ABSTRACT
A new automobile use paradigm of one-way car sharing is conceptualized in a framework of service dominant logic. A conceptual model of value proposition for one-way car-sharing is examined for effects on regional vehicle inventory and levels of utilization. Research in phase I, reported here, focuses on literature review to gain insight on antecedents of successful car-sharing systems and secondary data collection for development of a geographic information system application to use for travel demand and trip assignment analysis in phase II.

INTRODUCTION
Modern technology has opened a wide range of opportunities and changed interactions in ways that would be unimaginable to those in the early 1900s when the automobile was introduced mainstream. In the realm of technological change it is imperative to recognize the importance of integrating new practices and business models, along with technology, to not only gain a competitive advantage but also to build efficient sustainable models to provide the best use of resources overall. One area this idea is taking off is in the SMART concept; SMART stands for Self-Monitoring, Analysis and Reporting Technology. Today, SMART, technology and sustainability go hand in hand. Many things are ‘smart’; from smart phones to smart grids, to smart cities, smart cars and even smart mobility in transportation. One trend in particular related to smart mobility is the idea of car-sharing as presented in the scenario below.

Imagine a world where you walk out your front door, gain access to the first available car – which is only 200 feet away, you know this because you used an app on your SMART phone to check availability and reserve it – after a quick swipe of your phone or card over the windshield, the car unlocks and you drive to your destination. At your destination you take your belongings and lock the car, thus signaling the completion of use, paying only for the use of the vehicle during that particular trip. You have no monthly car payment or insurance fees, no maintenance requirements, and no worries of a breakdown. In turn, the next person can use the same car in a similar fashion to complete a trip to another destination. You on the other
hand, will grab another car when you have concluded your business and are ready to leave for a new destination. This scenario is referred to as one-way car-sharing and is a reality only in certain areas (Kaufman, 2013; Firnkorn and Muller, 2011); this system changes the value in use of the automobile.

Car-sharing in itself is not a new concept; ZipCar for example, has become popular in several areas of the U.S. Previous literature and mainstream media alike discuss car-sharing in the context of sustainable mobility (Frost and Sullivan, 2013; Kaufman, 2013; Köhler et al., 2009; Ornetzeder et al., 2008; Loose et al., 2006; Pretenthaler and Steininger, 1999) and as a response strategy to mobility-related problems (Firnkorn and Muller, 2011). The world has grown around the use of automobiles which inevitably shapes the scope for redefining sustainable mobility (Nieuwenhuis et al., 2004). In general, transport is a crucial part of economic competitiveness as is evidenced in commercial and cultural exchanges and it is identified as playing a fundamental role in competitiveness, growth, and employment. The car industry is the single largest manufacturing sector in the world and is a major generator of wealth and employment (Nieuwenhuis et al., 2004; Köhler et al., 2009). Consequently, the problem becomes how to retain the positive social and economic benefits associated with automobile transport (Kohler et al. 2009).

Furthermore, any changes to the automobile paradigm need to be carefully examined in a broad context to prepare for any potentially harsh social and economic responses that could be triggered by changing just a few or even one element (Nieuwenhuis et al., 2004). Thus, several success factors have been identified across the literature to motivate the adoption of a broad scale car-sharing system. These factors are investments in information communication technology (ICT) (Firnkorn and Muller, 2011; Kaufman, 2013) or SMART systems (Bohdani, 2012), public private partnerships (PPP) (Loose et al., 2006), promoting public knowledge for smart mobility (Bohdani, 2012), and finally, identifying consumer preference dynamics (Prettenthaler et al., 1999; Loose et al., 2006; Kohler et al., 2009) are all key elements in developing effective policies.

Motivated by the idea of smart and sustainable mobility, the shift from ownership to use has been introduced for private vehicle mobility (Prettenthaler et al., 1999). This is not a widespread system but is catching on in the EU (e.g. Loose et al., 2006; Firnkorn and Muller, 2011; Frost and Sullivan, 2013) and to a lesser extent in some U.S. urban areas (e.g. Kaufman, 2013; CCS, n.d.). When the automobile system is looked at from this new perspective, it is often not the ‘material’ automobile that is desired by users, but the mobility that use of the automobile provides. If the view of this economic structure is considered through the lens of service dominant logic (Vargo and Lusch, 2008; Maglio et al., 2009), then the ‘service’ of the automobile could be satisfied on the basis of one ‘material’ item for many users (Prettenthaler et al., 1999). When considering one-way car-sharing through the lens of service dominant logic, the sustainable value propositions of the new paradigm become more evident.

