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Assessing Public Transportation Options for Intercity Travel in U.S. Rural and Small Urban Areas: A Multimodal, Multiobjective, and People-Oriented Evaluation

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ASSESSING PUBLIC TRANSPORTATION OPTIONS FOR INTERCITY TRAVEL IN U.S. RURAL AND SMALL URBAN AREAS: A MULTIMODAL, MULTIOBJECTIVE, AND PEOPLE-ORIENTED EVALUATION

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Vasiliki Dimitra Pyrialakou

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In memory of

My father, Dimitrios E. Pyrialakos,
without whom I would never have had the courage to pursue my dreams.

My academic father, Matthew G. Karlaftis,
without whom I would never have had a dream to pursue.

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NOMENCLATURE

Accessibility is the ability, potential, or ease of reaching desired opportunities.

Connectivity is the ability of a transportation system to facilitate travel between places.

Disadvantage is a circumstance or condition unfavorable to success.

Mobility is the ability, potential, or ease of people to travel between places; this term refers directly to the movement of people (and/or goods).

Opportunities are any desired destinations or sites providing employment, goods, and/or services.

Private transportation is any personal transportation mode (such as automobile or motorcycle) or any mode that can be shared only with a prior private arrangement (such as taxicab, carpool, school bus, sightseeing service, or private commuter shuttle).

Public (or mass) transportation is any shared passenger transportation service open to the general public (or segments of the public); the term might refer to both intra-city services (such as buses, heavy rail, and light rail) and intercity services (such as intercity passenger rail, commuter rail, high-speed rail, intercity buses, and airlines).

Realized travel behavior describes the observed travel choices of an individual (or group), which might or might not differ from the individual's travel preferences.

Transport disadvantage is the disadvantage of a population group or area due to lack of mobility and/or lack of accessibility.

Transport (or travel) need is a quantification of people in an area (e.g., number, percentage, or comparable relative or absolute measures) who are in need of public transportation services.

ABSTRACT

Pyrialakou, Vasiliki Dimitra. Ph.D., Purdue University, August 2016. Assessing Public Transportation Options for Intercity Travel in U.S. Rural and Small Urban Areas: A Multimodal, Multiobjective, and People-Oriented Evaluation. Major Professor: Konstantina Gkritza.

The transportation needs and available resources of rural and small urban areas differ from those of larger urban areas. In the U.S., the accessibility and connectivity of such areas rely heavily on the highway system and, consequently, on personal automobile use. Transportation infrastructure and services are unevenly distributed in space, and thus accessibility levels are expected to differ across areas. As a result, individuals have different mobility levels depending on where they live, work, and travel. However, physically, financially, or socially disadvantaged individuals typically suffer the impacts of an automobile-oriented community disproportionally, experiencing higher transportation costs and enjoying fewer benefits.

The U.S. literature on rural transportation is limited, but planners, policy makers, and researchers have been engaging in an ongoing discussion on rural transport challenges and transport networks. Much of the recent discussion has focused on intercity and/or interregional travel. Intercity bus and passenger rail services have decreased over the past decade, and today many rural and small urban communities have no intercity passenger transport options. Passenger rail can help provide these intercity transportation options and mitigate rural transport disadvantage. Studies suggest that passenger rail growth can bring regional economic benefits, mobility and accessibility improvements, and other social benefits. In the U.S., a nationwide passenger rail and high-speed rail (HSR) network has been suggested as a promising passenger transport solution, and a number of rail corridors have been planned or considered for development.

This dissertation work stemmed from a need for public transportation research regarding rural and small urban areas and focuses on assessing public transportation options for intercity travel in these areas.

Three research questions are addressed:

1. Is investment in public transportation in U.S. rural and small urban communities crucial to reaching the communities' long- and short-term goals, and is this investment viable in light of key issues relevant to the communities?
2. Is passenger rail and/or HSR the most advantageous public transportation mode in such areas?
3. What conditions should be fostered and how can these conditions be encouraged to promote the development and use of passenger rail/HSR?

To address these topics, a three-part research framework was developed that involves assessing transport disadvantage in an area, evaluating the existing transportation modes, and investigating the potential for a ridership increase that can further support the improvement and expansion of public transportation systems. To illustrate this framework, the case study of Indiana and the Hoosier State line, a short-distance corridor operating four days per week between Indianapolis and Chicago, was used.

The developed research framework was found to be especially suited to evaluating short-distance rail corridors and competing modes along the line that connect medium/small urban and/or rural communities. However, the principles may be used to evaluate a broader system. Other methodological contributions include the design of a comprehensive approach to assess transport disadvantage in U.S. rural and small urban areas and the development and testing of a theoretical model to explore public attitudes towards passenger rail.

This dissertation provides a well-documented, practice-ready, and easy-to-use framework that can support planning and policy decisions at the community or state level and the supply decisions of transportation providers while contributing to the evaluation of passenger rail systems proposed in the U.S. The framework is easily replicable and accounts for the availability of data and resources.

In terms of empirical contributions, recent developments regarding the Hoosier State train provided an opportunity to address a timely topic for Indiana, the Midwest, and the U.S. This dissertation's findings can assist stakeholders involved with shaping the future of the Hoosier State train and Indiana's passenger rail system. The findings can also help evaluate passenger rail and HSR systems that have been proposed, informing future plans for the development of those systems in Indiana and the Midwest.

CHAPTER 1. INTRODUCTION

Today, equitable access to transport is a crucial goal worldwide to enhance quality of life and ensure equal chances for people to access basic needs (such as education and health services) and employment opportunities (International Transport Forum, 2011). In the United States (U.S.), equitable access to transportation is recognized as a civil and human right (The Leadership Conference Education Fund, 2011). Nevertheless, as The Leadership Conference (2011) highlights, specific groups such as low-income people, people with disabilities, the elderly, and some rural populations suffer limited transportation choices and therefore challenges in accessing basic needs and opportunities.

In rural and small urban areas, the transportation needs and available resources are expected to differ from those of larger urban areas. In the U.S., the accessibility and connectivity of such areas rely heavily on highway systems and the use of personal automobiles. Clearly, this has strong implications for the transport-disadvantaged populations living in these areas. Even though the U.S. literature focusing on topics related to rural transportation is limited, planners, policy makers, and researchers have recently started considering rural transport challenges, and there is an ongoing shift towards considering accessibility during planning in rural areas. A large part of the recent discussion and research on rural passenger transport topics focuses on intercity and/or interregional travel. In the U.S., many rural and small urban communities have no intercity passenger transport options available. Over the last decade, the coverage of both intercity bus and passenger rail services has been decreasing.

Passenger rail can play an important role in intercity transportation and can help in the mitigation of rural transport disadvantage. Studies suggest that passenger rail growth has the potential to bring regional economic benefits, mobility and accessibility improvements, and other social benefits. In the U.S., the development of a nationwide passenger rail and high-speed rail (HSR) network has been suggested as a promising and “greener” passenger transport solution, and recently a number of rail corridors have been planned or considered for development.

In view of the above, this dissertation focuses on assessing public (mass) transportation options for intercity travel in U.S. rural and small urban areas, in terms of both the existing services provided and the potential for the systems' expansion. In addition, this dissertation aims to contribute to the evaluation of the passenger rail and HSR systems that have been proposed in the U.S. The rest of this chapter further describes the research motivation, research goals and framework, research settings, and contribution of this dissertation.

1.1 Research Background: Transportation in Rural and Small Urban Areas

Literature suggests that different countries can be classified into one of three categories in terms of the status of transportation in rural areas. The first category consists of less developed (or developing) countries. The second and third categories include developed countries, with the key distinguishing criterion being population density. Specifically, the second category includes countries with relatively high population densities in rural areas—such as Western Europe and Japan. In these countries, one expects both a high rate of personal vehicle ownership and an existing public transportation network in rural areas, as allowed by both the population densities and the relatively short distances between communities. Finally, the third category includes the U.S., Canada, Australia, and New Zealand. These countries have rural areas with relatively low population densities, personal vehicles have the largest mode share, and the public transportation network is underdeveloped (Nutley, 2003).

Nutley's research (1996, 2003) suggests that between the countries of the second and third categories there is a fundamental difference on the issue of rural transportation. Specifically, not only is the divergence of transport patterns and available resources between urban and rural areas more extreme in the third category, but the society's perception and confrontation of this divergence also differs. This difference in "perspective" is captured in all aspects of research and practice, from policy approaches (encouragement of automobile use, low fuel costs), to planning approaches (a focus on highways, air transportation, and telecommunications), to researchers' approaches (a lack of academic literature on the unique transportation problems of rural areas or on accessibility and connectivity). A current review of the U.S. scientific literature supports the argument that the U.S. falls under this third category; a very limited amount of research focuses on rural transportation and the unique problems of accessibility and connectivity in such areas.

It is noted here that although the U.S. setting is unique and presents significant differences compared to other countries, the international literature can provide insights into transportation in U.S. rural and small urban areas. Much research has been conducted internationally to identify the unique transport challenges and needs of rural areas (for example Nutley, 2003; Kamruzzaman and Hine, 2012; Smith et al., 2012); to investigate and measure the effects of various transport-related factors, such as the lack of transit modes (Nutley, 1996), and non-transport-related factors, such as the use of advanced technologies (Velaga et al., 2012); and to evaluate possible solutions and alternatives (Buschbacher, 2012; Jackson et al., 2012). In addition, much literature has focused on exploring issues of rural accessibility, access, and transport disadvantage (see for example Farrington and Farrington, 2005; Kamruzzaman and Hine, 2011), especially in regard to transport-disadvantaged groups, such as the rural elderly (for example Ahern and Hine, 2012). Such international research has been taken into consideration in this dissertation and is discussed in the following chapters where appropriate.

The very limited amount of literature focusing on transportation in U.S. rural and small urban areas is one of the major motivators of this dissertation. The rest of Section 1.1 presents a brief overview of other topics that prompted the author to focus on the subject of public transportation options for intercity travel in U.S. rural and small urban areas.

1.1.1 The Social Aspect of Rural and Small Urban Transportation

Both the transportation needs and the available transportation resources (infrastructure and services) differ between rural and urban settings in the U.S. The modern development of rural and small urban communities has typically been automobile-oriented. Therefore, such communities are commonly expected to have lower accessibility levels than large urban communities. Studies commonly suggest that transport-disadvantaged groups (such as the elderly and low-income individuals) in rural areas have mobility levels similar to or higher than corresponding groups in urban areas (Pucher and Renne, 2005), as well as similar transport patterns (Kamruzzaman and Hine, 2012). Nevertheless, this finding does not imply that rural areas do not lag behind their urban counterparts in terms of accessibility and transport options, but rather that rural areas are significantly automobile-dependent. This dependence on the highway systems and the use of personal automobiles in such areas, however, does not come without consequences. These include—among other outcomes—environmental concerns, such as increased emissions per household (Center for Neighborhood Technology, 2011), and social issues, such as limited access to transportation and, consequently, limited opportunities for captive demographic groups such as the elderly and low-income people. In addition, individuals captive to public transport or dependent on others for rides do not have the flexibility to travel, and, due to routing and budget constraints, are less able to reach opportunities and are more prone to social exclusion. Essentially, the choice and ability to own an automobile in rural areas shape an individual's quality of life (Pucher and Renne, 2005; Kamruzzaman and Hine, 2012).

This dependence of rural areas on automobiles is also related to the concept of *forced automobile ownership*. This is a concept that has been extensively discussed in the international literature, especially in the context of rural areas and other areas that lack public transportation services (for a discussion, see Currie and Senbergs, 2007a). “Forced automobile ownership” refers to the fact that, because an automobile can be a necessity in areas lacking transportation services, disadvantaged households might be “forced” to suffer very high costs relative to their income in order to purchase and operate an automobile. Because the term “forced automobile ownership” can be somewhat misleading, to highlight that the term is not necessarily connected with the choice, willingness, and/or desire to purchase an automobile, the term “high automobile ownership in low-income households” has also been used in the literature.

Similar to the above concept but with a focus on travel outcome instead of automobile ownership is the concept of *forced mobility*, a term introduced by this dissertation. Applied to population groups that are expected to have limited mobility (such as the elderly), this concept refers to an increased (above average) mobility that can be linked with the necessity to travel in order to reach opportunities in areas lacking sufficient transportation services. This increased mobility can manifest in a high number of trips made and a high amount of mileage traveled.

Finally, the literature has touched upon the financial dimension of rural transport disadvantage. The limited related research suggests that rural residents might suffer relatively higher transport-related costs than their urban counterparts (see Jones and Lucas, 2012; Smith et al., 2012; Hawk, 2013). For example, research by Smith et al. (2012) concludes that households in rural England suffer significant additional transport-related costs than their urban counterparts. As both Smith et al. (2012) and Jones and Lucas (2012) identity, one of the key factors contributing to this inequity for rural households is related to the stronger dependence of these households on automobiles and potential changes in fuel prices. One could argue that this factor is not as relevant in the U.S. because typically fuel costs are lower in rural areas. Nevertheless, U.S. data from the National Household Travel Survey also suggest that rural households have higher transportation costs than urban ones, especially costs pertaining to automobile purchases and fuel costs (see Hawk, 2013).

These and other issues related to rural transport disadvantage are discussed in Chapter 4.

1.1.2 Transportation Planning in the U.S. Rural Areas

Even though the academic and scientific literature regarding rural transport in the U.S. has been limited, recently planners, policy makers, and researchers have been involved in an ongoing discussion focusing on rural transport challenges and transport networks (Stommes and Brown, 2002; Rosenbloom, 2003; Transportation Research Board, 2003; Kidder, 2006; Brown, 2008; Marsico, 2009, sec. House Appropriations Committee; American Public Transportation Association, 2012; TRIP, 2015). The importance of rural accessibility and connectivity has been highlighted, and recurring topics have included the limited provision of public (mass) transportation options and the lack of a well-connected network, whether among rural transit systems across counties or between different transportation options such as intercity buses, passenger rail, and local rural transit. In addition, the relationship between transportation systems and local economies or economic growth has been discussed, as has been the role of rural public transportation provision in mitigating social inequalities and the importance of providing options for transport-disadvantaged populations such as the elderly, the disabled, low-income people, and individuals without access to personal automobiles. Finally, the ongoing discussion has also considered the effects of a changing society on transportation needs, including population changes, such as demographic changes and in particular the aging of the rural population, and regional changes, such as sprawl and the reduction of rural opportunities.

Today, U.S. planning and forecasting research acknowledges the uniqueness of rural transport. To this end, national research supported by federal agencies such as the Federal Transit Administration and the Federal Highway Administration has attempted both to deepen the understanding of how the character of rural areas affects and is affected by various aspects of transport and to design suitable frameworks and models to approach rural transportation planning (Burkhardt et al., 1998; FHWA, 2001; Transportation Research Board, 2003; Burkhardt, 2004; Twaddell and Emerine, 2007; Ripplinger, 2012; Schiffer, 2012; Vanasse Hangen Brustlin, Inc. et al., 2013).

In addition to providing more suitable frameworks to approach rural transportation planning and operation, these studies verify the arguments made by planners and researchers discussed above. For example, early research showed that rural transit brings significant economic benefits to the rural U.S. (Burkhardt et al., 1998), and the FHWA (2001) proposed that rural areas prioritize planning for multimodal systems and the coordination of transportation planning and land use and development planning. Along the same lines, research focusing on the connections between transportation and land use has identified that accessibility is the key challenge in rural communities (Twaddell and Emerine, 2007). Other relevant challenges that have emerged include transportation safety and interregional connectivity. Twaddell and Emerine (2007) also conclude that further research focusing on public transportation, intelligent transportation systems, and planning for Native American communities is needed.

It is noted here that another factor that should be considered when exploring topics related to rural transportation is the unique U.S. rural typology. Rural America is very diverse (Burkhardt et al., 1998; Kidder, 2006; TRIP, 2015), and many researchers and planners therefore distinguish between different types of communities, for example basic, developed, and urban boundary rural communities (FHWA, 2001) or exurban, destination, and production communities (Twaddell and Emerine, 2007).

1.1.3 Rural Public Transportation

Generally, statistics show that several European countries and Canada have a higher public transportation use rate than the U.S. and in some cases (such as Germany) offer superior services (Buehler and Pucher, 2012). In urban and densely populated areas, it is expected that the share of people using public transportation would be higher in general. However, studies (both early, such as Nutley [1996], and more recent, such as Buehler and Pucher [2012]) show that the U.S. has particularly lagged behind several European countries in promoting public transportation in such areas. Many factors, such as different policies, automobile ownership rates, and fuel prices, might have led to this divergence. However, other countries have fostered the development of public (mass) transportation to encourage the use of alternative modes to automobiles (such as commuter rail, buses, and non-motorized transportation).

The U.S. literature on rural mass transportation, whether local or intercity, has been limited. Among the few existing studies, Burkhardt et al. (1998) conducted one of the first comprehensive attempts to quantify the economic impacts of rural transit. The goals of the study were to investigate the effects of rural transit on the quality and quantity of economic activity in general and on specific demographic segments and to determine the opportunities that rural transit could potentially provide to better facilitate economic growth. More recently, Ripplinger (2012) proposed a framework that can potentially support the performance evaluation of rural transit and assist decisions regarding the allocation of financial resources. This study estimated the benefits of consolidating rural transit agencies, as well as other alternatives, and evaluated the economic justification for subsidizing rural transit. The research included a case study of North Dakota to represent transit agencies that provide services to rural areas.

Yang and Cherry (2012) investigated the demand for intercity buses in Tennessee, specifically the link between race, employment status, income, and disabilities and the choice of mode (personal automobile or bus). In addition, the authors suggested a framework for prioritizing network expansion and identifying service gaps, with a focus on connecting rural and urban areas. In terms of the demand, the results of the study were in line with previous research suggesting that riders of intercity buses are commonly nonwhite, low-income individuals with lower education levels and limited access to personal automobiles. Similar studies on regional intercity buses have been conducted recently (for an overview of the main studies, refer to Yang [2013]). Turning to local public transportation, Chakraborty and Mishra (2013) conducted a statewide case study in Maryland to investigate the relationship between transit demand, land use, and various socioeconomic factors. The findings suggested that the determinants of transit demand and their power vary across urban, suburban, and rural areas.

Finally, the topic of rural air transport has recently attracted some research attention (for example, see Rasker et al., 2009; Grubesic et al., 2013; Çağrı Özcan, 2014; Wei and Grubesic, 2015). Studies have focused mainly on economic issues, whether related to transportation costs and air transport performance (Grubesic et al., 2013; Wei and Grubesic, 2015) or to economic impacts (Rasker et al., 2009; Çağrı Özcan, 2014).

Generally, topics pertaining to rural public transportation, including demand issues, are attracting increasing interest in the U.S. literature. The studies summarized above and other recent studies on similar topics can be useful tools for planning-related decisions and can provide valuable insights for the current markets. Nevertheless, they do not significantly contribute to the understanding of the challenges of rural transportation in the U.S. and do not necessarily provide comprehensive planning and policy guidance because they focus more on transport demand and less on the societal needs, challenges, and consequences of the current transportation networks. Furthermore, these studies investigate the status quo and rarely consider changes in public preferences that may be brought about by policies and other solutions.

1.1.4 Intercity Travel

In 2003, the Bureau of Transportation Statistics (BTS) conducted a geospatial analysis to explore the coverage of rural areas by intercity mass transportation modes (air transport, intercity passenger rail, and intercity bus) (U.S. Department of Transportation et al., 2005). The study concluded that approximately 93% of U.S. rural residents can reach at least one intercity passenger option, with more than 69% living within coverage of more than one option. The same study estimated that 7% of rural residents live in areas without any intercity passenger options. More recently, the BTS provided an overview of the changes in coverage over the next few years, from 2005 to 2010 (Firestine, 2011). The study showed a significant decline in coverage (around 4.4%), and it was estimated that approximately 3.4 million people living in rural areas lost access to intercity passenger transportation in this period. This loss is mainly due to the discontinuation of intercity bus services and—to a lesser degree—of passenger rail services.

