler market typically using other so-called sustainable alternatives (public transit for example). This suggests that
DRS, an auto-based mode, could compete for market share, perhaps, with active modes and transit services financed through the public purse. The descriptive analysis also showed that of those DRS users who also used public transit, females comprised a higher percentage. Females have been shown to use public transit more than males (Cristaldi, 2005; Polk, 2003) and, as this thesis has shown, this is true in the context of the specialized population of users interested in DRS as well. The difference between whether this is a choice or constraint is hard to discern (Hanson, 2010), but the consistency in which females continue to utilize public transit under different circumstances reflects the influence of gender outcome, irrespective of the direction of the relationship.

The significance of gender in DRS use, as illustrated by the regression model, supports the conceptualization, in this thesis, of the DRS process using the socio-ecological model. Conceptually, gender and age were the only factors that spanned all five spheres of influence in the socio-ecological framework: intrapersonal, interpersonal, institutional, community, and public policy. Gender is an interpersonal factor that influences mobility, with household context, whether imposed or chosen, a central factor affecting labour force participation, mobility options, decisions, and outcomes. Travel behaviour and patterns by gender and other demographic characteristics have been examined in the literature, with the research focusing on distance, travel mode and purpose. Doyle and Taylor (2000) centered their research around ethnicity, whereas Pucher and Renne (2003) focused on age, income, amongst others. This work has produced a better understanding of how men and women from different races, ethnicities, income levels, and occupations travel (McLafferty and Preston, 1991). The underlying consensus in these studies has been that, although travel behaviour differs across socioeconomic and demographic groups, travel behaviour for women is changing across all groups due in part to chaining household roles and participation in the labour force. It is not surprising, then, that gender emerges from this thesis as a key factor related to the completion of a DRS based activity, gender appears as a universally challenging theme in travel behavior research.
Pisarski’s study of U.S. travel examined travel modes and found that both genders’ share of major travel modes was very similar (Pisarski 2006). The study also analyzed trip lengths and the time men and women left their homes for the morning commute. The findings for both were consistent with earlier results relating to women having more household responsibilities: women tend to make a greater amount of shorter trips to meet household needs, and thus leave for their work-commute later in the day. This sort of complexity with regard to activities and scheduling is precisely the type of activity-travel pattern that flexible mobility tools like DRS systems are designed to accommodate. This finding is further supported by studies that have indicated females to be more likely to rideshare, and more willing to rideshare than men. Buliung, et al., (2009) studied carpooling, concluding that females were 1.3 times more likely to form successfully carpools than men. Patterson, et al. (2005) reached a similar conclusion based on suburban survey data. Ferguson (1995), which analyzed US national survey data to comment on socioeconomic and demographic factors that might affect carpooling, concluded that women with children were more likely to form household-based carpools. Carpooling and dynamic ridesharing are not the same thing, and so the finding that females tend to successfully use DRS more often than males is unique, providing one more example of how gender relates with mobility.

Belk (2010) suggest that for some women, tendency toward feeling greater responsibility than men towards their families affects their travel options and preferences (Belk, 2010). The multitasking role of women in the household, and their increasing participation in the employment market has also been shown to influence travel behaviour (McLafferty and Preston, 1991). In addition, the safety of the environment may also be a greater concern for women, with fears such as vulnerability to assault resulting in avoidance of certain places during certain times (Valentine, 1989; Pain, 1991). The coupling of household responsibilities, labour market constraints, and the gendered perception of mobility related safety risks, suggests that any analysis of travel choice or preference must consider gender as a central theme (Hanson 2010).
A significant amount of the gender-transport discourse has focused on commuting distances, and travel activity, less attention has been paid to how males and females construct and engage in carpooling, or other forms of shared rides. Much of the research on ridesharing and gender has focused on how rides are shared between genders, the preference for roles in ridesharing situations, propensity to rideshare based on travel constraints, and the general preferences of genders given discrete choices (Patterson et al, 2005; Levin, 1982). The research suggests that women tend to rideshare more than men (Patterson et al., 2005), and women prefer the role of passenger in a ridesharing setting more than men (Levin, 1982). The research has been narrow and too focused on journey-to-work travel, with key relevant issues being ignored (Law, 1999). The research has not fully examined the motivations, intentions, and psychology behind shared mobility. This thesis has attempted to address some of these knowledge gaps. For example, motivations behind seeking shared mobility through a DRS arrangement appear to be gendered, with males looking at the arrangement as a social opportunity more than females. In contrast females tended to seek shared mobility for environmental reasons more so than males. More work is needed here, though, at the intersection of psychoanalytic and feminist perspectives on shared mobility strategies.