Combining streams of literature from business, transportation, and planning, this paper seeks to examine the antecedents required for a successful car-sharing platform. Furthermore, the paper applies principles of management science to examine the effects of automobile utilization and inventory management of the system, thus offering some insight into system value propositions. Will adopting a free floating car-sharing program truly reduce a region’s vehicle inventory while improving overall vehicle utilization? Much of the previous work on car-sharing systems is dedicated to the environmental effects of such a system (e.g. Firnkorn and Muller, 2011). Few, if any, previous studies examine the potential value propositions of a car-sharing paradigm. As such, this paper contributes to the literature by bringing the antecedents of car-sharing together and also by providing insight into potential value propositions by proposing effects of inventory levels and vehicle utilization of a car-sharing system.
The remainder of this paper is organized as follows. The literature review and proposition development is discussed next. This is followed by a description of the data and methodology for development of the geographic information system (GIS) framework which is constructed for further analysis in the next phase of this work. Finally, discussion and conclusions bring the paper to a close.

LITERATURE REVIEW

Service Dominant Logic (S-D Logic)

S-D logic uses service as the fundamental purpose of economic exchange (Vargo and Lusch, 2008; Maglio et al., 2009). S-D logic provides a service based foundation with a focus on service driven-principles (Vargo and Lusch, 2008; Maglio et al., 2009) where service is defined as the “application of competences (knowledge and skills) for the benefit of another party,” (Vargo and Lusch, 2008). Through this logic, value creation moves from the producer to a process of collaboration between parties for co-creation. Value co-creation in S-D logic assumes there is no value until something is used. Thus, offerings must be integrated between firms, customers and private/public resources for value creation (Vargo et al., 2008).

In value co-creation the market transforms into a forum of dialogs between the consumer, the firm, consumer communities, and even networks of firms (Prahalad and Ramaswamy, 2004) that ultimately make up a value network. In value networks, value is co-created through a combination of “players” in the network (Peppard and Rylander, 2006). These value networks compete to capture rents from the positive network effects of the system (Fjeldstad and Haaneas, 2001). Value networks rely on mediating technology which “facilitates the exchange relationships among customers distributed in space and time. The firm itself is not the network. It provides a networking service,” (Stabell and Fjeldstad 1998, p. 427) such as network promotion and contract management, service provisioning, and network infrastructure operation (Stabell and Fjeldstad, 1998).

One key driver of value creation in S-D logic is the use of operant resources. Operant resources are knowledge based intangible resources which accordingly are capable of acting on other resources for value creation. This is a shift from the traditional view of Goods-Dominant logic (G-D logic) where value is based on operand resources. In contrast to operant resources, operand resources are tangible goods and require action to make them valuable. G-D logic is an economic exchange view based on production of goods where services are viewed as a type of good (e.g. intangible) or just an add-on to enhance a goods value. In G-D logic the same principles used to manage production of goods are also used to manage services (Vargo and Lusch, 2008; Maglio et al. 2009). Traditionally, Porter’s (1980, 1985) value chain model has been used to portray the linkages between value added activities. The focus of Porter’s model is the end product and all linear activities are required to produce it. The objective then is creating a quality product at the lowest possible cost through economies of scale and the efficient utilization of capacity and flows of information (Fjeldstad and Haaneas, 2001).

In contrast, a service system as an open system (1) capable of improving the state of another system through sharing or applying its resources (i.e., the other system determines and agrees that the interaction has value), and (2) capable of improving its own state by acquiring external resources (i.e., the system itself sees value in its interaction with other systems). Service systems are dynamic bundled configurations of resources, both the operant resources that perform actions on other resources and operand resources that are operated on (Vargo and Lusch 2004). An established services strategy is to create value through well-defined and relatively stable value production logic (Moller et al., 2008). A value creation strategy for incremental service innovation uses services for the incremental addition of value (Moller et al.,
2008). “Radical service innovation describes an approach that pursues value creation through novel service concepts,” (Moller et al., 2008 p. 34) such as new technologies, offerings, or business concepts.