Still, the more recent BTS study suggests that 90% of rural residents have access to at least one intercity passenger option. Nevertheless, a few points should be noted here. First, it is interesting to explore the coverage figures only for bus and rail, because air transport might not be directly competing with intercity bus and/or rail. Typically, the trips covered by air transport might be longer than those of other modes, and the population segments that are able to or choose to travel by air might be different than the segments that use other modes (for example, due to cost limitations). In 2010, approximately 78% of the rural population in the U.S. was covered by intercity bus (a decline from 89%) and 40% by intercity rail (a decline from 42%); the combined figures are not reported. Finally, another important observation is related to the "last mile" problem. Both BTS studies consider that an area is served by passenger rail, intercity bus, or a small (medium/large) airport if the area is within 25 miles (75 miles) from a station or an airport. Thus, considering that many rural areas in the U.S. are not served by local/regional public (mass) transportation, the rural residents who do not have access to intercity passenger transportation options are considerably more numerous in reality. This is especially true for transport-disadvantaged populations that do not have access to a personal automobile.

Recently, intercity passenger transportation has also been gaining increasing attention from federal organizations, which are supporting national research projects. A number of guidebooks and other reports pertaining to intercity buses (such as Fravel, 2011) and passenger rail (such as Coogan et al., 2016; Meyer et al., 2016; Morgan et al., 2016), have recently been published. Some highlights from the passenger rail studies are provided in the next section.

Interregional travel (between 100 and 500 miles) is another topic for which more research and pertinent data are needed, especially to understand the need and demand for such travel. The limited research has highlighted the role that public (mass) transportation, including intercity passenger and high-speed rail, can play (Transportation Research Board, 2016). Today, interregional trips are typically being made by personal automobile, especially for non-business purposes. Air travel is also frequently used for business trips between major cities. Intercity passenger rail services are typically supplied by the National Railroad Passenger Corporation (Amtrak). Most of the passenger rail routes spanning between 100 and 500 miles are within the Northeast, Midwest, and West. There are also 15 long-distance routes that can serve interregional travel throughout the U.S., though the service for such trips might be inconvenient due to the low frequency and sometimes inconvenient schedule of trains, depending on the origin and destination cities (Transportation Research Board, 2016).

A lack of data is a limitation when attempting to explore issues related to interregional and intercity travel in the U.S. Studies such as Transportation Research Board (2016) or the study by Ashiabor et al. (2007), which was one of the first attempts to develop forecasting models for intercity travel in the U.S., have used data collected from the most recent national survey that provided comprehensive information pertaining to long-distance travel. This was—and still is—the 1995 American Travel Survey. It is evident from the discussion on the provision of intercity passenger services above that this data set is outdated, especially for rural areas. Another option to obtain the required data is to conduct a regional survey, such as that conducted by Ripplinger et al. (2012), who collected data in North Dakota and Minnesota and used the data to identify intercity transportation market segments. However, this is not an easy solution and probably limits the geographical scope of the research.

1.1.5 Passenger Rail

In the U.S., the development of a nationwide commuter and HSR network has been suggested as a promising and “greener” passenger transport solution that could potentially improve the connectivity of rural and small urban areas. Much research has focused on the evaluation of rail energy consumption, transportation supply, and other impacts of HSR. Previous research at the state or corridor level in the U.S. suggests that investments in new HSR infrastructure have the potential to reduce energy consumption and greenhouse gas emissions, given efficient planning that will ensure sufficient ridership and investment (Chester and Horvath, 2010; Sonnenberg, 2010).

In addition, it is anticipated that passenger rail growth will bring regional economic benefits, such as business growth, mobility improvements, and other social benefits (Randolph et al., 2008). Recent research also suggests that passenger rail services can be proven to be financially sustainable even in areas with lower population densities, and not necessarily just in high-density urban areas (Wang and Lo, 2016). Furthermore, the electrification of rail transportation is expected to promote energy independence, transportation safety and efficiency, and better community interconnectivity (FRA, 2009) and has a great potential to reduce energy consumption and intensity (DiDomenico, 2015).

Research related to rural passenger rail has been very limited. To the author's knowledge, no U.S. academic studies have been focused on this topic. Internationally, Jackson et al. (2012) investigated the demand and willingness to pay for rural rail services in the United Kingdom. The study also explored factors that can affect the mode choice between rail and bus, such as cost, travel time, frequency of service, and reliability. The authors suggest that, for rural services, speed might be a secondary factor while comfort and reliability might be the most important factors for passengers.

In terms of intercity passenger rail, recent reports published by the National Cooperative Rail Research Program (NCRRP) provide some useful insights on various pertinent topics. For example, Coogan et al. (2016), in an exploration of demand-related issues, conclude that future demand for intercity passenger rail transportation is expected to come from a shift from personal automobile rather than bus or air. In terms of factors that affect mode choice decisions, the authors suggest that inconvenience is the most important element. For rural areas, the inconvenience of bus and rail is related to low frequency of service and inconvenient schedule, which is in line with the findings of Jackson et al. (2012).

1.2 Research Goals and Research Framework

While some research has been conducted in the U.S. to justify the need for intercity public transportation systems and investigate the effects of different public transportation modes, these studies have generally focused on evaluating transportation options in view of specific factors, such as environmental benefits and territorial cohesion or connectivity. Specifically for passenger rail, studies suggesting that investment in these systems is not cost-effective give more weight to quantifiable (tangible) benefits than non-quantifiable benefits (such as regional benefits like increased economic competiveness, increased access to labor/job markets, and other quality of life improvements). Along the same lines, such studies are often based on the current conditions of the systems and rarely consider the effects of changes in public preferences due to policies and the fostering of conditions that encourage mode shifts.

Nevertheless, the transportation community has identified an ongoing shift in the transportation planning paradigm from mobility-based to accessibility-based, a paradigm shift that is required in order to achieve a sustainable transportation future (see Litman 2003, 2013a, 2013b). What is being emphasized through this shift is that transportation planning should focus on providing access to services, activities, and employment opportunities to people rather than on just providing connectivity among places. The new paradigm advocates inclusionary, expanded techniques in every aspect of planning, from considering alternative transportation modes to expanding the evaluation of transportation systems using more comprehensive performance indicators and accounting for all direct and indirect impacts and benefits (Litman, 2013a, 2013b). In the U.S., the current U.S. Department of Transportation Strategic Plan 2014-2018 (U.S. Department of Transportation, 2014) reflects this shift, broadening the nation's strategic transportation goals to include safety, economic competitiveness, quality of life in communities, and environmental sustainability.

To meet today's and tomorrow's transportation planning needs, conventional evaluation practices for transportation investments, which are typically roadway- and automobile-oriented, must be abandoned, and a multiobjective, multimodal, and people-oriented evaluation must be embraced. To achieve this goal, it is crucial to establish a comprehensive transportation systems evaluation that will account for society's contemporary planning goals.

In view of the above, this dissertation proposes a framework to assess public (mass) transportation options for intercity travel in U.S. rural and small urban areas. In order to contribute to the evaluation of the passenger rail and HSR systems that have been proposed in the U.S. in general and in Indiana specifically, the main focus has been placed on passenger rail.

The main research goals of this dissertation are as follows:

1. Investigate whether investment in public transportation in U.S. rural and small urban communities is crucial to reaching the communities' long- and short-term goals and is a viable option in light of key target issues relevant to the community, such as environmental sustainability, economic competiveness, quality of life, and demand.
2. Investigate whether passenger rail and/or HSR is the most advantageous public transportation mode in such areas.
3. Under the hypothesis that public transportation development in such areas would be socially beneficial and that passenger rail/HSR is the most advantageous mode, investigate the conditions that should be fostered and how those conditions can be encouraged (considering social, political, market-related, and other aspects) to promote the development and use of passenger rail/HSR.

To achieve these research objectives, a comprehensive research framework was developed. Figure 1.1 presents the flow chart that captures the proposed research framework, the fundamental research components, and their key elements. The yellow highlighted elements refer to the most prohibitive steps of the data collection in terms of the difficulty of obtaining or accessing the information.

As Figure 1.1 shows, the framework is composed of three fundamental components: the assessment of transport disadvantage in an area, the evaluation of the existing transportation modes, and the investigation of the potential for a mode shift from automobile to public transportation that can further support the improvement and expansion of public transportation systems. The last two components are interconnected because it was expected that a number of common underlying factors would affect both the suitability of the various transportation modes in light of the community's goals and the potential for a mode shift from automobile to alternative transportation modes.

To illustrate the developed framework, a case study of Indiana was completed focusing on rural and small urban communities and using data collected for the case of the Hoosier State train (i.e., a short-distance corridor passenger rail line operating four days per week between Indianapolis, Indiana, and Chicago, Illinois, with four intermediate stops) and competing modes along the line. Chapter 3 presents the empirical setting of the case study.

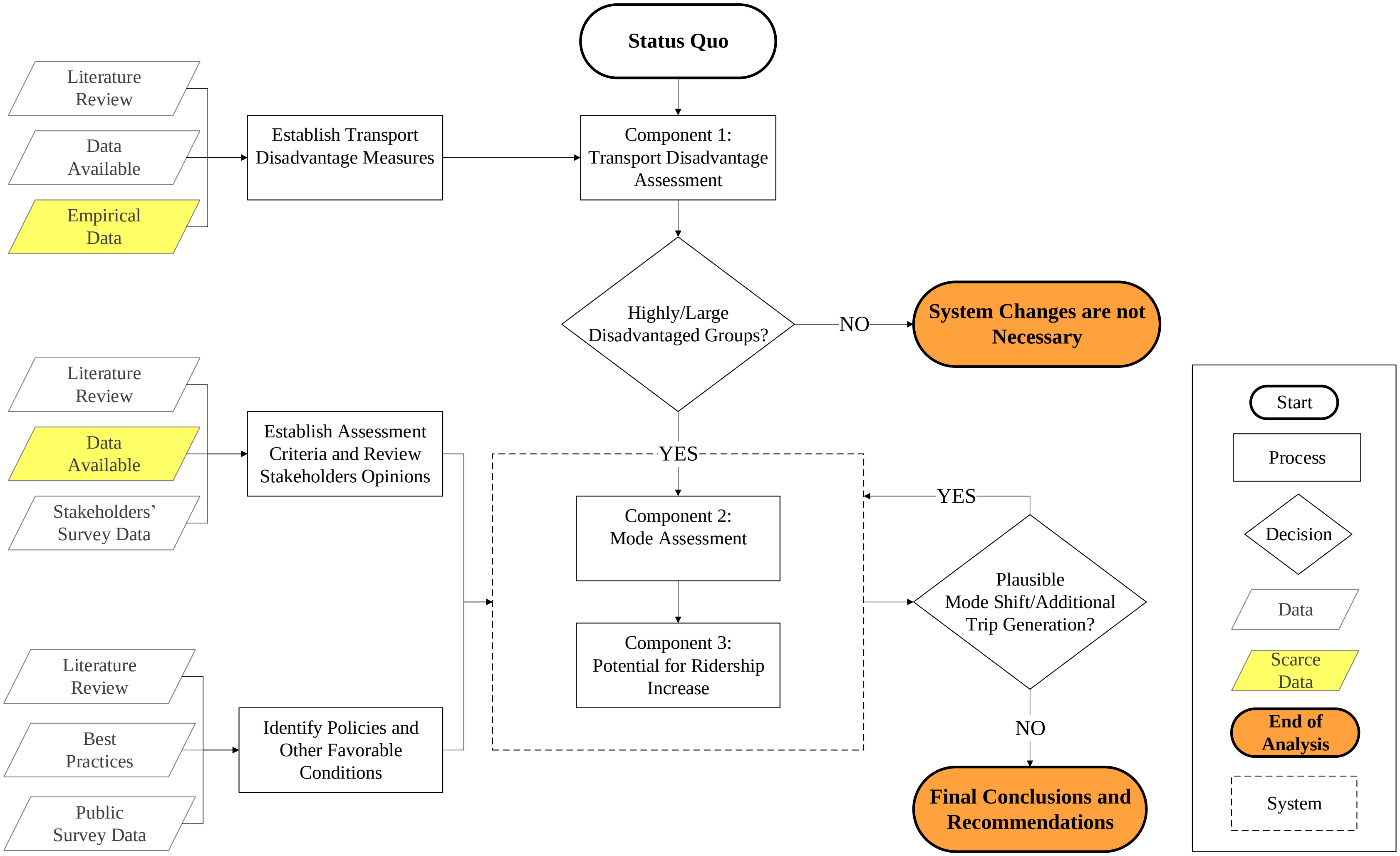

Figure 1.1 Dissertation Framework Flow Chart

1.3 Research Setting

It was expected that the decisions made regarding data collection and analysis would affect the results and their interpretation. The research setting used for implementing the developed framework was selected in such a way as to produce research results that are practice-ready and useful to the community.

Specifically, the geographical level of this analysis is the state (in terms of the case study, Indiana), which allows an investigation of a broader spectrum of planning policies and plans that can promote public transportation. The aggregation level of the analysis (when relevant) is the census tract, which is the smallest geographical unit for which consistent data are available. As for the trip characteristics considered, this research focuses on intercity (medium- to long-distance) trips, through which residents of rural areas can access a wide array of opportunities that rural areas might lack. Trip purposes are not explicitly considered, though the research aims to capture day-to-day activities (such as employment, school, and shopping), emergency activities (such as trips to hospitals and clinics), and trips to access other opportunities and basic needs (such as recreation, participation in sports, and family visits).

1.4 Dissertation Contribution

There has been an increasing interest in public transportation research, especially in rural and small urban areas, whose residents are at a disadvantage because of the lack of a well-connected public transportation network. This dissertation addresses this topic in terms of intercity travel and contribute to the evaluation of the passenger rail and HSR systems that have been proposed in the U.S. Specifically, this dissertation supports the development of an accessibility-based, multiobjective, multimodal, and people-oriented systems evaluation. The developed research framework is especially suitable to evaluate short-distance rail corridors (less than 750 miles), and competing modes along the line, that connect medium/small urban and/or rural communities. However, the principles of this framework may be applicable to the evaluation of a broader system. Other methodological contributions include the development of a comprehensive approach to assess transportation disadvantage in U.S. rural and small urban areas (first component of the framework) and the development and testing of a theoretical model to explore attitudes towards passenger rail (third component of the framework).

In terms of practical implications, this dissertation aims to provide a well-documented, practice-ready, and easy-to-use framework that can support both planning and policy decisions at the community or state level and the transportation supply decisions of transportation providers.

Special attention has been given to designing a framework that is easily replicable and that accounts for the availability of data and resources.

In terms of empirical contribution, the recent developments regarding the Hoosier State train provided an excellent opportunity to address a timely topic for Indiana, the Midwest, and the U.S. in general (as discussed in Chapter 3). It is anticipated that the findings of this dissertation will assist the stakeholders involved with shaping the future of the Hoosier State train and the wider passenger rail system in Indiana.

1.5 Dissertation Organization

This dissertation includes seven chapters. Chapter 2 is concerned with one of the first challenges researchers face when focusing on research pertaining to rural transportation: the question of what is "rural". Chapter 3 introduces the empirical setting of this research. Chapters 4 through 6 present the developed methodology, with one chapter for each of the three fundamental components of this study noted above. Finally, Chapter 7 assembles the conclusions of this dissertation based on the findings of each component and closes the dissertation with remarks on the study, policy and planning implications, and the limitations and future directions of this research. Figure 1.2 presents a dissertation map.

Parts of this dissertation have been published in the 2014, 2015, and 2016 proceedings of the American Society of Mechanical Engineers (ASME) Joint Rail Conference (JRC), the 2013 proceedings of the Transportation Research Board Annual Meeting (TRB), and the Journal of Transportation Geography, published by Elsevier. Sections of these publications are included herein with the permission of ASME, TRB, and Elsevier, respectively, and the corresponding parties are acknowledged at the beginning of each chapter.

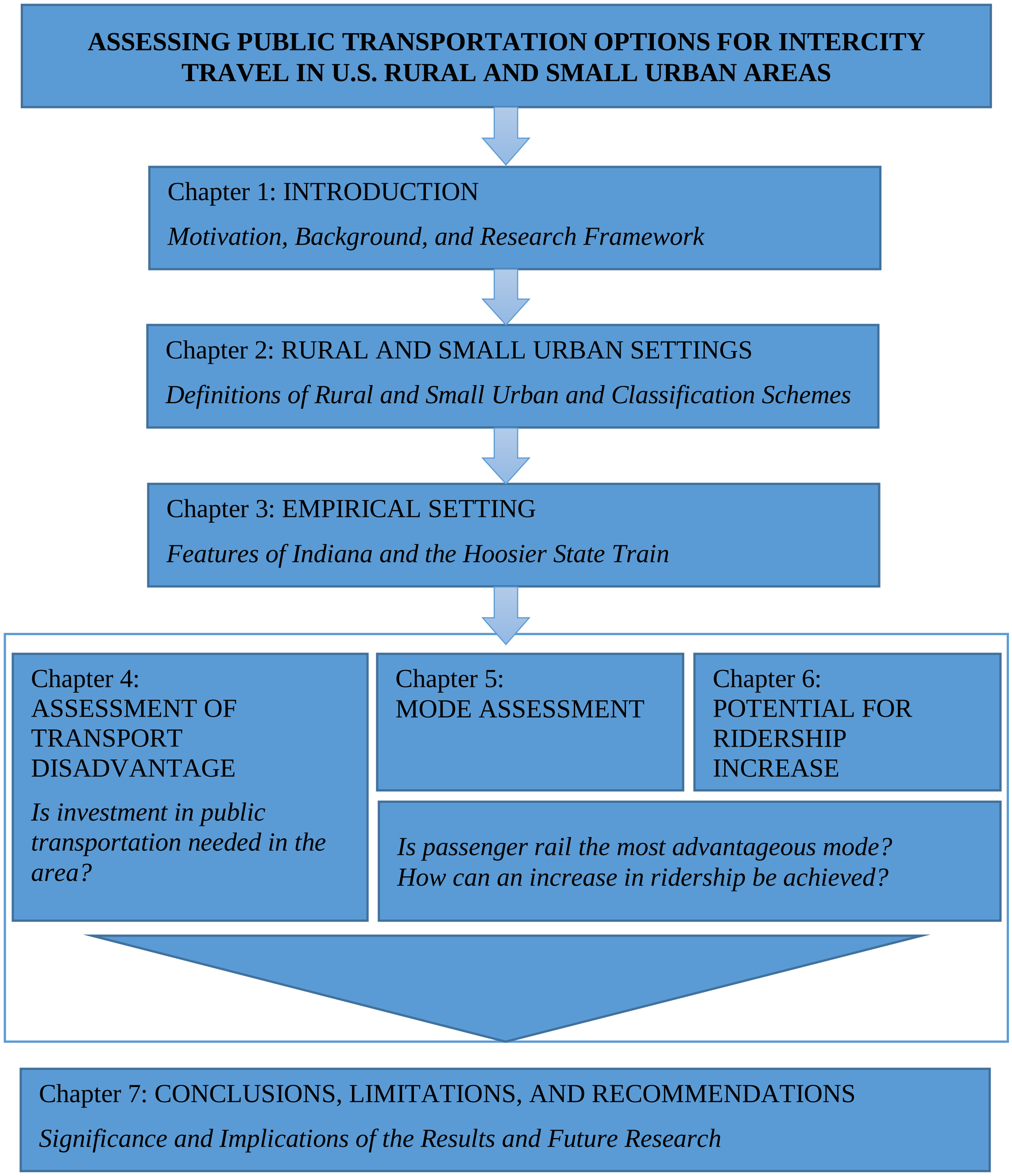

Figure 1.2 Dissertation Map

CHAPTER 2. RURAL AND SMALL URBAN SETTINGS

The focus of this dissertation is the evaluation of public transportation options for intercity travel in U.S. rural and small urban areas. Defining rural and small urban areas appropriately is a challenge inherent in this research, as it is in any research related to rural transportation, as well as in any attempt at large-scale systems planning, operations, or evaluation. Various organizations, such as the U.S. Census Bureau and the U.S. Office of Management and Budget, have developed different classification schemes to classify areas by urbanization level, with overlapping results in some cases. In addition, the absence of a more detailed, suitable, and broadly recognized classification scheme drives researchers to develop new research-oriented schemes or to apply general schemes adapted to better facilitate the scope of their research. For instance, Chakraborty and Mishra (2013) designed a new classification scheme that delineates the statewide modeling zones (subdivided by the authors) into urban, suburban, and rural using a combination of household and employment densities. Notwithstanding the usefulness of research-oriented schemes, the broad use of such schemes produces study results that are not comparable and further confusion within the research and planning community on the concept of "rural." Today, transportation planners agree that some planning issues may arise from the fact that the term "rural" is vague and lacks a single definition (FHWA, 2001; Kidder, 2006; Twaddell and Emerine, 2007).