At an institutional level in the socio-ecological model, gender is theorized as contributing to different employment outcomes within a constrained labour market, which affect the ability to consume mobility. Viewing this institutional influence from the perspective of employment location, a Department for Transport (2010) report found that 80% of females commute to the same place every day, whereas 67% of males do the same. It can be theorized that females, facing greater employment constraints than males, may produce more consistent travel patterns, at least for work trips. Whether this is a consequence of household or societal context or simply preference is a matter of interest and further research. In either case, the gendered nature of mobility, and in this instance, employment, are
intrinsically connected to the degree that, as asked by Hanson (2010), the question of whether mobility shapes gender or whether gender shapes mobility can be extended to the institutional context.

Factors such as safety, policing, and local services that affect mobility are classified as belonging to the community sphere of influence in the socio-ecological model. This sphere of influence extends to an individual’s social networks as well, which in the case of GoCarShare.com, was a driver of the dynamic ridesharing experience. GoCarShare.com provides users with the option to access their services using an account on the popular social networking site, Facebook. This feature directly connects an individual’s need for mobility to their social network, potentially enabling ridematching within the network. The relationship between social network use and dynamic ridesharing is difficult to ascertain, mainly due to the wide scope of social network use and the low penetration of dynamic ridesharing as a travel mode. It is worthwhile, however, to note that females outnumber males in active Facebook members in the U.K and the U.S (Social Bakers, 2012); although this does not establish causality or explain the higher rate of female DRS in the respondent group, it can potentially steer the course of future research focused on establishing a link between social network software use and dynamic ridesharing. In the context of the socio-ecological model, this thesis framed the influence of physical and spatial social networks (e.g., circle of friends) and virtual social networks such as Facebook within the community sphere of influence.

The socio-ecological model as applied in this thesis also placed gender within the public policy sphere. Females have consistently experienced more mobility constraints than males for every age group; examples include reduced accesses to automobiles, lower rates of accessible mobility, and lower drivers license rates (Department for Transport, 2010). However, increases in drivers licensing rates for females (although still lower than males) were shown to result in more women using private cars as a primary mode of travel, thus allowing them greater access to employment opportunities that were
previously beyond their reach (Pazy et al., 1996). The increase of female driver’s licensing rates has increased travel demand, and has been noted others (Wachs, 1991; Pisarski, 1996; Lave, 1992; Spain, 1997). The female tendency to execute dynamic ridesharing trips, found here, can be theorized as being partially influenced by such issues. Specifically, that public policy has not fully articulated the relationship between gender and mobility, and as a result has arguably not developed a corrective means for leveling gender-based mobility disparities. In a gender-neutral environment, it would be expected that males and females would face approximately the same amount of difficulty or ease in meeting their mobility desires and needs, but as Department for Transport (2010) found, females have consistently faced greater mobility challenges.

The key underlying behaviour is that women continue to trip-chain more frequently than men in order to execute household-related tasks such as shopping, errands and social activities relating to the family, while their role in the labour market has increased (McGuckin and Murakami, 2007). Women require greater travel flexibility and the elasticity provide by the automobile is increasingly relied upon to meet their travel demand needs (Strathman and Dueker, 1995). In the absence of such flexibility, females, who generally value the sharing of resources more than males (Belk, 2010), are likely to pursue alternative modes of travel such as dynamic ridesharing. This inclination to seek alternative modes of travel due to a diverse set of constraints, in essence synthesizes the central role of gender in influencing an individual’s mobility options.

The newness of GoCarShare.com and the relative infancy of dynamic ridesharing as a TDM measure present challenges for the thesis. The sample size of 260 for the survey is relatively small, with a disproportionate number of male respondents. Future research can improve on this by analyzing the behaviour of males and females independently, followed by a cross-examination and comparison based on more even sample sizes. The survey conducted was of a subset of GoCarShare.com users whose
demographic, mobility and technological characteristics were canvassed as part of the questionnaire. However, how the respondent population compares to the larger set of registered users of GoCarShare.com in terms of these characteristics is not known, and it follows that there is no accurate means of comparing the user-base of the company with the larger Edinburgh population. Future research can address this limitation by conducting a more expansive survey, perhaps by incorporating more than one company into the research. The respondents were also primarily older than 19 year of age, so the examination of the effect that children have on the mobility of adults is limited. Research that extends this thesis will benefit from targeting a population which includes children, such as regions with high density of residential areas.