Furthermore, the co-creation of value in service systems depends on the strategic alignment or synchronization of goals and objectives of the service innovation activity between the client and the provider (Moller et al., 2008). When examining the proposition of value in a car-sharing system value is co-created in two main ways; (1) as revenue stream to the provider, and (2) as a cost savings to the user. The resulting system provides a framework for goal alignment among system actors that will support the co-creation of value.

A car-sharing business model provides a new form of economic exchange. Business models provide a framework for taking technical inputs and converting them to economic outputs (Chesbrough and Rosenbloom, 2002). Essentially, business models explain how companies work and how value is delivered from them (Margretta, 2002). They are used as a simplified representation for understanding a firm’s underlying core logic and for the strategic choices used to create and capture value within the value network (Shafer et al. 2005). Thus, business models provide an overall picture of a company and how it aims to generate revenues. In the car-sharing paradigm for example, car companies are recognizing the potential for economics gains with this new model. For example, Diamler owns Cars2go, a successful car-sharing company in select North American cities and also in the EU. BMW is offering DriveNow, while Volkswagen and Ford are exploring this market as well (Kaufman, 2013). A closer examination of car-sharing systems is discussed next.

Car-Sharing

The world fleet of vehicles is growing fast (OECD, 2000). In approximately 60 years it has grown more than ten times over. In 1950 there were 70 million cars, trucks and buses by 2010 there were more than 700 million cars alone in the world fleet (WRI, 2010). Furthermore, it is expected that the total number of cars will at least triple between 2010 and 2050, mainly because saturation levels are not reached until there are approximately 850 vehicles per 1000 inhabitants (Firnkorn and Muller, 2011; IMF, 2005). Currently, developed economies have saturation levels of approximately 500 cars per 1000 inhabitants; in comparison, emerging economies such as India have approximately 50 cars per 1000 inhabitants (Jayaram et al., 2012). Given these long-term trends, the analysis of any car-sharing system should be considered in the context of the potential to support changing consumption decisions (Halme et al., 2004; Lintott, 1998) within the mobility sector (Firnkorn and Muller, 2011). Car-sharing provides a system for managing fleet size while still realizing value in use without (or with limited) sacrifice from participants.

Car-sharing, described by Loose et al., (2006), is defined as the sharing of vehicle services among members, thereby giving them access to a fleet of vehicles on demand. Thus, members are able to use a car, but do not own the car. Accordingly, the car-sharing system is important in promoting the use of sustainable modes of transport and works very well when car use is complementary to other modes of transport, particularly public transportation (Frost and Sullivan, 2013; Pretenthaler et al., 1999), but also walking, cycling, or rental car trips (Pretenthaler et al., 1999).

Traditionally, car-sharing organizations have been set up as non-profit organizations motivated primarily for two groups. One, individuals with periodic car use demand who do not want to entirely forego car use. For these individuals, car-sharing can be a dramatic cost savings over ownership where both explicit and time cost savings are recognized (Pretenthaler et al., 1999). Two, for individuals examining cost incentives between modal split, when a car is owned the sunk fixed costs are often considered and make the option of using public
transportation less attractive due to the investment in their own vehicle. The variable cost of using one's own car is often less than public transport fares, thus inducing car use rather than public transportation options.

When car sharing is introduced all costs are distributed across use; as such, the marginal costs of each single use are close to average costs, thereby leveling the playing field between public transport and private vehicle use (Prettenthaler et al., 1999). One can even conclude that car sharing systems are more economically just. The cost of car ownership is ripe with high fixed costs and comparably low per trip variable costs. This model encourages individual car owners to drive more while excluding some individuals from ever using a car at all. Car-sharing can fill the gap between pay-for-use public transportation and car ownership (Jensen, 2010).

Traditional car-sharing systems are set up with fixed stations where users begin and end their trips from the same location, for example ZipCar is modeled this way. A newer model has been introduced with a free-floating set-up (Firnkorn and Muller, 2011). also coined as an on-demand car-sharing system (Mukai et al., 2005). The free-floating, or on-demand, element allows users to start and end at any point within a specific area, resulting in a flexible one-way usage system. Firnkorn and Muller (2011) examine the environmental effects of a free-floating car-sharing system called car2go launched in Ulm, Germany. Their findings indicate reductions in CO2 usage per average car2go-user. Additional findings from survey results indicate that a free-floating car-sharing system could contribute to reducing private vehicle ownership in cities (Firnkorn and Muller, 2011; Frost and Sullivan, 2013). The focus of this paper is to analyze the efficiency of utility and value propositions from a one-way car-sharing system.