Planning and operating effective transportation networks relies heavily on the knowledge of current and future aspects of transport, such as transport patterns, needs, and demand. However, several temporal and spatial factors affect these aspects. Key factors include population and population density, terrain and distances, and market and economic structures.

These factors are reflected in the land use and urbanization levels of an area. A broad classification system based on several criteria (including the aforementioned factors) that has been commonly used in transportation planning and that attempts to capture the variation in such factors is rural versus urban communities. Rural communities are smaller in terms of population and have lower population densities, are more isolated (separated by greater distances), oftentimes have rougher terrain, and depend more on primary economic activities (such as agriculture, farming, fishing, and mining) and secondary economic activities (such as production and manufacturing).

In view of the above, the effect of urbanization levels and associated land use on various transport aspects is easy to recognize. However, literature focusing on the interactions between transportation systems and land use or urbanization levels supports the notion that transportation and land use have a bi-directional relationship (Sinha and Labi, 2007). That is, it might be possible that the existing transportation networks and infrastructure systems, as well as the existing transportation aspects previously discussed, could both be affected by the urbanization level of an area and affect the future urbanization levels at the same time. Therefore, it is of great importance that transportation factors are also considered in the delineation of urban-rural areas, especially for transportation planning and research applications. Nevertheless, classification schemes rarely consider transportation factors in a straightforward manner, and there has been no literature to assess the suitability of the available schemes for transportation and planning research that also considers the status of the transportation networks under a comprehensive approach.

The goal of the following sections (Sections 2.1 and 2.2) is to outline and compare the different classification schemes and evaluate their ability to capture the key elements of the bi-directional relationship between transportation systems and urbanization levels. Based on the comparison, the delineation scheme that is best suited for this research is chosen. This chapter was published in the peer-reviewed proceedings of the 2013 Transportation Research Board (TRB) Annual Meeting as Pyrialakou et al. (2014). The author would like to acknowledge the anonymous reviewers and the attendees of the session for their valuable feedback.

2.1 Classification Schemes and Transportation Networks

2.1.1 Classification Schemes and Criteria

In the U.S., a number of classification schemes have been suggested, considering various factors such as population, population density, land use, and others, to differentiate urban from rural communities. Each scheme's classification criteria, as well as the level of aggregation considered, commonly depend on the primary purpose each scheme has been developed to serve. Herein, five of the most broadly used and recognized schemes and an additional scheme designed to serve transportation purposes are compared. The following is a brief description of the schemes and a demonstration of the corresponding delineated areas in the Midwest region (Figure 2.1).

In this section, the Midwest region is used as a representative case study of the urban-rural variations in the U.S.

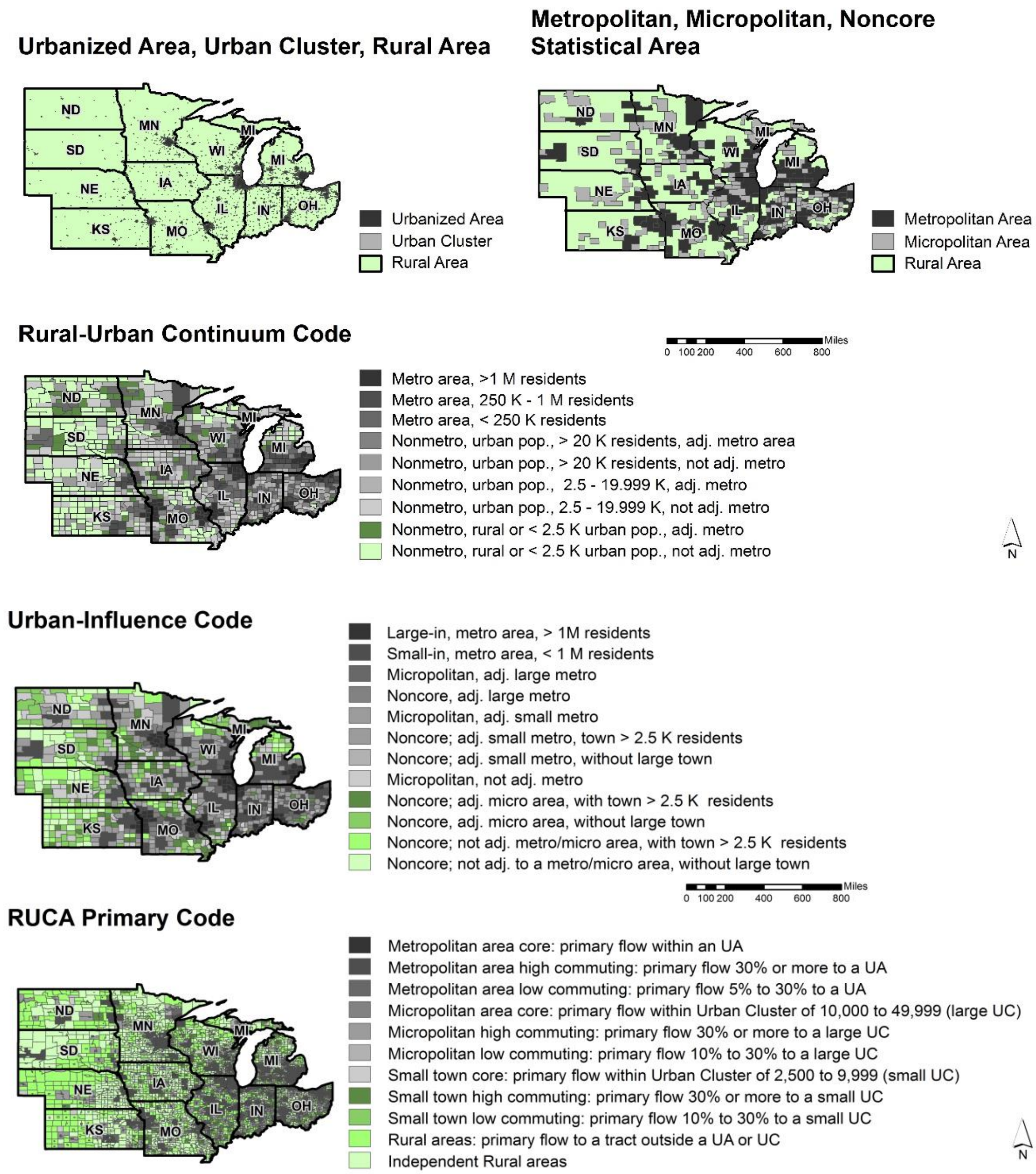

Figure 2.1 Midwest Region, Areas by Urbanization Level, Classified by Different Classification Schemes

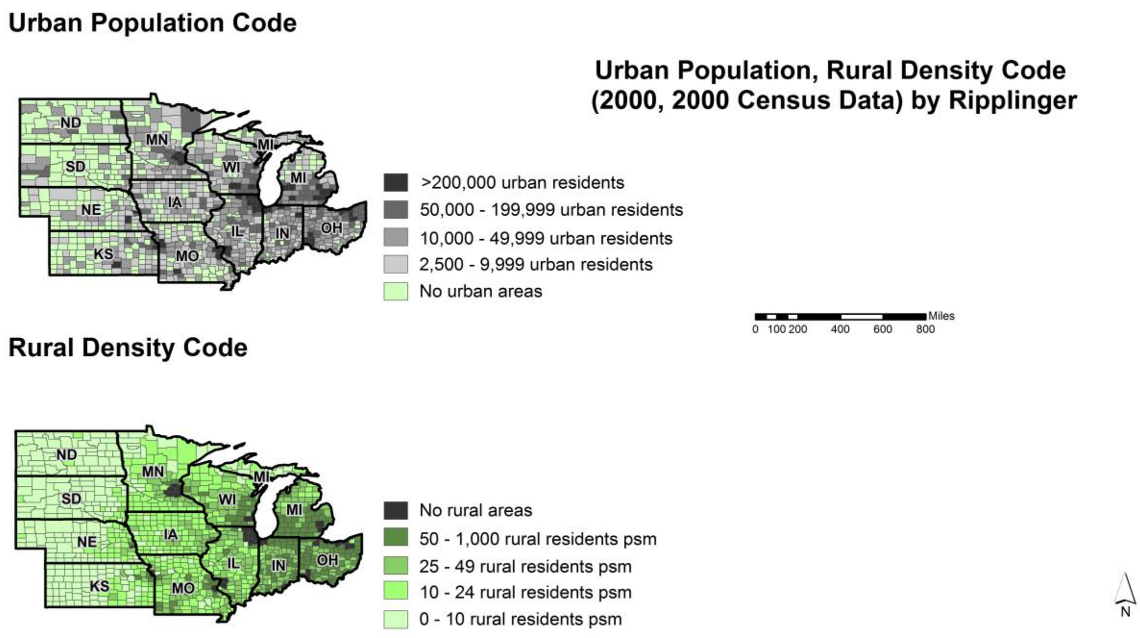

Figure 2.1Midwest Region, Areas by Urbanization Level, Classified by Different Classification Schemes (Continued)

2.1.1.1 Urban and Rural Areas (2010) by the Census Bureau

The Census Bureau's *urban areas* include developed, dense territories covering residential, commercial, and other "urban" land use, classified based on the decennial census and other data by tract and block. Urban areas can be of two types: *urbanized areas* (50,000 residents or more, at least 1,000 per person square mile [ppsm]) and *urban clusters* (2,500-50,000 residents, at least 500 ppsm). *Rural areas* include all areas outside of urban territories ("2010 Urban and Rural Classification, U.S. Census Bureau," n.d.).

2.1.1.2 Metropolitan and Nonmetropolitan Statistical Areas (2010) by the Office of Management and Budget (OMB)

Metropolitan (metro) areas include large counties—defined as counties containing a core urban area with 50,000 residents or more—and adjacent areas that maintain high-level interaction with the core, as indicated by commuting ties. *Nonmetro areas* include *micropolitan (micro) areas*, i.e., counties containing a core urban area with 10,000 to 50,000 residents, plus adjacent areas, and *noncore areas*, i.e., counties outside of core statistical areas. In this scheme, an employment interchange measure capturing the percentage of workers living in the "smaller" area and working in the "larger" area is used as an indicator of the interactions ("ties") between areas (U.S. Census Bureau, n.d.).

2.1.1.3 Rural-Urban Continuum Code (2003, 2000 Census Data) by the Economic Research Service (ERS)

The ERS uses the OMB's Metro-Nonmetro classification scheme to further partition metro areas into three categories based on the county's size and partition nonmetro counties into six categories based on the urbanization level and proximity to a metro area (United States Department of Agriculture (USDA), Economic Research Service (ERS), n.d.).

2.1.1.4 Urban Influence Code (2003, 2000 Census Data) by the ERS

Similarly to the Continuum Code based on the OMB classification system, the ERS further partitions metro areas into two categories based on size, micro areas into three categories based on proximity to a metro area, and noncore areas into seven categories based on proximity to a metro area and whether they include a town of 2,500 residents or more (USDA, ERS, n.d.).

2.1.1.5 Rural-Urban Commuting Areas (RUCA) (2000, 2000 Census Data) by the ERS

In this scheme, the ERS uses criteria similar to those of the OMB classification system to delineate tracts into metro, micro, and rural areas. Additionally, these areas are further partitioned into 10 categories based on the largest daily commuting flows, and these 10 categories are further partitioned based on secondary (second largest) commuting flows. In this scheme, commuting flows are considered as an indication of the economic integration of core urban areas and their adjacent territories. Data for the commuting flows are constructed from the American Community Survey (ACS) data set, which is part of the Census Transportation Planning Package (FHWA, n.d.).

2.1.1.6 Urban Population-Rural Density Code (2000, 2000 Census Data) by Ripplinger et al.

Ripplinger et al. (2008) designed a new classification scheme (Urban Population-Rural Density Code) in order to account for some of the deficiencies of the above schemes when used in transportation research. The Urban Population-Rural Density Code scheme is a two-part scheme partitioning counties into a five urbanization levels and five rural levels. Specifically, the scheme uses the urban population to partition the urban areas and the rural density to partition the rural areas. To achieve this, the scheme builds on the urban-rural classification scheme, aggregating the urban and rural population from the block to the county level (Ripplinger et al., 2008).

2.1.2 Transportation Networks

Accessibility within U.S. rural areas is highly dependent on the highway network and the use of personal automobiles. According to the 2009 National Household Travel Survey (NHTS) (Santos et al., 2011), in 2009 the average vehicle miles traveled (VMT) for the population 35-45 years of age in rural areas was 40.45 VMT/day, while the corresponding VMT in urban areas was 30.11 VMT/day. At the same time, 83% of the transit trips in the U.S. were made in large urbanized areas (Chu, 2012). Nevertheless, for a more comprehensive analysis, other transportation elements should be considered. In the analysis presented in this chapter, the following transportation networks and other infrastructure systems are considered, as shown in Figure 2.2 for the Midwest region.

- Primary and secondary roadway network, as collected from the TIGER/Line 113th Congressional District Shapefiles (U.S. Census Bureau, 2010a), corresponding to 2010 data.
- Passenger rail network, as collected from the Oak Ridge National Laboratory Center for Transportation Analysis (CTA) Transportation Networks database ("CTA Railroad Network," n.d.), corresponding to 2012 data.
- Amtrak network and stations, as collected from the National Transportation Atlas Database (NTAD) 2011 (Research and Innovative Technology Administration (RITA), 2011).
- Airports, as collected from NTAD 2011 (Research and Innovative Technology Administration (RITA), 2011) and categorized based on the current Federal Aviation Administration (FAA) criteria[1].
- Alternative fuel stations, as collected from NTAD 2011 (Research and Innovative Technology Administration (RITA), 2011).

[1] The FAA airport categorization rules can be found at http://www.faa.gov/airports/planning_capacity/passenger_allcargo_stats/categories/.

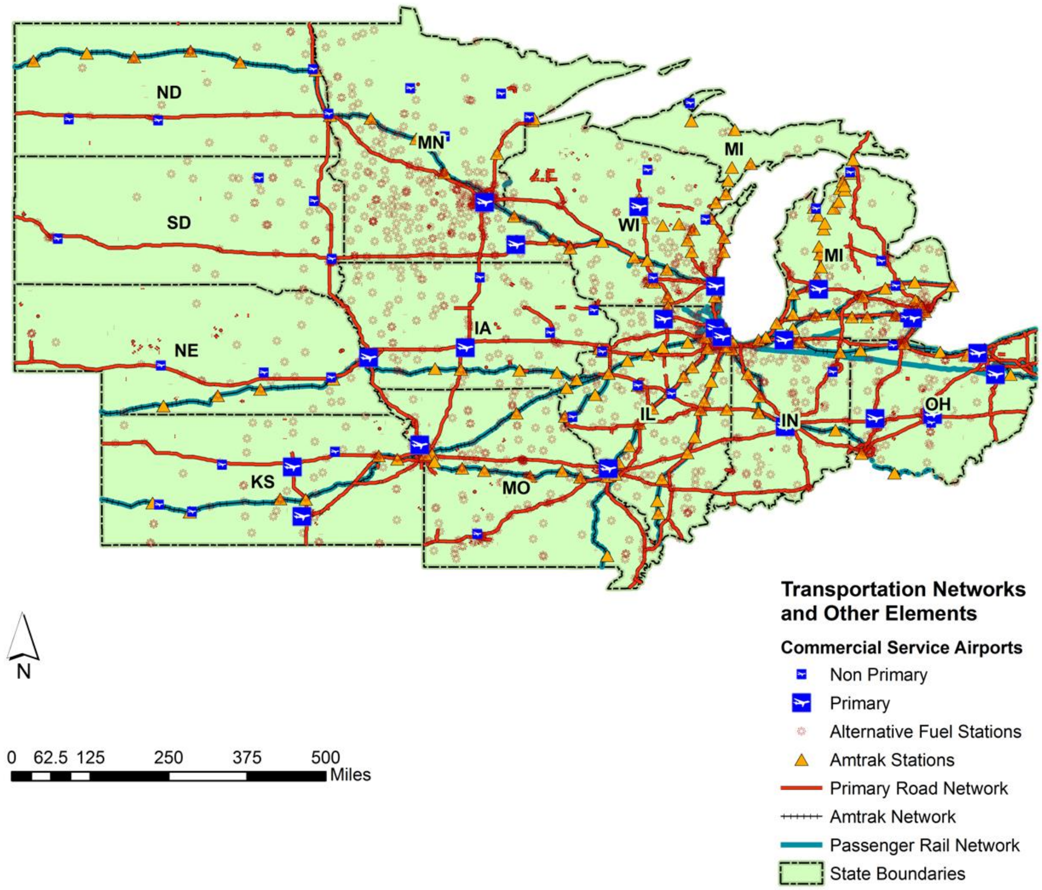

Figure 2.2 Midwest Region, Transportation Networks and Other Infrastructure

2.2 Comparison of Classification Schemes

This section presents a comprehensive comparison of the selected classification schemes. To cover the most relevant aspects of rural/urban classification, the comparison focuses on the following aspects of the selected schemes: aggregation level, number of classes, territorial boundaries of the delineated areas, urban-rural population, other transportation-related area characteristics, and the complexity and efficiency of the schemes.

2.2.1 Aggregation Level

The urban-rural classification scheme is based on data aggregated by census tract and block, the rural-urban commuting areas scheme is based on data aggregated by tract, while all other schemes are based on data aggregated by county. The chosen level of aggregation is strongly affected by the original purpose the classification scheme was developed to serve. For instance, the metro-nonmetro classification scheme, aggregated at the county level, was originally developed for data collection and statistical purposes. The county is an efficient aggregation unit for this purpose because the level of detail provided by such aggregation is suitable for an efficient analysis.

Because the Census Bureau aggregates data at the block/tract level, the Census Bureau's urban areas can be considered to most accurately represent the location of the urban population. In contrast, metropolitan areas are centered around one or more urban counties (urban cores) and selected adjacent counties. Thus, the aggregation level of metropolitan areas might be inadequate to capture transportation patterns and needs. Aggregation at the tract and/or block level provides a more suitable geographic framework for transportation analysis, especially near large urbanized areas. In contrast, aggregation at the county level does not capture the differences between urban and rural communities within the same county. Figure 2.3 demonstrates the differences resulting from two aggregation levels (by tract/block on the left and by county on the right) in the Chicago metropolitan area. As evident from the position of the passenger rail network within the delineated areas, aggregation by tract/block results in a more precise delineation of the urban area of Chicago. However, when data collection and manipulation is required at the block level, the collection and computational burden is noticeably increased, resulting in unwieldy classification schemes.