## 7 Conclusion

The current trend of increased automobile ownership and use coupled with urban sprawl is considered by many to be unsustainable (Litman, 2007). Using a case study approach situated within a historico-technical narrative, this study examined dynamic ridesharing as a creative way to alleviate the pressures being exerted on transportation systems and increase their sustainability. As illustrated by the case studies, dynamic ridesharing has yet to make a significant impact on how individual’s travel, and the reliance of dynamic ridesharing on the ability to easily communicate key ride information in a time-sensitive manner has always been a hurdle in its adoption. However, advances in technology in the last two decades, in tandem with a technologically minded consumer have resulted in improved information flow that can potentially increase its adoption.

This thesis had four major objectives. First, a review of the literature coupled with case-study description and assessment was used to chronicle both innovation in ICTs and parallel innovation in rideshare concepts and applications. It was found that advances in technology have reduced some of the barriers encountered in early DRS implementation, especially ones related to communication and
transmission of ridesharing information. Although not presently solved, a roadmap to addressing the security and safety concerns associated with DRS has also been formed, with the leveraging of social networks to gain trust a fundamental concept. Second, the study design enabled conceptual exploration of DRS use and its correlates using a socio-ecological framework. This framework was used to inform subsequent empirical study of DRS activities, users, and the use process through descriptive statistical analysis and logistic regression modeling. Third, the thesis was designed to explore the types of activities that are conducive to dynamic ridesharing. For the sample used here, DRS appeared to support leisure activities more than others. Fourth, the thesis was designed to support conceptual and empirical investigation of DRS use. In the presence of a particularly technologically capable sample of users, gender emerged as the most significant correlate of DRS use. The work contributes to quantitative research on gender and mobility, and does so in a manner that addresses concerns raised by others about conducting research on gender and transport at too large a scale (Hanson, 2010).

The view that technology can be an enabler for dynamic ridesharing has often been suggested (Section 3.3), and this thesis has examined the potential influence of technical competence on the construction of dynamic ridesharing arrangements, and found that although it is an enabler in terms of facilitating rideshares, the larger issue that influences dynamic ridesharing is not technology, but the central demographic characteristic of gender. The types of technologies examined, of course, offer a gateway to the kind of technologically heavy DRS option studied in this thesis. In a sense then, the exploration of technological factors was conducted in a manner that sought out the specialized users within an already specialized population. The factors that influence dynamic ridesharing were conceptualized within the socio-ecological model, which was used to construct a regression model by relating model variables to factors in the socio-ecological model. Gender emerged as a central construct from the analysis and the focal construct of much of the discussion (Hanson 2010).
Dynamic ridesharing is an alternative travel mode that may be gaining momentum. By situating the use of the unused capacity of automobiles, within a spatial and temporally dynamic context, DRS could have the potential to alleviate some of the pressures being exerted on transportation systems. Convenience of this mode, afforded to the technologically enabled public (note that not everyone is part of this cohort, some opt out, and others are excluded), could produce increased interest over time. A planning response to these pressures should consider incorporating dynamic ridesharing as a key measure, especially in view of technological advancements that has seen the consumer become more technologically sophisticated, enabling them to use tools that can facilitate dynamic ridesharing in a significantly more seamless manner than in the past two decades. If, however, DRS is to make a significant impact in the manner in which people travel, identifying target populations and travel activity types to which the mode is best suited should be an important operational consideration. Surprisingly, it would seem that many systems are launched, without much attention given to such activity-travel analyses.

Ongoing challenges relating to responsiveness, safety, perception, and attitudes have been examined in this thesis, and it was hypothesized that integration with social and trust networks, real-time transmission of ridesharing information, could help alleviate these concerns. This thesis’ key findings relating to DRS-sensitive activities, and the significance of gender has potentially uncovered an opportunity for policy makers, event planners, and DRS system developers to improve their marketing and planning efforts. Although technology is a vital catalyst in any dynamic ridesharing initiative, it is the intersection of gender and mobility at the personal, interpersonal, community, institutional, and policy levels that appears to be a critical human factor in affecting the use of dynamic ridesharing.
8 References


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