Several studies previously mentioned have examined the positive effects of car-sharing systems (e.g. Firnkorn and Muller, 2011; Pretenthaler et al., 1999). Loose et al. (2006) present results from a study initiated by the German Federal Ministry of Transport that examined the conditions of success for car-sharing organizations (CSOs). The German study was based on a traditional car-sharing model and was conducted to provide recommendations in order to advance the car-sharing concept. The main objective was to examine how individual stakeholders could contribute to further development of the future car-sharing system, including how to influence an increase in car-sharing users (Loose et al., 2006). Recommendations from the study were disseminated to various entrepreneurs, stakeholders and government agencies with significant influence on the future development of car-sharing in Germany. The recommendations were divided into specific areas including the development of cooperation between public and private enterprises, corporate communication and marketing to target groups, and areas of organizational and system development (Loose et al., 2006). Other suggested success factors including platforms of technology (Bohdani 2012, Firnkorn and Muller 2011; Kaufman, 2013), knowledge of smart systems (Bohdani, 2012) and consumer preferences (Prettenthaler et al., 1999; Loose et al., 2006; Kohler et al., 2009) will also play a role in a successful car-sharing system. These factors should still be relevant for a one-way car-sharing system. The following sections evaluate each of these factors in turn.

**Smart Technology**

SMART technologies are increasingly being incorporated into everyday items (Morosov, 2013) such as cell phones, cars, and even cities. Similar technologies used in smart transportation systems can be integrated in car-sharing programs to develop a platform that supports real-time data structures for program users. Bohdani (2012) explains how these same technologies can be used to improve energy conservation, reduce carbon emissions, and boost economic development. This becomes possible because smart transport systems overlay existing IT and communication infrastructures and are used to exploit increasing interconnectedness and
openness among users. Furthermore, smart actually covers a wide range of applications, from smart electric vehicle charging, city traffic monitoring and real-time traveler information to the installation of highway intelligence via sensors. Thus, providing people the opportunity of greater control for example, how and when they access transport and time management efficiency through traffic jams or waiting for public transport (Bohdani, 2012). Considering the data structures and connections of smart technology, it is certainly plausible to add car-sharing programs to a wider range of users on this platform (e.g. Kaufman, 2013).

In this context, the UK government has plans to set up systems to demonstrate how technology can further develop national transport systems (Bohdani, 2012). Some analysts estimate that between 2012 and 2020 approximately $22.4bn will be invested in smart transport. Considering the diffusion and evolutionary process of technology and innovations (Rogers, 1995), it is expected that these radically different technologies will be able to be developed to the point where they can outcompete the initially cheaper and preferred current and near-to market technologies (Kohler et al., 2009). For example, as more and better smart technologies are integrated between transport systems and mobile devices, shifting behavior toward the use of car-sharing programs as an integrated transport choice and away from car ownership becomes as convenient, less costly, and more socially responsible for users. Furthermore, the development of a free-floating system without booking requirements or fixed stations will trigger technological innovations (Firnkorn and Muller 2011) by encouraging the development of applications that support the industry.

Public Knowledge/Awareness

One of the biggest hurdles of car-sharing is bringing awareness to the public domain. A German study examining market potential for car-sharing programs in the late 1990s found that only 23% of the participants knew what a car-sharing program was. Poor promotional activities were identified as a major weakness for broadening the awareness and the development of car-sharing for Germany’s program (Loose et al., 2006).

It is suggested that the use of smart technology increasingly leads to greater public knowledge (Bohdani, 2012) about smart transport options. Therefore, as more car-sharing systems become integrated with higher levels of smart technology it should become easier for users to connect to the system for a seamless experience. One example is the use of Personal Travel Assistant (PTA). PTA is a Web-based service that enables users to make real-time travel decisions based on both cost and carbon impact through any Web-enabled device from any location. The PTA differs from typical map-based direction finders or trip planners by offering a ‘virtual assistant’ to access real-time traffic and transportation information, and impacts of mode choice (Bohdani 2012). Car-sharing systems integrated into a PTA application can be valuable to users for informed decision-making. In areas where public transportation is limited, one-way car-sharing programs can be integrated with a PTA application at the end of the public transport depot for the final leg of a trip.