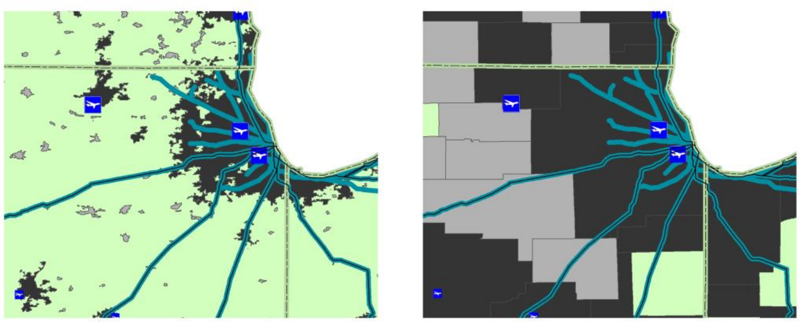

Figure 2.3 Chicago Metropolitan Area, Example of Differences in Aggregation Levels

2.2.2 Number of Classes

The number of classes affects the level of detail depicted in each class. A scheme with a greater number of classes might be more efficient in capturing a higher percentage of the variation in several aspects of transport.

Two or three classes of urbanization might not be sufficient to capture the variation of transportation patterns, demand, and needs. This idea is demonstrated in Figure 2.4, where one can see that the highway density variations do not seem to have any correlation with the different classes in the first two schemes (urban-rural scheme, map a; metro-nonmetro scheme, map b), whereas in the next two schemes (rural-urban continuum code, map c; urban influence code, map d) some patterns can be identified. For instance, in the last scheme (urban influence code) it seems that micropolitan areas that are not adjacent to metropolitan areas as well as completely rural noncore areas adjacent to micropolitan areas have a less dense network.

The urban-rural scheme focuses on a detailed delineation of urban territories. However, the scheme does not capture the variation and diversity prevalent in U.S. rural communities, as discussed in Chapter 1, due to the combination of small aggregation units and only one class for rural areas. The metro-nonmetro scheme might capture some of the variation in rural communities, with the micropolitan areas being territories having both urban and rural characteristics. However, such classification is ambiguous and results in confusion and uncertainties. The OMB scheme itself can be handled in two different ways: in terms of metro-nonmetro (micro and noncore) areas and in terms of metro and micro core-based statistical areas (CBSA) and noncore areas.

2.2.3 Territorial Boundaries of the Delineated Areas

Urbanized areas and urban clusters do not strictly follow municipal boundaries, such as towns, cities, or counties. This might be an issue when the urban-rural scheme is used in planning and evaluation at the project level of analysis. Because the scheme uses Census tracts and blocks, the resulting delineated areas represent a combination of units with the same urbanization level. Thus, a territory delineated as urban can include multiple towns and/or cities and extend across more than one county. In the same manner, one metropolitan area might extend to more than one state, which can be seen as a disadvantage when using the OMB scheme for governance-related planning.

a) b) c) d)

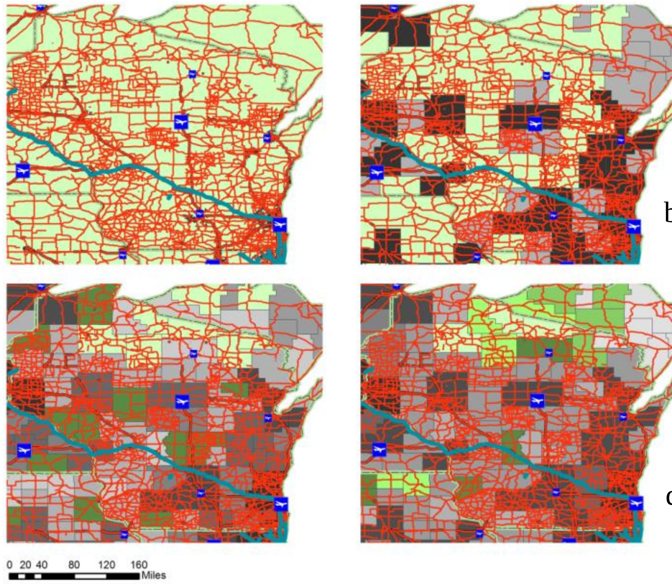

Figure 2.4 State of Wisconsin, Example of Differences Resulting from Different Numbers of Classes

2.2.4 Urban-Rural Population

The Census' urban-rural scheme is the most used and recognized scheme. In addition, as previously noted, the urban areas defined by this scheme can be considered to most accurately represent where the urban population is located. Thus, a classification scheme that considers either the urban areas as such or the urban population would be of great advantage.

In addition to the urban-rural scheme, other classification schemes that directly account for the urban population include the rural-urban continuum code, the rural-urban commuting areas, and the urban population-rural density schemes. The OMB scheme, although it considers to some extent the urban-rural classification (using adjacency to the areas delineated as CBSA), it does not specifically account for the size of the urban population. In addition, there is significant overlap between the OMB's metropolitan areas, which are supposed to represent urban areas, and the Census' rural areas. As calculated by the ERS from the 2000 U.S. Census data, approximately 51% of the rural population in the U.S. lives in metropolitan areas. The urban influence code attempts to improve the OMB classification by including additional criteria such as proximity and size, but it still does not fully separate the urban and rural populations.

2.2.5 Additional Transport-Related Area Characteristics

Demographic criteria pertaining to population and population densities can be related to several aspects of transport. All schemes consider, in one way or another, population size. On the other hand, none of the ERS metro-nonmetro–based classification schemes directly account for population density. This might be considered a drawback if one accepts that density plays a significant role in certain aspects of transport, such as transport patterns, needs, and potential demand.

The addition of a proximity criterion might be an improvement on the metro-nonmetro classification scheme because adjacency and proximity to urban cores might affect the transportation patterns between the core and the outside communities, especially for commuting trips. The same applies for the addition of a commuting flows criterion, which captures the current transport patterns and relationships between the urban core and adjacent areas in a more straightforward manner.

2.2.6 Complexity and Efficiency

Increasing the classes as well as the classification criteria can be a trade-off between accuracy and efficiency. Efficiency in this context refers to both the computational and data collection efficiency, which reflects the ease of design and replication of the scheme, and the communication efficiency, which reflects the effort involved in understanding and using the scheme.

The urban influence code provides more detail than the OMB classification, but the former might be considered less efficient because of the abundance of codes and classes. In the same manner, the RUCA scheme improves the OMB classification by accounting for criteria similar to that of the OMB classification, but with the addition of the commuting links between metro, micro, small town, and rural areas, aggregating at the same time the delineation at the tract level. However, the RUCA scheme results in a very complex and unwieldy classification system.

Finally, the urban population-rural density scheme (Ripplinger et al., 2008), results in a scheme with 25 (5 by 5) classes, which might be considered inefficient because of the large number of classes, as the authors acknowledge. At the same time, the scheme is quite complicated and difficult to understand and use because the two separate parts of the scheme overlap. This complexity is most obvious at the extreme levels; for example, the counties designated as “1e” are the counties with the highest possible urban population and the highest possible rural density.

This complexity can be considered a deficiency resulting from both the two-part nature of the scheme and the aggregation of the block/tract urban/rural population features at the county level.

2.3 Concluding Remarks

The main shortcomings of the schemes compared in this section pertain to the aggregation level, the number of classes, the resulting territorial boundaries of the delineated areas, the consideration of the urban population, the consideration of additional transport-related area characteristics, and the overall complexity and efficiency of the scheme. The use of any of these schemes for transportation research has its advantages and disadvantages. Each scheme captures different spatial characteristics relevant to transportation, such as population density or urban land use. While urban areas are, in general, well described in these schemes, a critical shortcoming that has been identified by this research is the absence of a similarly detailed categorization of rural areas.

A classification scheme that accounts for the shortcomings identified above and that considers the transportation network during the delineation process was designed and evaluated for the case of the Midwest (refer to Pyrialakou et al., 2014). However, it was decided to not utilize this scheme; instead, for the remainder of this dissertation, the urban-rural categorization scheme used by the U.S. Census Bureau is adopted. Even though this scheme has many shortcomings, the most relevant of which is that it does not account for any direct transport elements, such as commuting flows, it is the single most recognized scheme and is commonly used for planning purposes at the state and national levels. Because a key goal of this dissertation was to provide an easy to use and replicate framework that can support policy and planning decisions, the widespread recognition of this scheme was a crucial factor to consider. In addition, the detailed aggregation level (at the block/tract level) of this scheme was determined to be the most suitable for this study because it provides a suitable level of detail.

The following chapter describes the empirical setting of the case study.

CHAPTER 3. EMPIRICAL SETTING

This dissertation proposes a framework to assess public (mass) transportation options for intercity travel in U.S. rural and small urban areas. To illustrate the developed framework, a case study of Indiana was completed focusing on rural and small urban communities and using data collected for the case of the Hoosier State train and competing modes along the line. This chapter presents the empirical setting of the case study of Indiana and the Hoosier State train and briefly discusses the development of passenger rail in the state to provide context. This chapter contains sections published in Pyrialakou and Gkritza (2015, 2016), reprinted here with permission from ASME (copyright ASME).

3.1 The State of Indiana

The state of Indiana is the 38th largest state in the U.S. in terms of size, with an area of 36,418 square miles. It is located in the Midwest and has a population of 6,619,680 (U.S. Census estimate as of 2015). Indianapolis is the capital and largest city, with a population of 853,173.

In general, the state is adequately connected by a dense roadway network that includes a number of Interstate, US, and Indiana highways. A number of Amtrak routes that run through the northern part of Indiana (the Blue Water, Capitol Limited, Lake Shore Limited, Pere Marquette, and Wolverine routes) serve only a small part of the state, while two routes (the Cardinal and Hoosier State routes) run through central Indiana. The Cardinal, the major passenger rail route serving Indiana, operates three days a week between New York City and Chicago. In addition, the Hoosier State line, which will be used as a case study in this dissertation, operates the other four days of the week between Indianapolis and Chicago (its services will be discussed in more detail below). Furthermore, four primary commercial airports are located in Indiana. The main one, Indianapolis International Airport, is located seven miles from downtown Indianapolis and provides numerous daily flights operated by American Airlines, United Airlines, Delta, Southwest, and others. Finally, there are at least two main intercity buses, Megabus and Greyhound Lines, Inc., that serve the demand between Indianapolis and Chicago with several trips per day. Greyhound Lines, Inc. also provides a connection between Chicago and

Indianapolis to the city of Lafayette. In addition, Barons Bus Lines and Hoosier Ride Intercity Bus Service (a collaboration between the Indiana Department of Transportation, Greyhound Lines, Inc., and Miller Transportation) provide limited service to smaller cities like Fort Wayne, South Bend, Muncie, Bloomington, and Gary.

Figure 3.1 depicts Indiana's urban and rural areas together with the main passenger transportation infrastructure (an interactive map can be also found online at http://dx.doi.org/10.1016/j.jtrangeo.2016.02.001).

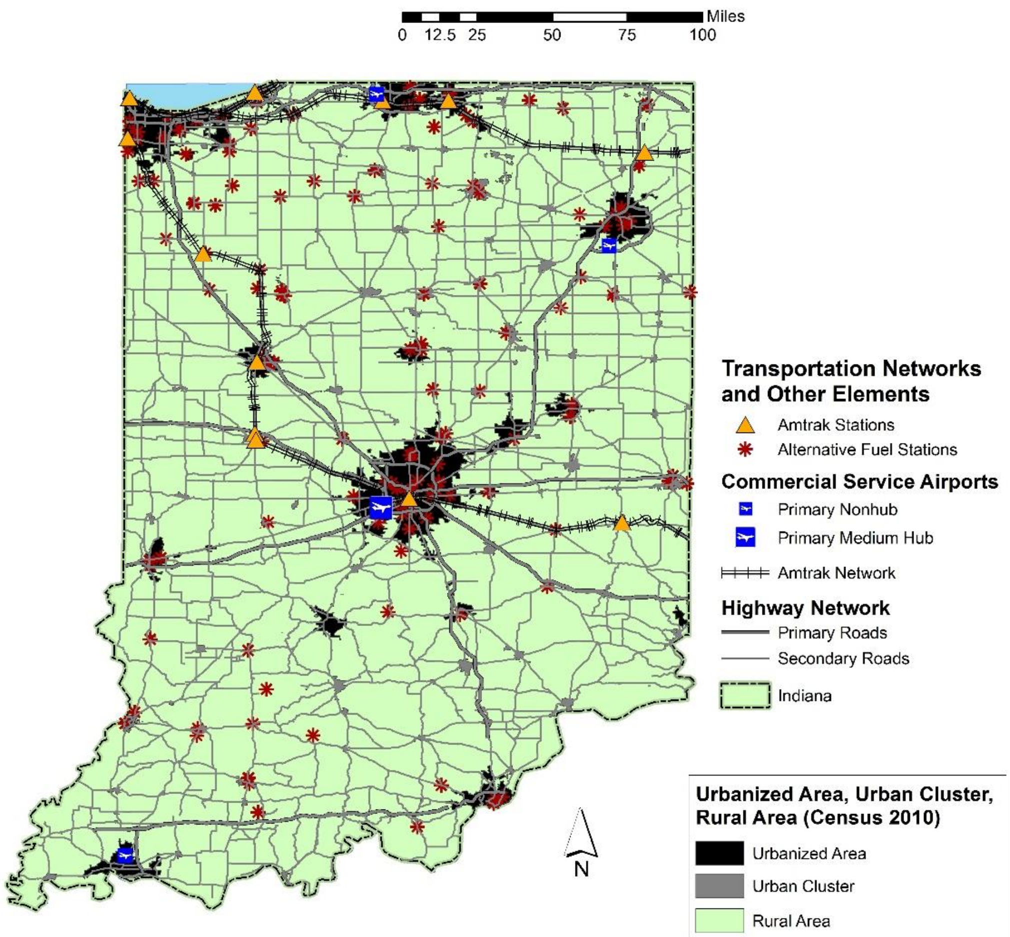

Figure 3.1 Transportation Networks and Stations in the State of Indiana

In the state, only 8% of urban households (living in urbanized areas as defined by the 2010 U.S. Census) and 2% of rural households do not own a personal automobile. The percentage of urban households that have one automobile is more than the corresponding percentage of rural households (37% and 16%, respectively), while the percentage of urban households with three or more automobiles is significantly smaller than the corresponding percentage of rural households (17% and 45%, respectively) (U.S. Department of Transportation, 2009). At the same time, transit serves only parts of the urbanized areas, and intercity buses run typically only between major and university cities like Indianapolis, Lafayette, and Bloomington and to and from Chicago. Specifically, there are only eight large fixed-route transit systems (within the city limits of medium to large urban areas such as Indianapolis, Lafayette, Fort Wayne, Gary, and South Bend), nine small fixed-route transit systems (within the city limits of medium to small urban areas such as Anderson, Valparaiso, Terre Haute, and Columbus), and five urban demand-response transit systems (within the city limits of small urban areas such as Kokomo and La Porte). In the rest of the state, there are a number of rural demand-response systems (42 systems running across counties). These systems typically run limited hours (usually 6:00 a.m. to 6:00 p.m.) and only during weekdays and commonly cover more than one county at the same time. Passengers must request and reserve service in advance by contacting the agencies. These services are also somewhat unstable. For instance, SIRPC used to run buses to and from Jennings County but cancelled the service in 2013 (INDOT, 2014). The services offered by the rural demand-response systems are not considered in this dissertation because they are neither reliable nor convenient, and it would be very difficult to rely on them for daily or frequent trips. This decision was made after a thorough investigation of the services provided and the demand attracted by the rural demand-response systems in Indiana, using data from INDOT annual reports for the years 2003 to 2013 (for example, refer to Pyrialakou et al., 2016).

Part of urban Indiana still remains unserved by intercity buses, specifically within Jennings, Jefferson, Jackson, Bartholomew, Ripley, and Putnam counties (American Intercity Bus Riders Association, 2016). Intercity passenger services have generally been declining in Indiana. Between 2005 and 2010, approximately 2% of Indiana's rural population (more than 42,800 individuals) lost their access[2] to such services based on RITA's estimates (Firestine, 2011). The most noticeable change was in intercity bus services. Based on the same estimates, 95.7% of rural Indiana residents were served by intercity buses in 2005, while in 2010 the corresponding percentage was 85.6% (approximately a 10% decline). At the same time, a significant part of Indiana consists of small urban and rural areas, where land use mainly includes housing,

[2] Note that in the report by Firestine (2011), having access to intercity transportation is considered living within 25 miles of a non-hub or small-hub airport, intercity bus station, or passenger rail station providing intercity service or within 75 miles of a medium- or large-hub airport. Thus, as noted in Chapter 1, this report overestimates access to intercity passenger services in that it assumes residents have access to the airport or station.

agriculture, and farming and where employment and other opportunities are limited. Therefore, people who do not own a vehicle, as well as impoverished and other socially disadvantaged people, experience a lack of mobility and accessibility.

Indianapolis, the capital city, is the largest city in the state, both in size and population. Nevertheless, as estimated in Tomer et al. (2011), which profiled transit accessibility in the 100 largest U.S. metropolitan areas using data on transit, employment, and household income, the typical working-age resident of the Indianapolis metropolitan area (city and suburbs) can reach only 33% of the jobs in the area by transit within a 90-minute ride during a typical weekday morning commute (between 6 a.m. and 9 a.m.). In addition, only approximately 42% of residents in the labor force live in areas served by transit (based on transit stop proximity), with the corresponding estimation being only 8% in the suburbs. The national average across the nation’s 100 largest metropolitan areas is approximately 70% (94% of city residents and 58% of suburban residents). This places Indianapolis among the 15 large metropolitan areas in the U.S. with the lowest transit coverage.

3.2 Evolution of Rail in Indiana

From the early 19th century, Indiana, following the general trend in the Midwest, developed an extensive passenger railway system. Moreover, Indiana was a pioneering state in terms of working towards an integrated network. The coordination between freight and passenger rail services was a matter of focus, even long before the beginning of the 20th century. In fact, in 1849 various stakeholders in Indiana (including the Madison and Indianapolis, Indianapolis and Bellefontaine, Terre Haute and Richmond, and Peru and Indianapolis railroad companies) held a meeting in Indianapolis to make the first agreement of this sort between parties. The unanimous decision was to locate a joint railroad track, with an accompanying joint passenger depot, in Indianapolis (Daniels, 1938). Note that in the early years of the railroad, the network attracted mainly passengers and not freight. While the roadway network was still very inconvenient at the time (especially in the Midwest), and therefore road freight transport was limited to short distances, freight transportation using the canal network was prevalent (Gephart, 1909).

In the 1850s, the first Union Station in the world was built in Indiana (Daniels, 1938). During the first decades of the 20th century, more than half of the interurban rail mileage in the U.S. was located in the Midwest (Grant, 2010), and Indiana became known for having the most developed interurban rail services and for luxurious cars running though the state (Marlette, 1959).

Perhaps the rail network played such an important role in Indiana because the alternative at the time was the relatively primitive roadway network, one of the worst in the U.S. due to the rough and wet winters of the area. Nevertheless, since the 1920s Indiana's railroad services have been steadily declining, similarly to the national and Midwestern trends. The state's passenger rail network was finally highly affected by the deregulation of the 1970s and 1980s. Today, instead of the extensive passenger rail network serving Indianapolis in the early 20th century, there is only one train per day (either the Cardinal or the Hoosier State line).