Public Private Partnerships (PPP)

The necessity of developing public private partnerships is commonly acknowledged in the literature as a key success factor for car-sharing programs (Loose et al., 2006; Kohler et al., 2009; Frost and Sullivan, 2013). One particular success story is in Switzerland where the world’s largest car sharing organization (CSO) resides, the Swiss Mutual Benefit Association Mobility with 58,000 members (as of December 2003). Developing cooperation with the local public transportation (PT) company led to a breakthrough in the car-sharing market for Mobility. Season-ticket holders of PT were offered the opportunity to become dual customers of PT and
It is further acknowledged that institutional and behavioral change will probably be harder to achieve than technological change, policy makers must inspire the social change required for successful car-sharing systems. It will be important to demonstrate some of the wider benefits beyond economic value (e.g. reduced air pollution and more reliable public transport options) (Kohler et al., 2009). A survey of Car Sharing Organizations showed that one-quarter of the CSOs would welcome governmental support for car sharing, not necessarily in the form of subsidies but for legal and fiscal treatment similar to public transport as part of an integrated transportation system (Loose et al., 2006). A key challenge is the cost of installing infrastructure because public agencies are facing budget constraints in major cities, therefore companies will be looking for innovative ways to finance these integrative smart transport systems (Bhodani, 2012) and to build successful PPPs.

Consumer Preferences

Car-sharing is considered by some as an innovation in consumption technology. This new organizational form has a different combination of consumption inputs, thus changing the shares between private vehicle and public transport mobility (Prettenthaler et al., 1999). The availability of a private car makes it difficult to convince consumers to use alternative means of transport (i.e. public transport), certainly there is a close link between car ownership and car usage. For public transport systems to be successful, consumers must overcome car-oriented habits and practices (Loose et al., 2006). Car-sharing can fill the gap between private vehicle use and public transportation (Jensen, 2010). In order for consumers to make the required lifestyle changes, a sustained pressure from the environment on society must occur (Kohler et al., 2009). Concepts focused on the benefits of use rather than ownership play an important role in reducing the number and length of car journeys (Loose et al., 2006).

A major hurdle is overcoming consumer perceptions and preferences. Results of a German household survey indicate that both ‘objective’ and ‘subjective’ criteria are important for implementing successful car-sharing programs. Not only should the frequency and type of trips align with the practical functions of the program, so too should the consumers’ attitudes about driving, public transportation and sharing a car with others. These subjective criteria should not be undermined in their importance in influencing a person’s mobility behavior (Loose et al., 2006). The awareness and attitudes of potential consumers play an essential role in shaping the market.

THEORETICAL DEVELOPMENT/MODEL

Vehicle Inventory

One mobility-related challenge is the land use required for sufficient parking spaces of parked idle cars (Grazi and van den Bergh, 2008; Firnkorn and Muller, 2011). Building parking garages can cost between $30,000-$50,000 therefore, implementing a car-sharing program can be a cost effective alternative. Each car-sharing vehicle can replace as many as seven private vehicles (CCS, n.d.), effectively reducing regional vehicle inventory and in turn, the amount of land required for parking. For example, ZipCar and City CarShare have reported that 13% and 29% of members respectively have sold at least one car since joining the programs while up to
40% of members avoid buying one at all (CCS, n.d.). This is inline with other data that indicates static land consumption will be reduced through a reduction of the total number of vehicles in the city (Firnkorn and Muller, 2011). As a result, more land can be used to improve green spaces for recreation or other purposes.

The required regional vehicle inventory is defined as the number of cars essential to provide transport for the required number of trips within the region. Typically, a person (or family) that owns a car has exclusive use of it and when the vehicle is not in use it sits idle. Conversely, when a car sharing program is introduced in a region, individuals share the vehicle when it would otherwise be sitting idle. Therefore, fewer cars are required to service the same number of trips.