In recent times, passenger rail in Indiana has been limited to the following:

- Commuter rail in northern Indiana provided by the Northern Indiana Commuter Transportation District
- Two Amtrak lines serving a few cities in northern Indiana (Waterloo, Elkhart, and South Bend): Capitol Limited operating between Washington, DC and Chicago and Lake Shore Limited operating between Boston and New York City
- Two Amtrak lines running through Indianapolis: the Cardinal, a long-distance route operating between New York City and Chicago, and the Hoosier State line, a corridor service route operating between Indianapolis and Chicago

Still, as Figure 3.2 shows, ridership for Indiana stations has been generally increasing in the last decade. The figure presents the evolution of boardings and alightings per station based on data obtained from the Amtrak State Fact Sheets for Indiana (Amtrak, n.d.). the Total boardings and alightings in Indianapolis have more than doubled between 2003 and 2015. Despite this steady increase, since 2003 Amtrak services have been discontinued for 2 of the 13 stations located in Indiana: Jeffersonville in 2003, when the Kentucky Cardinal line from Chicago to Louisville was discontinued, and Nappanee in 2005, when the Three Rivers train between Chicago and New York was discontinued.

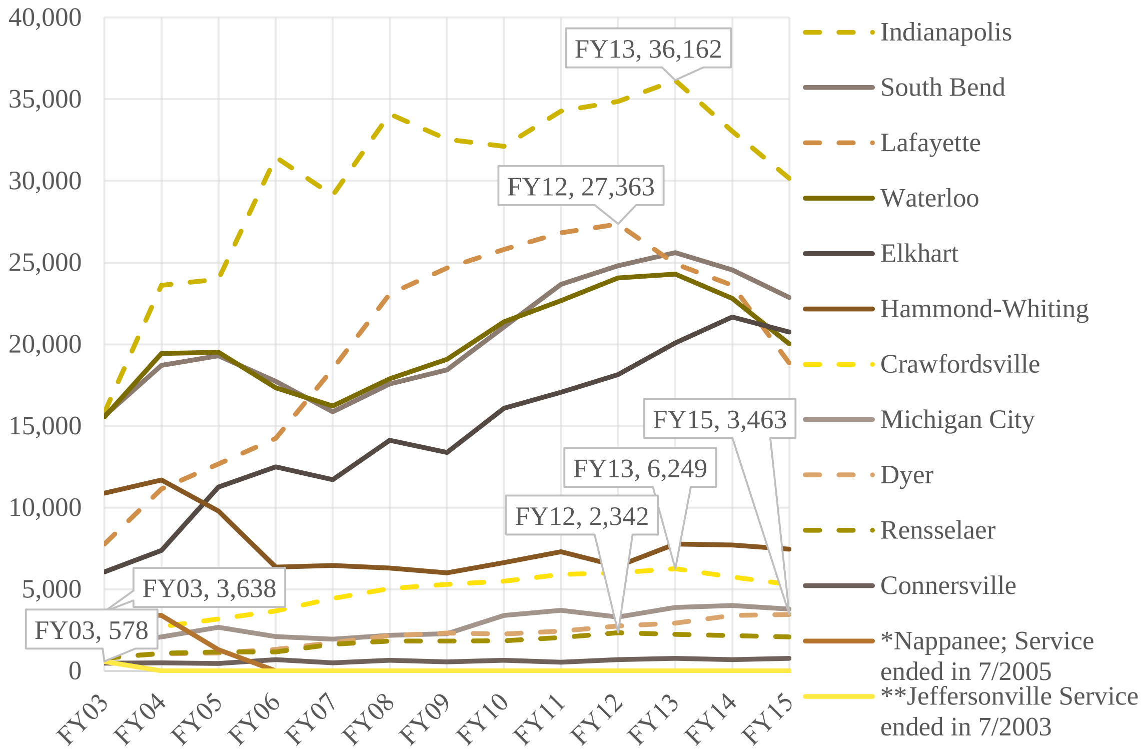

Figure 3.2 Ridership of Amtrak Stations in Indiana for Fiscal Years 2003-2015

Nevertheless, recent studies evaluating higher speed corridors present promising results. In addition, the state of Indiana and—perhaps more importantly—the community, public, and stakeholders still show enthusiasm for the vision of a passenger rail network that can compete with today's highway-oriented transportation culture. The future will show whether Indiana will further support the development of passenger and high-speed rail (Pyrialakou and Gkritza, 2015).

3.3 The Hoosier State Line

The Hoosier State line operates four days per week between Indianapolis, Indiana and Chicago, Illinois with stops in Indianapolis, Crawfordsville, Lafayette, Rensselaer, Dyer, and Chicago (see Figure 3.3). On the remaining three days of the week, the Cardinal line, which operates from New York City to Chicago, serves the area at the same times. In addition to providing passenger rail services, the Hoosier State serves as a shuttle for rolling stock between Chicago and the Beech Grove heavy maintenance shop. The Beech Grove facility is approximately seven miles southeast of the station in Indianapolis.

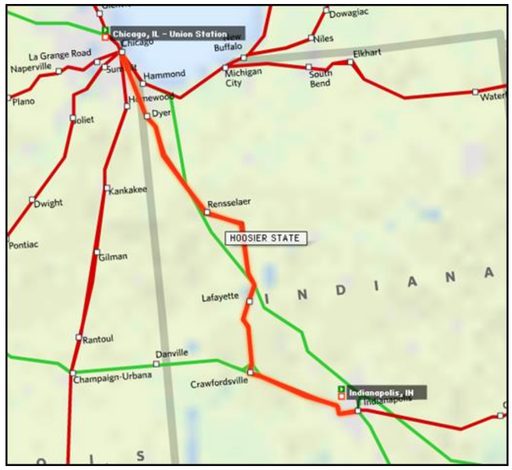

Figure 3.3 Hoosier State Line Corridor, from the Amtrak Route Atlas (Amtrak, n.d.)

The corresponding counties with passenger rail service along the Hoosier State line are Marion, Montgomery, Tippecanoe, Jasper, and Lake counties in Indiana, as well as Cook County, Illinois. Table 3.1 shows the 2010 population information for these counties and their classifications according to three of the urban-rural schemes discussed in Chapter 2: OMB metropolitan-micropolitan statistical areas, rural-urban continuum codes (RUCC) by the ERS, and urban influence code (UIC) by the ERS.

As seen in Table 3.1, three of the Indiana counties along the Hoosier State line can be considered large urban areas (Marion, Lake, and Jasper), one is a medium to small urbanized area (Tippecanoe), and one is a nonmetropolitan area (Montgomery). In addition, the population density varies significantly among the counties, from 60 ppsm to 5,495 ppsm.

Table 3.1 Urban-Rural Classification and 2010 Census Data

County	**Population**	**Pop. Density***	**OMB 2013**	**RUCC 2013**	**UIC 2013**
Cook (Chicago)	5,194,675	5,495	1	1	1
Marion (Indianapolis)	903,393	2,280	1	1	1
Lake (Dyer)	496,005	994	1	1	1
Jasper (Rensselaer)	33,478	60	1	1	1
Tippecanoe (Lafayette)	172,780	346	1	3	2
Montgomery (Crawfordsville)	38,124	76	2	6	3

* Persons per square mile (ppsm)

Table 3.2 Explanation of Rural-Urban Classification Codes in Table 3.1

Scheme	Code	Description
OMB	1	Metropolitan (metro) statistical area
2013	2	Micropolitan (micro) statistical area
RUCC	1	Metro counties in metro areas of 1 million population or more
2013	3	Metro counties in metro areas of fewer than 250,000 population
	6	Nonmetro counties with urban population of 2,500 to 19,999, adjacent to a metro area
UIC	1	Metro counties in large metro areas with at least 1 million residents
2013	2	Metro counties in small metro areas with fewer than 1 million residents
	3	Micro area adjacent to a large metro area

The Hoosier State corridor is 196 miles long and thus is classified as one of the 27 short-distance corridors in the U.S. (i.e., routes of less than 750 miles) as of 2011. Effective October 2013, under the funding provisions of the Passenger Rail Investment and Improvement Act (PRIIA) of 2008 (Section 209), all short-distance corridors should become state-supported, with the states being responsible for the costs associated with the route. For more information on Section 209, its provisions, and a list of the short-distance corridors, see The States Working Group (SWG) and Amtrak (2011).

As a result, at the beginning of the 2013 fiscal year, the Hoosier State line faced the possibility of service discontinuance. The counties affected the most by a possible discontinuance of the Hoosier State line are located in Indiana because it is likely that Indiana's counties are the trip generators and Chicago (or another Indiana county) is the trip attractor for home-based trips. By October 1, 2013, the State of Indiana through the Indiana Department of Transportation (INDOT), local communities, and Amtrak reached an agreement to support the Hoosier State line for the following fiscal year (2013-2014) with the option for four additional months of support (INDOT & Amtrak, 2013).

Eventually, INDOT was the first state DOT nationally to announce a Request for Proposals to seek competing solutions from independent providers, as allowed by the PRIIA, in order to obtain private-sector competitive bids for the operation of the Hoosier State train. After many obstacles and fruitless attempts, INDOT reached an agreement with Iowa Pacific Holdings effective August 2015 (INDOT and Iowa Pacific Holdings, LLC, 2015). The company has since been providing the locomotives for the line and collaborating with Amtrak to keep the train in service, with a shared vision to increase service frequency, improve speed and maintain a reliable schedule, and provide better onboard amenities. The result is a unique (first of its kind in the U.S.), complicated, five-part agreement between INDOT, local communities, Iowa Pacific

Holdings, Amtrak, and the host railroads (primarily CSX Corporation). The agreement between the parties expires June 2017. INDOT has estimated that for fiscal year 2016 it is contributing approximately $255,000 per month to the line in order to continue the existing services, with an additional $21,000 per month coming from the communities of Crawfordsville, Lafayette, Rensselaer, Tippecanoe County and West Lafayette.

3.4 Concluding Remarks

This chapter presented the empirical setting of the case study that is used to illustrate the framework developed for this dissertation. It was emphasized that a large part of Indiana has a rural and small urban character. In terms of passenger rail, however, Indiana has a very rich history. Nevertheless, and despite the potential that the area currently has for developing and improving its rail services, today the provision of such services is very limited. In fact, one of the major corridors of the state, served by the Hoosier State train, has repeatedly been in danger of discontinuance over the past three years. As discussed, however, INDOT and the communities along the Hoosier State line have played a crucial role in financially sustaining the line. This financing, together with the recent operational developments described below in Section 3.3, make Indiana and the Hoosier State train a unique case in the history of passenger rail in the U.S.

Therefore, the case of Indiana and the Hoosier State train provides a great opportunity to explore the potential of passenger rail in Indiana while contributing to the evaluation of the existing and proposed lines in the region. Chapters 4 through 6 of this dissertation present the developed methodology and the results of the case study, with one chapter for each of the three fundamental components of the framework described in Chapter 1.

CHAPTER 4. ASSESSMENT OF TRANSPORT DISADVANTAGE IN RURAL AND SMALL URBAN AREAS

Chapter 4 presents the methodology and discusses the case study results in terms of the first of the three fundamental components noted in the introduction, namely the assessment of transport disadvantage (shown in Figure 4.1). This component attempts to provide an answer to the question whether there is a need for public transportation provision changes in an area in view of the areas accessibility, mobility, and realized travel behavior.

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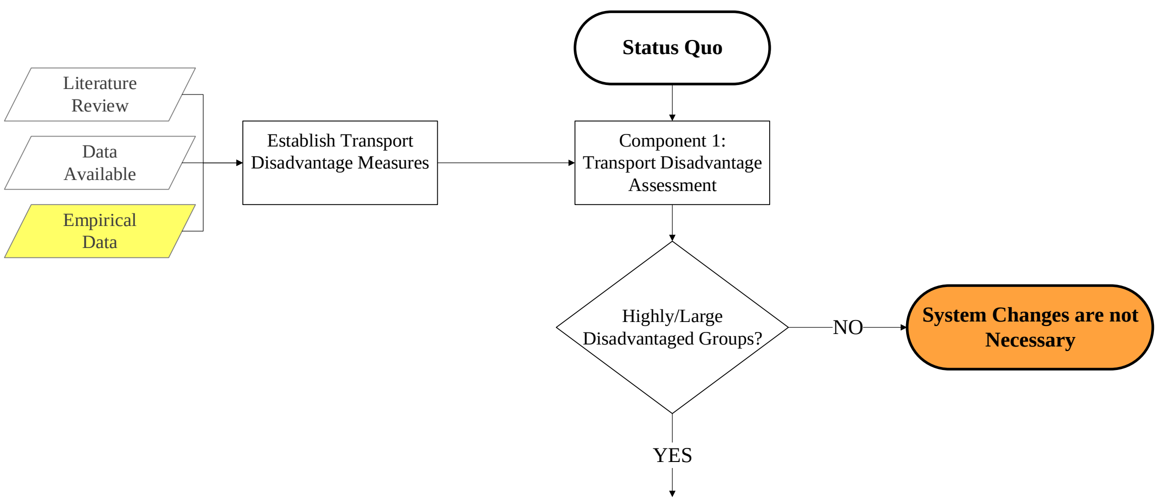

Figure 4.1 Component 1, Part of the Research Framework Flow Chart (from Figure 1.1)

4.1 Literature Review

4.1.1 Equitable Access to Transportation

The literature recognizes that the proximity of transportation services, and consequently of transportation benefits, will be unevenly distributed in space and thus—inevitably—different areas will have different accessibility levels and the residents of these areas will experience different mobility levels (Jones and Lucas, 2012; Martens et al., 2012). But space is only one dimension of this problem; apart from the spatial distribution of the social effects of transportation (both benefits and costs), the literature has also focused on the temporal, socioeconomic, and demographic distribution, as well as the "reinforcing effects" among those three factors (for more information, see Jones and Lucas, 2012).

As with most of the concepts discussed in this chapter, transportation equity does not have a single, widely accepted definition (for a discussion, see Foth et al., 2013; Martens et al., 2012). However, two approaches to the matter are well-recognized: a "horizontal" approach that ignores the differences in transportation needs among populations with different socioeconomic and demographic characteristics, and a "vertical" approach that accounts for such differences (see for example Levinson, 2002; Litman, 2002; Delbosc and Currie, 2011a; Foth et al., 2013; Welch and Mishra, 2013). Nevertheless, even among these two approaches, the definitions that researchers provide vary significantly; for example, Litman (2002) suggests that horizontal equity (or "fairness") is concerned with the fairness of cost and benefit allocation between individuals and groups who are considered comparable in wealth and ability. Horizontal equity implies cross subsidies (that one individual or group benefits at another's expense). It is sometimes interpreted to mean that consumers should "get what they pay for and pay for what they get", unless there is a specific reason to do otherwise. (p. 50)

Along the same lines, Delbosc and Currie (2011a) propose that

> [h]orizontal equity (fairness or egalitarianism) is concerned with providing equal resources to individuals or groups considered equal in ability (p. 1252)

while (Foth et al., 2013) suggest that

> [h]orizontal equity distributes benefits evenly to all groups. Some studies use this concept to define equity as equality in terms of uniform spatial distribution in a geographical region or the same distance from each resident to public facilities. (p. 2)

In any case, there is agreement that vertical equity considers—in one way or another—the increased transportation needs of individuals or groups, either due to their socioeconomic status or due to physical disabilities. Because of the inherent complexity of equity and the multiple definitions, the methodologies developed are numerous, ranging from simple coefficients (such as the Gini Coefficient) and indices to more comprehensive methods. An exhaustive literature review will not be undertaken in this chapter because it is outside the scope of this dissertation. Generally, however, it should be noted that both the international and U.S. transportation equity literature has focused on evaluating existing transportation systems, especially public transportation services, as well as potential transportation investments, and has attempted to provide guidance on how to incorporate the notion of equity in transportation planning and decision making.

For example, Delbosc and Currie (2011a) used Lorenz curves to evaluate the supply of public transportation services (including bus, train, and tram) in comparison with transportation need based on population and employment census data in Melbourne, Australia, considering both vertical and horizontal equity. As far as the vertical equity is concerned, the authors analyzed a number of socioeconomic factors including age, income, and automobile ownership. Along the same lines, Welch and Mishra (2013), also focusing on public transportation services, designed a graph-based methodology to evaluate transportation supply and used the Gini Coefficient to evaluate horizontal equity. The methodology was illustrated with a case study of the Washington D.C.-Baltimore region. Murray and Davis (2001), on the other hand, proposed an index-based approach to evaluate vertical equity as related to public transportation provision and illustrated this approach in Southeast Queensland, Australia. Specifically, the authors explored access to public transportation through the use of an access index and utilized a transport need index considering a number of socioeconomic and demographic factors (such as age, income, disability, and automobile ownership) to compare the potential need with the access to public transportation.

Much research has also focused on evaluating transportation equity in the context of access to employment, or spatial mismatch (i.e., the mismatch between areas where a low-income population is located and employment availability). For example, Foth et al. (2013), following a vertical equity approach, developed a social index accounting for median household income and percentage of unemployed, immigrants, and households that spend more than 30% of their income on rent in an area within Toronto, Canada. The authors evaluated the accessibility to employment and mobility levels based on travel time by different social indicator levels, as well as the changes over time (1996–2006). Using a different approach, Grengs (2010) applied a gravity-based model to investigate the differences in access to low-wage employment in Detroit and explored the role that automobile ownership plays in the spatial mismatch of the area.

The spatial mismatch hypothesis was originally developed by Kain (1968), who proposed that African Americans living in the city center due to lower housing values and racial segregation have a limited ability to access the most suitable employment opportunities for them, which had been transferred to the suburbs. Today, it is widely recognized that access to transportation plays an equally—if not more—important role than the distance from employment (Grengs, 2010). At the same time, the literature suggests that spatial mismatch not only might have a racial component, but it might also be a concern for low-income, low-skilled workers in general (Johnson, 2006) or individuals with no access to automobiles (Pickup and Giuliano, 2005).

Similarly, several methods have been developed to evaluate transportation plans. For example, Golub and Martens (2014) proposed an accessibility-based approach to evaluate transportation projects in terms of their equity effects and illustrated their approach in the San Francisco Bay Area, U.S. Specifically, the authors focused on the differences in access to employment opportunities between automobile and public transportation users and accounted for low-income and minority populations. In another study with similar goals, Manaugh and El-Geneidy (2012) suggested a methodology to evaluate the equity impacts of proposed projects in Montreal, Canada, considering both accessibility and mobility changes that the projects will bring, as well as the projects' effects on spatial mismatch. Specifically, the authors evaluated scenarios before and after the implementation of the projects that involved changes in accessibility to suitable employment opportunities that socially disadvantaged populations have, changes in travel time to employment centers by transit, and changes in time savings.

In view of the above, it should be recognized that the provision of public transportation services is driven by two primary and frequently competing types of goals: patronage- and coverage-oriented goals (Walker, 2008). Patronage-oriented goals aim at increasing the ridership of the mode and are concerned with the efficiency of the services. Coverage-oriented goals are closely connected with equity and aim at providing equitable services, whether in the context of horizontal equity (i.e., everywhere in an area) and/or in the context of vertical equity (i.e., focusing on transportation-disadvantaged populations) regardless of the potential for ridership.

In rural or, generally, low-density areas, which are the focus of this dissertation, the differences between these two goals are obvious. As Walker (2008) states, the key question to ask in order to identify patronage-oriented public transportation systems is "Would the service still run when and where it does if patronage were our only purpose?" (p.437). Thus, it is apparent that due to the commonly low patronage potential, public transportation systems in such areas are either non-existent or have coverage-oriented goals.

Therefore, it is assumed that the motivation behind an extension and/or improvement of public transportation services in the areas examined in this dissertation will be coverage-oriented rather than patronage-oriented. However, it is obvious that an attempt to provide uniform access to transportation (following a horizontal equity approach) for all the rural and small urban communities in an area will not be economically feasible for most U.S. areas. Therefore, this chapter of the dissertation focuses on the notion of vertical equity and attempts to develop a comprehensive approach to evaluate the need for public transportation provision in rural and small urban communities based on the existence of a transport-disadvantaged population, the lack of opportunities, and the existing travel patterns.

4.1.2 Why Does Transport Disadvantage Matter?

There is a growing body of literature on social exclusion, its components, and its effects. The term *social exclusion* has been defined in many ways across the literature. For this dissertation, the definition of social exclusion by Kenyon et al. (2002) is adopted:

> The unique interplay of a number of factors, whose consequence is the denial of access, to an individual or group, to the opportunity to participate in the social and political life of the community, resulting not only in diminished material and non-material quality of life, but also in tempered life chances, choices and reduced citizenship. (p. 209)

The heart of this definition is the notion of *denial,* which emphasizes the eliminated ability to participate in society. This concept of inability is implied by the vast majority of the definitions (Farrington and Farrington, 2005; Percy-Smith, 2000; Preston and Rajé, 2007; Pritchard et al., 2014) and highlights the existing opportunities rather than the choices and behaviors of individuals or groups (Farrington and Farrington, 2005).

Even though social exclusion and poverty have been closely coupled in many cases, they are substantially different terms (Church et al., 2000; Kenyon et al., 2002; Bocarejo S. and Oviedo H., 2012). In fact, poverty (among other economic factors) is one of the many components of social exclusion, and not necessarily the most significant. Kenyon et al. (2002) suggest nine major components (or dimensions) of social exclusion, namely economic, societal, social networks, organized political, personal political, personal, living space, temporal, and mobility. In this chapter it is argued that the last three components are inherently related to transport-related social exclusion, and, as such, they should be accounted for in any policy/planning attempt to mitigate transport-related social exclusion.

Mobility in this context refers to the ability of people to travel in order to reach (access) opportunities and "social networks". Mobility-related exclusion thus refers to the social exclusion resulting from the inability to access such opportunities, or the inadequate ability in a mobility-driven society, and relevant factors can be limited transport choices and reduced connectivity to any available opportunities (Kenyon et al., 2002). On the other hand, a number of exclusionary factors pertaining to living space, such as geospatial isolation (reduced accessibility), available transport services, and other neighborhood characteristics (e.g., safety and environment), can be directly or indirectly related to transportation. Finally, the contemporary literature acknowledges the importance of time-based exclusion, and of the related term "time poverty", and identifies the link between the temporal availability of transportation and social exclusion (Church et al., 2000; Kenyon et al., 2002; Cervero and Tsai, 2003; Jones and Lucas, 2012; Pritchard et al., 2014). Time constraints can substantially limit (in practice and/or in perception) the available transportation choices; for instance, single parents of multiple children are at a great disadvantage if carless, as are workers on weekend and night shifts.

Along the same lines, Church et al. (2000) suggest seven distinct factors relevant to transport-related exclusion:

- Physical exclusion: associated with physical and psychological barriers of people that are not accommodated by available transportation choices.
- Geographical exclusion: associated with reduced community connectivity.
- Exclusion from facilities: associated with reduced accessibility.
- Economic exclusion: associated with the ability to access employment opportunities.
- Time-based exclusion: associated with "time poverty".
- Fear-based exclusion: associated with modal and spatial actual and perceived safety.
- Space exclusion: associated with the perception of exclusion from public transport spaces due to management and surveillance tactics targeting socially excluded groups.

Despite the evidently important role of transportation in social exclusion, as Cass et al. (2005) argue, the literature had been ignoring it, and at the same time transportation research had, until recently, been traditionally driven by engineering, technical, and transport economic studies while marginalizing social inputs (Jeekel, 2014). Nevertheless, contemporary studies acknowledge the key role of transportation among the other components of social exclusion. Preston and Raje (2007) go as far as claiming that “social exclusion is not due to a lack of social opportunities but a lack of access to those opportunities” (p. 153), and, from a policy perspective, suggest five potentially effective initiatives: reduce transportation costs and increase frequencies; promote virtual mobility; increase accessibility (i.e., increase reachable opportunities and facilities); increase income in order to eliminate transportation budget restraints; and promote “production entitlements” (via policies targeted to strengthen family and neighborhood connections).

Note that lack of mobility and/or accessibility (i.e., transport disadvantage) does not always coincide with transport-related social exclusion (Currie and Delbosc, 2010). For instance, a high-income individual, living alone, working remotely, who owns two automobiles and resides in a remote area without any means of transit, is probably not socially excluded. At the same time, sufficient mobility and access to transportation (i.e., transport advantage) does not prevent social exclusion (Farrington and Farrington, 2005).

The literature also suggests that transport disadvantage is highly related to well-being. Specifically, the ability to access opportunities and connect with people and the autonomy to travel to activity sites are directly linked with the sense of well-being because they enable social interaction, employment, learning, and other benefits (Vella-Brodrick, 2011). Delbosc and Currie (2011b) suggest that transport disadvantage is likely to have a greater impact on the well-being of individuals who live in rural and remote areas and experience disadvantage than individuals who live in urban areas and experience disadvantage. In addition, Delbosc and Currie (2011c) conclude that transport disadvantage, combined with other manifestations of the social disadvantage phenomenon, such as unemployment, low social support, and relying on others for travel, can significantly diminish an individual’s well-being. On the other hand, as Currie (2011) and Vella-Brodrick (2011) argue, not only can transport advantage and increased mobility provide people with access to desired opportunities, and thus fulfill their needs and support their well-being, but the sense of well-being might also foster a mode shift (individuals might be more susceptible to changes).

4.1.3 Measures of Transport Disadvantage

The literature has produced a number of different methodologies to identify and quantify transport disadvantage and capture the relationships among disadvantage, social exclusion, and well-being. Generally, both quantitative and qualitative approaches that differ in the type of data used, aggregation level, and the research question being examined have been developed.

The quantitative approaches have mainly focused on measures and indices to identify transport disadvantage. Such measures can be categorized as process-based measures, which aim to evaluate transportation systems and/or areas using accessibility-, deprivation-, or mobility-based measures, and outcome-based measures, which aim to measure the actual outcome of the systems and typically utilize empirical data (Kamruzzaman and Hine, 2011).

4.1.3.1 Process-Based Measures

4.1.3.1.1 Accessibility-Based Measures

Accessibility refers to the potential—or ease—of reaching desired opportunities (or activity sites). *Opportunities* in this context refer to any desired destinations or sites providing employment, goods, and/or services. Thus, accessibility depends on both the transportation network (or mobility) and the distribution and quantity of opportunities, which can be reflected in the land use patterns. Accessibility is evidently a complex concept due to its multifaceted nature. Consequently, the assessment and quantification of accessibility is a challenging process (Litman, 2011).

Notwithstanding the associated assessment difficulties, accessibility has emerged as an important consideration for areas, and a necessity to ensure social equity. A vast body of literature has been exploring the subject for decades, and accessibility-related measures have been assessed and categorized based on a number of criteria and schemes. Herein two approaches are explored, one developed by Geurs and van Wee (2004) and another developed by Páez et al. (2012).

Geurs and van Wee (2004) identify four basic components of accessibility: land use, transportation, temporal, and individual. The land use component is associated with the spatial distribution of opportunities, as well as the quantity and quality of them. The transportation component reflects the travel impedance in terms of time, cost, and personal effort with which a trip to and from an opportunity is related. The temporal component pertains to the temporal variation of the constraints imposed on the access to opportunities, such as service times of modes and opportunities throughout the day. Finally, the individual component refers to the unique needs, abilities, and opportunities of individuals and population groups based on their socioeconomic, demographic, and physical characteristics.

As Geurs and van Wee (2004) discuss, an accessibility-based measure should account for all four components of accessibility; nevertheless, that is rarely the case. The authors identify four types of measures that have emerged from the literature and can be associated with all or some of the four components of accessibility:

- Infrastructure-based measures assess the efficiency, effectiveness, and performance of transportation networks and services; examples are travel speeds and peak-hour periods.
- Location-based measures focus on assessing the opportunities and the opportunities' characteristics within reach from a location; examples are travel time/cost between locations and amount of a specific opportunity type (e.g., schools) within a specific distance (e.g., 30 minutes travel time).
- Person-based measures are concerned with the individuals' capability of reaching an opportunity; examples can be travel time/cost between locations and individuals' temporal constraints.
- Utility-based measures focus on the economic aspect of accessibility, and specifically on the benefits from accessing opportunities; examples can be transport users' benefits and travel time and cost variations throughout a day.

Infrastructure-based measures alone account for the mobility aspect of accessibility and thus are directly related to the mobility-based measures, as one can infer from the description and examples. On the other hand, person-based measures frequently capture the observed travel patterns of individuals as a means to evaluate the ease of reaching opportunities and thus are closer to outcome-based measures.

Páez et al. (2012) developed a similar but simplified categorization of accessibility-based measures based on two components: the cost of travel and the quantity, quality, and distribution of opportunities. The authors suggest two perspectives—area- and person-focused—that can be either origin- or destination-oriented, and propose that the associated measures can be related to one of the following: trip origin or destination, potential trips, or trip purpose. For instance, area-focused measures related to trip origin could be the average number of opportunities within a distance from a census tract, while measures related to trip destination would be the population within a certain distance from an opportunity divided by the total population of the area.

The distinction between accessibility- and mobility-based measures is not always clear. As discussed, accessibility-based indicators that focus on specific aspects of accessibility can be easily categorized as mobility-based indicators (see, for instance, measures focusing mainly on the infrastructure). Thus, this categorization becomes more an issue of semantics than of substance. In this chapter, the focus is on accessibility-based measures that explicitly consider the potential of reaching desired opportunities, and not the actual outcome. Frequently, infrastructure-based measures, as categorized by Geurs and van Wee (2004), and area-focused measures, as categorized by Páez et al. (2012), fit this description. Among them, distance-based (or proximity), cumulative opportunity, and gravity-based measures are well established (Geurs and van Wee, 2004; El-Geneidy and Levinson, 2007). As Table 4.1 illustrates, such accessibility-based measures have been frequently estimated using observed travel data (such as data obtained from travel diary surveys). Such approaches attempt to explore the opportunities that are actually within the reach of individuals in their day-to-day lives based on their current travel patterns. Nevertheless, the use of observed travel data is not necessary. Depending on the methodology used, data pertaining to the opportunities available and/or travel time or cost data estimated using travel models can be sufficient (see for example Minocha et al., 2008; Golub and Martens, 2014).

Note that Table 4.1 presents a few relevant studies to provide context but is not intended to be exhaustive. For an in-depth discussion and a review of representative studies and measures of each category mentioned above, refer to Geurs and van Wee (2004) and Páez et al. (2012).

Table 4.1 Relevant U.S. Studies Using Accessibility-Based Measures

Study	Area and Data	Objectives	Measures and Methods
Ozbay et al. (2003)	▪ New Jersey and southern New York ▪ Socioeconomic and demographic data from the Complete Economic and Demographic Data Source, travel times between counties (calculated by a calibrated Tranplan model from the North Jersey Transportation Authority)	▪ Investigate the relationship between accessibility and economic growth for 1990-2000	▪ Relative accessibility index (accessibility of a county with respect to another) ▪ Gravity-based and cumulative opportunity measures ○ Employment opportunities ○ Within 60 minutes of travel ▪ Multiple linear regression model to investigate the relationship between accessibility and economic growth exploring a number of economic and demographic variables
Minocha et al. (2008)	▪ Chicago, Illinois ▪ Data pertaining to the transportation network (routes, schedules, etc.), transit trips and travel times (from CMAP 2005 model database)	▪ Assess employment accessibility ▪ Investigate public transportation services	▪ Regional transit employment accessibility index ▪ Estimated using gravity-based measures ○ Based on travel time by public transportation ▪ Used to identify areas with low transit services and low employment accessibility

Table 4.1 Relevant U.S. Studies Using Accessibility-Based Measures (Continued)

Study	Area and Data	Objectives	Measures and Methods
Lei and Church (2010)	▪ Santa Barbara, California ▪ Data related to the routes and schedule of the Santa Barbara Metropolitan Transit District	▪ Assess access provided by public transportation ▪ Account for temporal variations	▪ Route planning–based accessibility analysis tool ○ Use of accessibility maps ○ Based on travel time by public transportation ○ Able to account for targeted opportunities in the area (case study used large marketplaces, shopping mall, university, hospital, courthouse, transit center, and others)
Golub and Martens (2014)	▪ San Francisco Bay Area, California ▪ Demographic, employment, and land-use data; travel times by public transportation and automobile for various scenarios (obtained from Bay Area modeling system)	▪ Evaluate transportation investment plans ▪ Assess the effects on accessibility distribution among population groups (focus on low income and minority individuals)	▪ Cumulative opportunity approach ○ Access to manufacturing and service jobs ○ Within 45 minutes travel time ○ Public transportation and automobile ▪ Ratio of public transportation to automobile access
El-Geneidy et al. (2006), El-Geneidy and Levinson (2007)	▪ Minneapolis-St. Paul region, Minnesota ▪ U.S. Census Longitudinal Employer-Household Dynamics data set and travel times by public transportation and automobile (from planning model maintained by the Twin Cities Metropolitan Council) ▪ Home sale records for 2004	▪ Evaluate accessibility using different accessibility measures ▪ Explore changes in accessibility over time (1990-2000) using automobile and public transportation ▪ Explore the effects of accessibility on house prices	▪ Gravity-based and cumulative opportunity measures ○ Access to jobs ○ Within 15 minutes travel time ○ Public transportation and automobile ▪ New accessibility measure called "place rank" developed ○ Accounts for opportunities an individual passes over to reach an opportunity in another area (indicator of the attractiveness of an area) ▪ Hedonic analysis to explore relationship between accessibility and house prices

Table 4.1 Relevant U.S. Studies Using Accessibility-Based Measures (Continued)

Study	Area and Data	Objectives	Measures and Methods
Scott and Horner (2008)	▪ Louisville, Kentucky ▪ Travel diary survey for 2000, geocoded data pertaining to selected opportunities	▪ Investigate the relationship between urban form and accessibility ▪ Explore differences by socioeconomic characteristics	▪ Gravity-based, cumulative opportunity, and proximity measures ○ Focus on four aggregate types of opportunities (i.e., retail, service, leisure, and religious) and 30 disaggregate types (i.e., the 10 most popular destinations for retail, service, and leisure) ○ 2, 5, 15 and 20 minutes cumulative-opportunity explored ▪ Wilcoxon rank sum test to explore differences in accessibility levels of five population groups: rural residents, single-person and single-parent households, low income, women, and elderly
Casas (2007)	▪ Buffalo-Niagara region, New York ▪ Travel diary survey, geocoded opportunity database, and roadway network	▪ Evaluate accessibility and transportation exclusion ▪ Explore differences between disabled/non-disabled populations	▪ Cumulative measures ○ Total number of opportunities (related to dining, entertainment, shopping, and personal errands) within reach of activity space ▪ Comparison tests and Poisson and negative binomial regressions were used to explore differences between disabled/non-disabled population

4.1.3.1.2 Deprivation-Based Measures

In addition to accessibility-based measures, deprivation-based measures have been used to examine the issue of social exclusion and social disadvantage from a planning and policy perspective. *Deprivation* here refers to an "unmet need, which is caused by a lack of resources of all kinds, not just financial" (Social Disadvantage Research Centre, 2001, p. 4).

Deprivation indices have been used by a number of countries, especially Anglo-Saxon countries, to evaluate the provision of services in sectors like health, education, and transportation (for a discussion, see Haase and Foley, 2009). Such measures are intended to be easily constructed and thus rarely consider the quality of transportation services in a comprehensive manner. In most cases, deprivation indices rely solely on census variables (Haase and Pratschke, 2005) and thus are closer to mobility-based measures. In a number of cases, the indices have not considered accessibility factors, or such factors are noted for future consideration (see for instance Noble et al., 2006a). In other cases, mobility factors—mainly related to automobile ownership—are captured through such indices (see for instance Atkinson et al., 2014; Sánchez-Cantalejo et al., 2007). Any measures developed in the U.S. typically belong in the latter category and are limited in scope (for an example see Sharpe and Smith, 2005).

However, deprivation-based measures can be similar in nature to accessibility-based measures in that they can account for the existence and type of opportunities that an individual or group has (or does not have) access to. This approach has been followed mainly in the U.K. Table 4.2 includes a number of representative cases that utilized information pertaining to access to basic needs and opportunities.

Table 4.2 Deprivation-Based Measures

Source	**Area**	**Focus**	**Measures and Methods Related to Accessibility**
Noble et al. (2006b)	▪ U.K.	▪ Income, employment, health and disability, education skills and training, housing, and geographical access to services	▪ English Index of Deprivation 2000 (ID) and Index of Multiple Deprivation 2000 (IMD)[a] ▪ Geographical access to services: ○ Road distance to general practice (GP) surgery, supermarket or convenience store, primary school, post office
Welsh Government (n.d., 2014)	▪ Wales, U.K.	▪ (2000) Income, employment, health, education, housing, geographic access to services ▪ (2005) Physical environment was added ▪ (2008) Community safety was added	▪ Welsh Index of Deprivation and Multiple Deprivation (WIMD) ▪ Geographical access to services: ○ Average travel time by public and private transport to the nearest food store, GP surgery, post office, public library, leisure center, primary school, secondary school, pharmacy, and petrol station
The Scottish Government (2012)	▪ Scotland, U.K.	▪ (2003) Employment, income, health, education, skills and training, geographic access to services, ▪ (2004) Housing was added ▪ (2005) Crime was added	▪ Scottish Index of Multiple Deprivation (SIMD) ▪ Geographical access to services: ○ (2003) Road distance to GP surgery or health center, supermarket or general store, primary school, petrol station, bank or building society, community internet facility ○ (2004) Drive time to GP surgery, supermarket, primary school, petrol station, post office ○ (2005, 2009, 2012) Drive time to GP, shopping facilities, petrol station, primary and secondary schools, post office; Public transport travel time to GP, shopping facilities, post office

Table 4.2 Deprivation-Based Measures (Continued)

Source	Area	Focus	Measures and Methods Related to Accessibility
Northern Ireland Statistics & Research Agency (n.d.)	▪ Northern Ireland, U.K.	▪ (2001) Income, employment, health, education skills and training, housing, geographic access to services ▪ (2005, 2010) Physical environment replaced housing, and crime was added	▪ Northern Ireland Multiple Deprivation Measure ▪ Geographical access to services (weights in parentheses): ○ (2001) Average distance to GP surgery (2), accident and emergency (A&E) hospital (2), dentist (1), optician (1), post office (1), library (1), museum (1), pharmacy (2), and social security office or training and employment agency office (1) ○ (2005) Road distance to GP surgery, A&E hospital, dentist, optician, pharmacist, job center or jobs and benefit office, post office, food store, the center of a settlement of 10,000 or more people ○ (2010) Fastest road travel time from/to GP surgery, A&E hospital, dentist, optician, pharmacist, job center or jobs and benefit office, post office, food store, large service center, financial services, and other general services

[a] The 2004 and later ID accounted for the geographical access to services as a subdomain barrier and not as one of the domains.

Despite the extensive use of deprivation indices, there has been no consensus as to the best way to incorporate accessibility factors in their construction. As seen in Table 4.2, in many cases, even within the same country, the methodology used and opportunities considered changed from one year to another. In addition to measures developed within the U.K., other countries have attempted to use similar methodologies, but have mainly focused on specific services (such as health); for example, the quality of life index published by Natural Resources Canada in the Atlas of Canada accounted for the distance to the nearest hospital (Sharpe and Smith, 2005). In view of the above discussion, it can be seen that deprivation-based measures do not explicitly focus on the transportation aspect, even though they might consider it, but rather attempt to explore the social disadvantage of individuals in a broader context.