Another mobility related challenge for many users is cost. It is shown that in switching from ownership to car sharing, overall car use (in terms of miles driven) goes down as members tend to use shared cars less than their private vehicles (Loose et al., 2006; Prettenthaler et al., 1999). City CarShare members in San Francisco on average drove 47% less after joining, as a result users save money (CCS, n.d.) in both holding and usage costs. Bringing these ideas together; when users share cars they drive less, with less cars, land usage and costs are reduced through a reduction of vehicle inventory, therefore:

\[ P1: \text{One-way car sharing will reduce the required regional vehicle inventory.} \]

**Vehicle Utilization**

When more users share a single vehicle, utilization will increase in terms of increased annual miles driven per vehicle. In other words, if the vehicle is in use more often, idle parked time is reduced which is also inline with the arguments from H1 in regards to reducing the required land use for parking. One would consider that car manufacturers might not be in favor of car-sharing programs. Traditionally, each user purchased their own car; in the new paradigm many users effectively share one car, hence car manufacturers may sell less. On the contrary, when several users share the same car, the utilization of the car increases and as a result, the mileage life of the vehicle is used up faster. Some car manufacturers already see the potential gains in the value in use proposition adherent with service dominant logic. For example, Diamler owns Cars2go while BMW currently offers DriveNow. In addition, Volkswagen and Ford are exploring this market (Kaufman, 2013).

Using general accounting principles, when fixed costs are spread out over higher volumes the portion of fixed costs on a per unit basis decreases. Table 1 provides an example of value proposition that can be gained for car-sharing organizations, notice that costs decrease as utilization increases. This concept builds incentives for the car-sharing organization to maximize each vehicles utility in the system. The organization can build in dynamic pricing schemes to maximize profit potential.

<table>
<thead>
<tr>
<th>Annual Miles Driven</th>
<th>Annual Cost</th>
<th>Hourly Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>5,000</td>
<td>$6,299</td>
<td>$17.26</td>
</tr>
<tr>
<td>12,000</td>
<td>$7,831</td>
<td>$8.94</td>
</tr>
<tr>
<td>20,000</td>
<td>$9,581</td>
<td>$6.56</td>
</tr>
</tbody>
</table>

(Source: Jensen, 2010)
Logically, when car-sharing systems are in place, and many users share a vehicle the utilization of the vehicle will increase. Furthermore, if organizational value proposition increases with higher vehicle utilization, incentive is provided for:

\[ P2: \text{One-way car sharing will increase regional vehicle utilization.} \]

**Car Pooling**

The car pooling concept entails sharing a vehicle toward a common destination, based on a priori agreements (Dimitrakopoulos et al., 2012). Yan et al. (2011) used a network flow technique to examine a long-term many-to-many car pooling model. The model was shown to be effective; a similar approach could be applied for car pooling integrated with a car-sharing system. Essentially, car pooling combines duplicate users in a single car-sharing trip. Consequently, providing the potential for further reductions in regional inventory and even higher vehicle utilization, in terms of more occupants per vehicle for time in use. This is an important distinction in the value-in-use concept. Each occupant has a value for the trip and would be willing to pay accordingly. Using information communication technologies (ICTs) in conjunction with intelligent transportation systems (ITSs) (Dimitrakopoulos et al., 2012) can provide a platform for car pooling within a car-sharing system. In order to maximize profit, car sharing organizations should exploit the potential increasing returns with car pooling that are associated with lower costs of a smaller vehicle inventory and greater potential for profit through higher vehicle utilization. Therefore:
P3a: Car pooling in one-way car sharing will further reduce the required vehicle inventory.
P3b: Car pooling in one-way car sharing will further increase regional vehicle utilization.

METHODS AND DATA

In general, the data required to make a comparison for car-sharing studies is commonly captured either by a longitudinal or a cross-sectional analysis, the latter offers generic options in order to compare the status quo with the future, the past or a hypothetical scenario (Finckorn and Muller, 2011). Secondary data was collected for the Lucas County, Ohio area, developed into shapefiles and loaded into a desktop version of ESRI ArcMap 10.1, a Geographic Information Systems (GIS) platform. Coined as “Geographic Analytics” in business publications and used to some extent for supply chain analysis (Acksteiner et al., 2013), GIS is known for providing data management and analysis capabilities beyond that of standard database management platforms (i.e. MS Access). The same database management functions are available in GIS; however, in addition the locational referencing system of a GIS allows data sets to be visualized in layers to conduct more detailed locational referenced analysis. This is particularly valuable when working with datasets for transportation infrastructure similar to this project. The following data sets for Lucas County, Ohio were collected and loaded into the GIS created for this project:

- Street, highway, and interstate networks (TMACOG)
- County Zoning (AREIS, 2010)
- Parcel boundaries and characteristics (AREIS, 2010)
- Census and American Fact Finder
  - Block-group boundaries and data (2010)
  - Economic variables (e.g. population, workers in households, etc.)
- Traffic counts (TMACOG)
- Lucas county demographics profile – Census
- Toledo MSA Zone-to-Zone trip tables by traffic analysis zones (TAZ) (TMACOG)
  - Breakdown for travel type (will give better time of day indicators for trip assumptions)
- Toledo MSA TAZ shapefiles (TMACOG)

The following data was derived from public data sources to gain insight into the current number of drivers and vehicle inventory for the study area:

- Derived: Lucas County Licensed Drivers and Vehicles
  - Lucas County makes up 3.89% of Ohio’s population
  - Estimated 297,862 licensed drivers in Lucas County
  - Estimated 402,516.7 registered vehicles in Lucas County.

The above listed and derived data is input for the current conditions state of the study. Figures 2 – 5 below are the visual output of the datasets as they appear in the GIS platform. Herein lays the groundwork for using network analysis tools to develop a travel demand and trip assignment simulation optimization model. These models can be used to determine optimal
system performance of a regional free floating one-way car sharing program to compare results with the current state and make a determination of value proposition for the program.

**Figure 2. Census Tracts, Streets, Highways and Interstates in Lucas County**

**Figure 3. Zoning, Streets, Highways Interstates in Lucas County**

**Figure 4. Census Tracts, Streets, Highways & Interstates with Traffic Counts in Lucas County**

**Figure 5. Population by Block, Census 2010**

**DISCUSSION AND CONCLUSIONS**

The United States has room for widening the span of users in car-sharing programs. These systems promote a cost effective sustainable way for managing transportation issues regarding parking, congestion, and CO$_2$ pollution control. Furthermore, the alignment of the potential for users to decrease costs while providers turn a profit makes for a sustainable value-in-use system based on S-D logic. Since the 1990s, several CSOs in central Europe have enabled the car to become a successful example of continuous service use without individual ownership (Prettenthaler et al., 1999). The first phase of this work contributed to the literature by synthesizing antecedents for car-sharing programs. These were identified as the development of public private partnerships (PPPs), technology (Bohdani 2012, Finkorn and Muller 2011; Kaufman, 2013), public knowledge and smart systems (Bohdani, 2012; Loose et al., 2006) and
Managerial Decisions in Your Firm

consumer preferences (Prettenthaler et al., 1999; Loose et al., 2006; Kohler et al., 2009) for successful car-sharing systems.

Furthermore, development of datasets in a GIS platform set the stage for model development and analysis in the next phase. Results are expected to contribute to car-sharing and management literature by testing the feasibility of value-in-use propositions in a non-population dense midsize urban area. These results should provide in new insight for fleet inventory management and vehicle utilization with the implementation of a car-sharing program in such an area. Additionally, the potential for profits to organizations coupled with cost savings to users will provide an idea of the value proposition of the system. There is reason to expect that this study will contribute in some small way toward changing the current paradigm.

FUTURE DIRECTIONS AND LIMITATIONS

Even in a free-floating car-sharing system it is expected that a few depots will need to be located for service and availability purposes. Thus, the next step is to use the data collected in Phase I to identify these car-sharing depot locations in order to maximize service levels. Then the development of a trip assignment and travel demand model between TAZ areas will be done to compute current vehicle utilization rates. Next, by implementing inventory management principles to examine service levels and required inventory the outcome from the current system data will be simulated with an incorporated car-sharing system for one-way trips. The new required inventories and vehicle utilization levels will be calculated and compared with original results. Finally, the model will be re-configure and run with the implementation of car pooling and results will be interpreted.

One limitation to this study is the exclusive use of secondary data. Mixed methods are recommended for robustness. Another limitation is the use of one study area. Incorporating additional study areas would add to the generalizability of the results. Nonetheless, it is hoped that the rigorousness of the study will provide valuable data and results for providers looking at new business models of value-in-use for car-sharing systems. Additionally, it is envisioned that researchers can replicate the methodology in other regions for generalizability of the results.

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