4.1.3.1.3 Mobility-Based Measures

Mobility refers directly to the movement of people (and/or goods) and the ability—or ease—of people to travel between places (or activity sites). Direct outcome-based indicators of mobility are the person-miles or vehicle-miles traveled over a period of time (people-oriented) and the realized travel speeds (area-oriented). Such measures can be estimated with the use of survey data and traffic count data (Litman, 2011).

As previously discussed, the distinction between accessibility- and mobility-based measures is not always clear. In this chapter, measures are considered to be mobility-based if they attempt to capture the essence of mobility as reflected by the definition and thus focus on the ease of people to travel between activity sites, and not the activity sites themselves. Table 4.3 presents some representative studies that have focused on such mobility-based measures.

Table 4.3 Studies Using Mobility-Based Measures

Study	Area and Data	Objectives	Measures and Methods
Currie et al. (2009), Currie and Senbergs (2007a), Currie and Senbergs (2007b)	▪ Metropolitan, Regional, and Rural Victoria, Australia ▪ Travel survey and census data	▪ Investigate the relationship between transport disadvantage, social exclusion, and well-being	▪ Forced car ownership (i.e., high car ownership on low incomes) ▪ Zero car ownership ▪ Multiple regression analysis ▪ Relative level of public transport supply and public transport service measurement ▪ Spatial transport needs measurement ▪ Spatial distribution analysis
Wu and Hine (2003)	▪ Northern Ireland ▪ Census and public transportation network data ▪ Noble Index of Deprivation (by Northern Ireland Statistics and Research Agency [NISRA])	▪ Investigate relative accessibility levels of different areas and hours of the day ▪ Assessment of the impact of network changes ▪ Focus on different age and religious groups	▪ Noble Index of Deprivation ▪ Public Transport Accessibility Levels indices for different public transport service time periods ▪ Spatial population analysis (where people live relative to the accessibility levels)
Dodson et al. (2007)	▪ Gold Coast City, Australia ▪ Census and public transportation network data	▪ Investigate the relationship between transport accessibility and social status; urban context ▪ Focus on how socially vulnerable groups are affected by transportation supply accounting for access to employment and social or community services	▪ Temporal (a given combination of service frequency and daytime period) mapping of public transport services ▪ Various disadvantaged groups (e.g., unemployed, low income households) ▪ Spatial service gaps that affect some groups relative to others; access to high-quality transport services ▪ Explores novel geographic information systems (GIS) techniques

Table 4.3 Studies Using Mobility-Based Measures (Continued)

Study	Area and Data	Objectives	Measures and Methods
Currie (2010)	▪ Metropolitan Melbourne, Australia ▪ Census and public transportation network data	▪ Explore the quality and spatial distribution of public transport supply ▪ Focus on transport-disadvantaged groups	▪ Public transport supply measure accounting for share of area with good/bad access, level of service provided ▪ Social disadvantage measures: ○ Australian Bureau of Statistics Index of Relative Socio-Economic Advantage/Disadvantage ○ Transport needs index ▪ Need-gaps (comparison of supply and need) ▪ GIS techniques

In the U.S., studies that have utilized mobility-based measures exclusively are rare. However, a number of studies have used the National Household Travel Survey (NHTS) data, exploring both outcome- and mobility-based measures such as number of trips, travel distances, mode shares, access to private vehicles, and access to transit (see for instance Giuliano et al., 2001; Giuliano, 2005; Pucher and Renne, 2005). The international literature has also used mobility-based measures supplemented by outcome-based measures such as distance to activity sites (see for instance Currie and Senbergs, 2007a, 2007b; Currie et al., 2009).

A number of measures that aim to quantify and compare the available transportation supply and transport need—capturing as a result the gap between the two—have emerged from the literature. *Transport (or travel) need* is defined as a quantification of people in an area who are in need of public transportation services (e.g., the number, percentage, or any other similar relative or absolute measures). Consequently, the need or mobility gap reflects the impacts of reduced mobility or, equivalently, denotes the gap between the transport need (of a population group or an area) and the transport supply (the opportunities available from an accessibility perspective).

To quantify the transport supply, a number of well-established methods can be used to account for spatial and temporal coverage. However, even though transport need is an easily understood concept, the quantification process of this need is neither straightforward nor uniquely defined. Generally, transport need is identified either using expressed need and qualitative evidence related to the existing transport demand (for example, through survey techniques) or using socioeconomic and demographic information to quantify the transport-disadvantaged population. The complexity of quantifying transport need lies in the assumptions behind who is considered transport disadvantaged. Two very common considerations are lack of a personal vehicle and low income; however, other factors can also play a role in the disadvantage of individuals (for an extensive discussion on the matter, see Denmark, 1998; Currie and Delbosc, 2011). For example, to quantify the transport need in Metropolitan Melbourne, Currie (2010) designed a need index that considers—in addition to adults without a personal vehicle and low-income households—factors such as age, disability, employment, and distance from the Melbourne business district's center. In the U.S., the Transit Cooperative Research Program (TCRP) Report 161, which focuses on rural passenger transportation, accounted for the number of individuals in an area without a personal automobile. Specifically, the proposed method quantifies the transport need in an area in terms of trips as the number of individuals with no personal vehicle available, times the difference between the number of trips made by households with one vehicle available and the trips made by households with zero vehicles. The method utilized data from the 2009 NHTS (Vanasse Hangen Brustlin, Inc. et al., 2013).

4.1.3.2 Outcome-Based Measures

Action space is a concept that has been extensively studied in behavioral geography. It is the area within which a person interacts with his/her networks and the environment. Action space has two major components linked with the direct and indirect contact between individuals, respectively. The first component is called *activity space*, which refers to the movement component of the action space and denotes the actual geographical space within which a person completes his/her everyday activities; it has both a spatial and a temporal aspect. The second component is called *communicating over space* and represents the connections a person sustains through alternative communications, such as telephone, social media, or others (Golledge and Stimson, 1997).

The notion of activity space has been well established in transport geography—and transportation research in general—to quantify the outcome of transportation systems and investigate travel behavior and patterns. Generally, activity space consists, for the most part, of three movements: within and around a person's home, between places where a person's regular activities are completed (such as work and shopping), and within and around those places (Golledge and Stimson, 1997).

Cognitive maps are also a commonly used research tool and refer to the outcome of a mental process (cognitive mapping) that represents an individual's mental representation of the environment within which he/she lives. This representation is not limited to spatial information, but might include a complex dynamic system of images, information, values, and attitudes (Golledge and Stimson, 1997).

A number of studies have proposed activity-based measures, which are outcome-based measures specifically aiming at quantifying the activity space of people and groups, and have explored the relationship between activity space, transport disadvantage, social exclusion, and other relevant concepts using detailed travel diaries or similar surveying elements (e.g., self-mapping). Table 4.4 presents a brief review of the most relevant studies on the subject.

Table 4.4 Studies Using Outcome-Based Measures

Study	Area and Data	Objectives	Measures and Methods
Schönfelder and Axhausen (2003)	▪ Halle/Saale and Karlsruhe, German ▪ Travel diary surveys	▪ Investigate the relationship between various socio-demographic characteristics, activity space, and social exclusion	▪ Three measures of activity space (two-dimensional ellipse, kernel densities, and shortest path networks) ▪ Basic statistical analysis tools and generalized linear model (GLM)
Kamruzzaman and Hine (2012)	▪ Rural Northern Ireland, U.K. ▪ Travel diary surveys	▪ Explore the activity spaces among various socio-demographic groups ▪ Investigate the relationship between any variation and transport disadvantage ▪ Account for space-time constraints	▪ Boundaries and fullness of the captured activity spaces ▪ Analysis of variance techniques and GLM
Rogalsky (2010)	▪ Knoxville, Tennessee, USA ▪ Travel diary surveys	▪ Focus on transport disadvantage of working, low income, single mothers ▪ Account for public transportation, accessibility, and space-time constrains	▪ Various travel characteristics such as distance traveled, max and min trip distance, duration of trip, lap times between trips, etc. ▪ Basic geographic information system (GIS) and statistical analysis ▪ Electronic recreation of trips without the use of car
Morency et al. (2011)	▪ Montreal, Toronto, and Hamilton, Canada ▪ Data sources: Greater Toronto Transportation Tomorrow Survey and Montreal's travel survey	▪ Explore factors that influence distance traveled ▪ Focus on specific groups: elderly, low income, and members of single-parent households	▪ Average distance traveled (as a proxy of activity space) ▪ Multivariate regression analysis

Table 4.4 Studies Using Outcome-Based Measures (Continued)

Study	Area and Data	Objectives	Measures and Methods
Nutley (2005)	▪ Rural Northern Ireland, U.K. ▪ Series of consistent travel surveys to provide time-series data	▪ Explore changes in travel behavior patterns ▪ Investigate the relationship between changes in travel behavior and social changes within rural settings ▪ Focus on groups expected to be disadvantaged	▪ Changes in various travel characteristics such as travel distances to a range of destination facilities, public transport and local services, accessibility, car ownership, mode of travel, travel frequencies and trip rates ▪ Basic statistical analysis
McCray and Brais (2007)	▪ Quebec City, Canada ▪ Low income women participating in five community programs ▪ Travel surveys, focus groups, self-mapping of individual activity space	▪ Propose an innovative GIS technique to organize/analyze focus group data and self-mapping ▪ Explore the reasons behind met and unmet transportation needs ▪ Account for space-time constrains	▪ GIS analysis ▪ Coding qualitative data ▪ Standard distance spatial model to measure dispersion ▪ Size of activity space
Kamruzzaman and Hine (2011)	▪ Rural Northern Ireland, U.K. ▪ Travel diary surveys	▪ Focus on key attributes of social exclusion ▪ Investigate the relationship between social exclusion attributes and transport disadvantage to assess effectiveness of attributes identified	▪ Six indicators of activity spaces identified ▪ Six participation indices developed based on the indicators ▪ Factor analyses for the participation index (PI) ▪ GLM
Mondschein et al. (2006)	▪ Los Angeles neighborhoods, USA ▪ Telephone surveys regarding spatial knowledge	▪ Explore cognitive mapping ▪ Investigate its relationship with travel behavior ▪ Focus on the relationship between spatial cognition and access to opportunities	▪ Information regarding individual’s cognitive map identifying cross-streets near commonly visited places (e.g., grocery store) ▪ Basic statistical analysis

As seen in Table 4.4, a number of activity-based measures have been utilized. These measures include the area, size, and other characteristics of activity spaces, a number of approximations for the activity space (such as travel distances), other travel characteristics such as the frequency and duration of participation in activities, indices that synthesize a number of the above measures (Kamruzzaman and Hine, 2011), and information regarding individuals’ cognitive maps. It should be noted that this literature review is not exhaustive, and a number of studies have used other outcome-based measures, not necessarily in direct link with activity spaces. For instance, Stanley et al. (2012) used trip rates to represent individual mobility. Nevertheless, among the outcome-based measures, the focus herein is on the ones related to activity-space because they provide more detailed information and can be considered representative of this category.

4.1.3.3 Comparison of Measures from a Policy and Planning Perspective

All three approaches that can be used to explore the transport disadvantage of an individual, group, or area—accessibility-, mobility-, and outcome-focused—have pros and cons, and therefore studies frequently combine measures based on more than one approach. For example, Pritchard et al. (2014) used outcome-based and mobility-based measures, while Currie and Senbergs (2007b) used mobility- and accessibility-based measures to relate transport disadvantage and social exclusion.

Accessibility-based measures, while they can provide valuable information, suffer from significant shortcomings because they do not take into account whether or not there are adequate transport choices available to reach surrounding opportunities (Kamruzzaman and Hine, 2011, 2012). On the other hand, mobility-based measures do not account for the availability of opportunities (Kamruzzaman and Hine, 2012). Naturally, a combination of accessibility- and mobility-based measures can be used for a more comprehensive analysis. Nevertheless, outcome-based measures commonly depend on aggregate demand, and thus it can be challenging to relate them to social exclusion and well-being, which are people-oriented concepts with a subjective nature (Kamruzzaman and Hine, 2011). An approach used to overcome this challenge is to tailor any outcome-based measure to the population groups of interest (Bocarejo S. and Oviedo H., 2012).

Outcome-based measures, on the other hand, have been suggested as more suitable measures that can provide valuable insights regarding personal travel, activity patterns, and any existing disadvantage. A number of studies highlight the strength of such measures to account for the uniqueness of individuals' needs and the inherent relativeness of the concept of accessibility (for a discussion, see Kamruzzaman and Hine, 2011, 2012). Nevertheless, the literature suggests that travel outcome and realized travel behavior might not be the most suitable indicators of transport-related social exclusion and transport disadvantage for a number of reasons (see for example Schönfelder and Axhausen, 2003). Herein *realized travel behavior* describes the observed travel choices of an individual (or group), which might or might not differ from the individual's travel preferences. First of all, an activity-based approach requires a large amount of personal, detailed, empirical data (from travel diaries, surveys, etc.), making this approach a less attractive alternative for planning and policy applications. In the U.S., the use of such approaches remains limited because there is no central, systematic collection of data at this level of detail. In addition, there is a strong possibility that the target population of such research (i.e., transport-disadvantaged individuals with higher probabilities of social exclusion) may not be in the sampled population, resulting in selection bias, because disadvantaged, unemployed or low income, and socially marginalized individuals are less likely to commit to travel surveys (Schönfelder and Axhausen, 2003). Finally, as Farrington and Farrington (2005) argue, outcome-based measures emphasize the choices of people (behavior) and not the accessibility of opportunities and disadvantage (equity), and thus might not be suitable to comprehensively assess transport disadvantage.

Notwithstanding the significant advantages of outcome-based measures—from a policy and planning perspective, targeting transport disadvantage and equitable access to transportation—exclusive use of such measures might provide limited insights. The literature suggests that even though transport-disadvantaged groups in different areas can have similar realized travel behavior, they suffer many consequences (such as transport dependency, travel constraints, and a relatively higher percentage of their income spent on owing a personal vehicle) to sustain it (Gray, 2004; Pucher and Renne, 2005; Kamruzzaman and Hine, 2012). Thus, assessing transport disadvantage for planning purposes should be realized through a multi-perspective and comprehensive approach, utilizing both process-based and outcome-based measures. The approach that this chapter proposes attempts to fill this gap.

4.2 Data and Methodology

There is a significant lack of U.S. data related to the transport disadvantage of specific sociodemographic groups that can support an investigation of transport need and disadvantage. In this chapter, methods based on all three types of measures discussed above (accessibility, mobility, and realized travel behavior) are explored using socioeconomic and demographic data from the 2010 and 2012 American Community Surveys (ACS), as well as the 2009 NHTS, aggregated at the tract level (2010 Census tract delineation). In addition, geocoded data related to the existing transportation systems and available opportunities are used. ArcGIS 10.1 by ESRI was used for the analysis.

First, following an accessibility-based approach, the accessibility levels of the study area are explored. Specifically, a GIS analysis is proposed that accounts for the spatial distribution of Indiana’s opportunities, coupled with the existing transportation infrastructures. The proposed approach can be considered location-based (or area-based) and utilizes the distance between the area of interest and an opportunity. Table 4.5 shows the opportunities of interest considered in the analysis, as well as the criteria used to identify areas with low, medium, and high accessibility levels. In addition, in the GIS analysis, passenger transportation stations serving long-distance travel (i.e., airports and Amtrak routes in this case study) were considered separately. To identify the various levels of accessibility, a buffer analysis was completed utilizing ArcGIS geoprocessing tools (where the size of the buffers was chosen based on the type of the opportunity considered). The distance shown in Table 4.5 represents the radius of the buffers. The travel times by automobile assume an average speed of 55 miles per hour (mph), while walking travel times assume an average walking speed of 3.3 mph (focusing mainly on the young population).

Table 4.5 Opportunities Considered in the Analysis

			Accessibility levels		
	Distance (miles)	Travel time (min)	Low	Medium	High
Large hospital	9	10 (auto)		✓	✓
Schools	1.1	20 (walking)			✓
Recreational facilities[a]	1.1	20 (walking)			✓
Museums	18	20 (auto)		✓	✓
Public libraries	14	15 (auto)		✓	✓
Amtrak Stations	28	30 (auto)	*not applicable*		
Airports	37	40 (auto)			

a: Recreational facilities considered are park/recreation areas, historic/culture sites, beaches, zoos, and other non-profit recreation sites

As presented in Table 5.5, it is assumed that an area can be described as having (1) low accessibility levels, if none of the opportunities considered can be reached within the travel time chosen (neither by walking nor by automobile); (2) medium accessibility levels, if schools and recreational facilities cannot be reached within the travel time chosen by walking, but the rest of the opportunities considered can be reached by automobile; and (3) high accessibility levels, if all opportunities considered can be reached within the travel time chosen and the travel mode assumed.

In addition, to investigate the transport needs of Indiana, a multi-parameter index is presented that utilizes mobility-based measures of transport need. The index accounts for eight population groups identified in the literature that are expected to have relatively low mobility levels:

- Three groups due to age or physical factors:
  1. Persons below 14 years old

2. Persons above 65 years old
3. Disabled persons

- Five groups that have a high probability of experiencing a lack of mobility choices based on age, income levels, or the absence of personal vehicle:

4. Unemployed
5. Not in the labor force
6. Persons below the poverty line
7. Households with zero vehicles
8. Single-parent family with working parent and children under 18 years old

Based on these eight population groups, eight separate measures are estimated (one for each group). Each measure is estimated as a relative ratio, within the corresponding disadvantaged group, at the tract level based on census data from the ACS. The 2006–2010 estimates were used for this analysis, with the exception of the disability data collected from the 2008–2012 estimates (U.S. Census Bureau, 2010b). Subsequently, the sum of the normalized values of the measures is calculated. Finally, the need index consists of the normalized sum on a scale of 0 to 100, with 0 denoting a very low transport need and 100 a very high transport need in the area. The need index accounts for all eight measures using equal weights.

Step-by-step sample calculations for a tract are presented below:

1. For each of the eight measures, obtain the number of individuals (or households) in each population category that live within the tract (p_{ij}; where *i*=1,…, 1,507 is the number of the Indiana tract and *j*=1,…,8 is the number of the population group). For instance, tract *i*=1 has $p_{11} = 864$ persons below 14 years old.
2. For each measure, calculate the relative measure based on the following equation:

$$\boldsymbol{m_{ij}} = \frac{\boldsymbol{p_{ij}}}{\sum_{i=1}^{1,507} \boldsymbol{p_{ij}}} \qquad \textit{(1)}$$

In the sample tract, the 864 persons correspond to $m_{11} = \frac{864}{1,331,067} * 100\% = 0.065\%$ of the population below 14 years old, where $\sum_{i=1}^{1,507} p_{i1} = 1,331,067$ is the total number of people below 14 years old in Indiana.

3. Calculate the normalized values for each relative measure using the following equation:

$$\boldsymbol{rm_{ij}} = \frac{(\boldsymbol{m_{ij}} - \boldsymbol{m_{ij}^{min}})}{(\boldsymbol{m_{ij}^{max}} - \boldsymbol{m_{ij}^{min}})} \qquad \textit{(2)}$$

where m_{ij}^{min} is the minimum and m_{ij}^{max} the maximum value within group *j*.

In the sample tract for persons below 14 years old, the following is the result:

$rm_{11} = \frac{(0.0065\%-0)}{(0.46-0)} = 14.03\%$

4. Calculate the sum of the eight normalized relative measures estimated in step 2 using equal weights. The following equation can be used:

$$\sum_{j=1}^{8} \boldsymbol{w_{ij}} * \boldsymbol{rm_{ij}} \qquad (3)$$

In this tract, we have $NI_i^{raw} = \sum_{j=1}^{8} w_{ij} * rm_{ij} = rm_{11} + rm_{12} + rm_{13} + rm_{14} + rm_{15} + rm_{16} + rm_{17} + rm_{18} = + \cdots = 0.1403 + \cdots = 2.2271$ with $w_{ij} = 1, \forall\, i, j$.

5. Finally, calculate the need index as the normalized value of the sum of the eight normalized relative measures using the following equation:

$$\boldsymbol{NI_i} = \frac{\left(\boldsymbol{NI_i^{raw}} - \boldsymbol{NI_i^{raw,min}}\right)}{\left(\boldsymbol{NI_i^{raw,max}} - \boldsymbol{NI_i^{raw,min}}\right)} \qquad (4)$$

where $NI_i^{raw,min}$ is the minimum and $NI_i^{raw,max}$ the maximum value of the estimated sum in step 4.

As a result of the above calculations, the sample tract has a need index of $NI_1 = \frac{(2.2271-0.0015)}{(4.0581-0.0015)} = 0.5486\ or\ 54.86\%$.

Note that different weights can be used in step 4. The need index constructed herein can be seen as a social indicator. Such indicators have been widely used in research and applications pertaining to equity. For a discussion, see Foth et al. (2013). The choice of the weights is an important matter for such indices and should not be made without careful consideration of the goals of the application. Herein it is intended that all population groups that might suffer low mobility levels be accounted for in a unified manner, following the applications of Murray and Davis (2001) and Foth et al. (2013). It is not necessarily implied that all population groups experience the same impacts due to their limited mobility, but rather that all groups are of equal importance in this analysis.

The literature has also used unequal weights (see for example Currie, 2004, 2010; Jaramillo et al., 2012). For planning-related applications, it is advised that the analyst use all the available quantitative and qualitative information pertaining to the population of interest and consider whether the assumption of equal importance among population groups holds true. For instance, there is an ongoing discussion pertaining to the aging population in Indiana; the need index could be used as a planning tool focusing on this issue by setting a larger weight for the population group of people aged 65 years or older. To identify the most disadvantaged target population groups, public involvement through surveys, public meetings, and focus group techniques can provide further insights. A number of weighting techniques are available, ranging from statistical reduction techniques (such as principal component analysis; see for example Pink, 2008) to negotiated weighting using ad hoc and selection techniques (Murray and Davis, 2001). Weights can be also estimated by conducting a trip behavior analysis that explores the travel patterns of specific population groups (see for example Morgan, 1992).

By combining the results of the mobility and accessibility approaches, the need gaps can be identified. As discussed in the literature review (Section 4.1), the need gap is most commonly identified through a comparison between the transport need and transport supply of an area. In this analysis, it is proposed that the levels of accessibility should also be taken into consideration, especially in rural and small urban areas where the public transportation services are very few or non-existent and the available opportunities might be limited. Thus, to identify need gaps a combination of the designed accessibility and mobility measures is used herein. Specifically, areas that suffer from a need gap are considered to be areas with high and very high transport need coupled with low accessibility levels. Note that this estimation might underestimate the results because areas with average transport need and/or accessibility levels could also be considered as disadvantaged areas.

Finally, this chapter illustrates an aggregated outcome-based approach based on NHTS data (Federal Highway Administration, 2009). In general, the approaches most commonly employed and with the most efficient outcomes are based on individual-level data collected using activity diaries or other similar methods. However, in the U.S. such data are scarce. Consequently, this analysis utilizes data from the only comprehensive database consistently collected, that of the NHTS. Nevertheless, the NHTS is a limited sample survey—the 2009 data set consists of 150,147 households, with 2,857 of the target households in Indiana (Federal Highway Administration, 2009). Therefore, an aggregation of the responses at the tract level is not a trivial matter. Recognizing this shortcoming, the Bureau of Transportation Statistics (BTS) has developed the 2009 Transferability Statistics, intended to provide estimates of average household person trips, vehicle trips, person miles, and vehicle miles traveled at the census tract level (Bureau of Transportation Statistics, n.d.). The present analysis uses the daily person miles estimated by BTS using the 2009 NHTS and the 2005–2009 ACS data, at the tract level. The estimates of person-miles were chosen as the closest indicator of the average trip length that individuals living in each area are traveling for day-to-day activities. BTS utilizes the collected demographic and household characteristics to develop a series of regression equations and transfer the results in a way that is tailored to the tracts' characteristics (based on the census ACS data), assuming households of different sizes and owning zero to four vehicles. Herein the features closest to Indiana's average (two-person, two-automobile households) are used. It is speculated that this measure will be highly related with the accessibility of an area; the fewer the opportunities in proximity to an area, the greater the trip lengths would need to be in order for people to reach employment and other opportunities. Note that this measure is an approximation of the trip length and does not provide any information regarding the number of daily trips. This can be a limitation because the number of trips per day as well as trip-chaining patterns can differ significantly between urban and rural areas, and using an average trip length can potentially mask these differences.

4.3 Results and Discussion

Following the methodology outlined in the previous section, the results of the Indiana case study are presented herein.

4.3.1 Accessibility-Based Approach

Figure 4.2 illustrates the results of the accessibility analysis. Areas with low, medium, and high accessibility are identified. In addition, tracts that are completely within low-accessibility areas are highlighted with a lighter color.

The results show that a large part of Indiana is characterized by low accessibility levels. In addition, the contiguous low-accessibility tracts in the southern and western parts of rural Indiana imply that these areas are at a greater disadvantage than other areas, with fewer and more scattered opportunities.

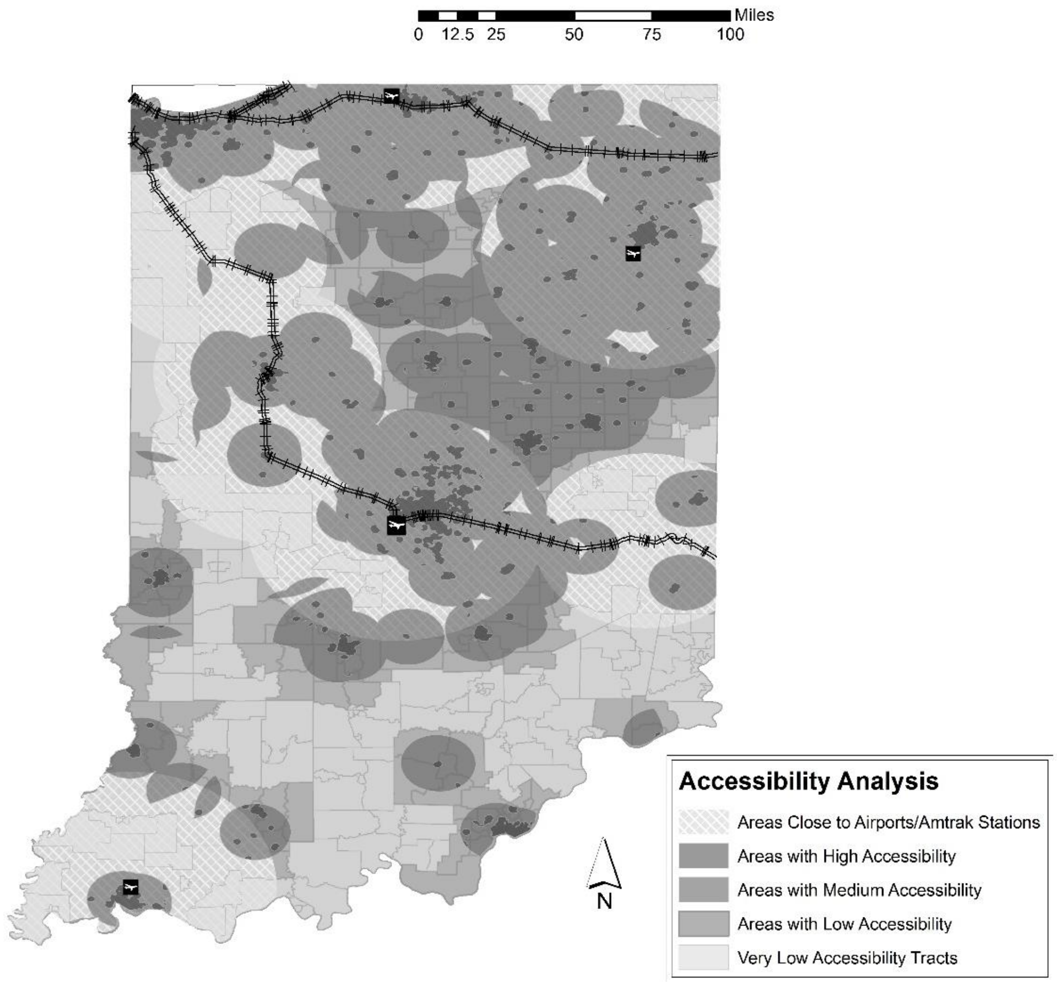

Figure 4.2 Results of the Accessibility Analysis by Tract

4.3.2 Mobility-Based Approach

Figure 4.2 presents the findings of the transport need index. The cut-off points for the transport need index of this application are based on equal intervals (very low is 0–20, low is 21–40, average is 41–60, high is 61–80, very high is 81–100).

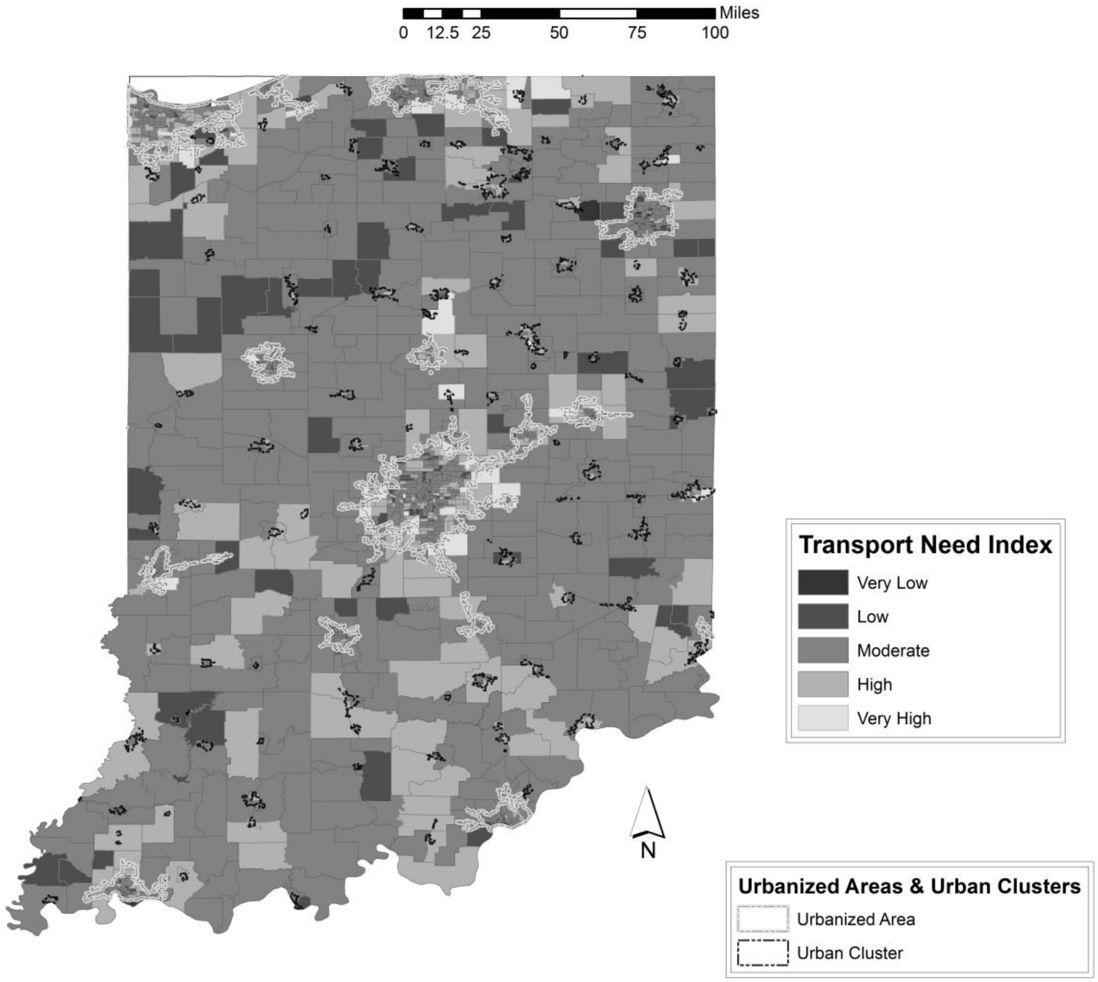

Figure 4.3 Results of the Transport Need Index by Tract

Table 4.6 shows the counties that contain the 10 tracts with the highest transport need and the corresponding total population of the tracts.

Table 4.6 Ranked Top 10 Tracts with the Highest Transport Need Index Values

Rank	County	Tract Population	Households	Index (%)
1	Marion	9,648	3,330	100
2	Elkhart	6,029	2,651	98
3	Tippecanoe	12,230	4,259	98
4	Hendricks	16,246	5,052	91
5	Marion	7,488	2,522	90
6	Marion	16,494	5,994	90
7	Marion	10,396	3,835	89
8	Elkhart	8,363	2,952	88
9	Marion	6,471	2,396	88
10	Elkhart	9,431	3,290	87

As seen in Figure 4.3, the results suggest that a significant percentage of Indiana has a high or very high transport need, while most of the state has a moderate transport need. Many of the tracts with population groups in need of public transport are located in rural Indiana, where public transport is, in general, unavailable.

Figure 4.3 and Table 4.6 also show that most of the tracts that have been identified as having a very high transport need are located in Marion County, near Indianapolis. This implies that a higher number of transport-disadvantaged residents is living within these areas relative to the rest of the state, which is in line with the fact that these areas have relatively large general populations (greater population densities). Note that the proposed transport need index has been constructed to explore the relative transport need within an area. As discussed in the literature review (Section 4.1), considering the unique nature of rural and small urban settings, it is assumed that the motivation behind the provision of public transportation services in such areas will be coverage-oriented rather than patronage-oriented, but at the same time an attempt to provide uniform access to transportation for every community within the state would not be feasible. Therefore, the transport need index aims at identifying the relative need of an area in order to assist not only in the identification of areas in need of public transportation, but also in the prioritization of such areas according to their needs.

To explore the spatial autocorrelation of transport need and identify any spatial patterns that might exist in the study area, the Moran's I coefficient is estimated following Anselin's (1995, 1996) methodology. To calculate the global value of Moran's I coefficient, the *Spatial Autocorrelation* tool in ArcGIS was utilized. In addition, the *Cluster and Outlier Analysis* tool was used to calculate the local Moran's I values and identify any spatial patterns, such as areas where tracts of high transport need or low transport need are concentrated, and/or any outliers, such as areas of low (or high) transport need where a high (or low) transport need tract is located. A first-order queen contiguity row-standardized weight matrix was chosen; this matrix identifies all the direct neighboring tracts for each tract, or tracts sharing boundaries and/or nodes.

Moran's I was found to be 0.15, significant at a 1% level (z-score of 9.72); this means that the null hypothesis of complete spatial randomness is rejected. Thus, there is evidence that the transport need in the study area is spatially distributed in a non-random manner. The positive value of Moran's I suggests that areas with high transport need and areas with low transport need are clustered.

Figure 4.4 shows the results of the local Moran's I analysis.

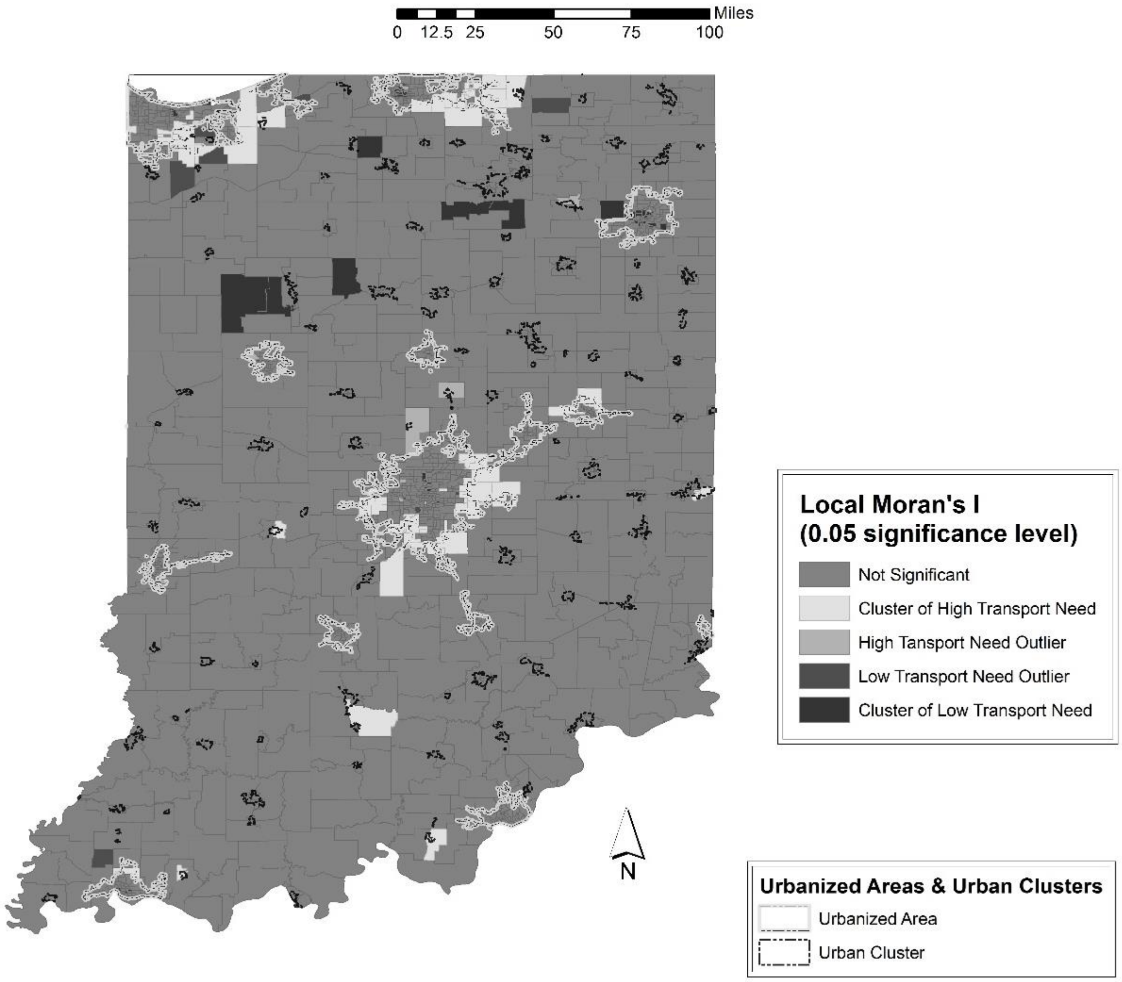

Figure 4.4 Results of the Cluster and Outlier Analysis Using Local Moran's I

As seen in Figure 4.4, clustering of areas with higher transport need occurs mainly in rural areas close to urban and urbanized areas. However, in the study area, spatial patterns were not identifiable for the most part; the local Moran's I was found to be insignificant in most of Indiana (at a 0.05 significance level). Despite the lack of spatial patterns in this case study, however, in other empirical settings where spatial patterns do exist, cluster and outlier analysis can potentially identify broader geographical areas that might be in need of public transportation.

4.3.3 Need Gap Assessment

Combining the areas that have been identified to be in high and very high need (based on the transport need index, Figure 4.3) and the areas with very low accessibility (Figure 4.2), the highly transport-disadvantaged areas can be spatially identified. As expected, based on the previous parts of the analysis, most of the areas characterized by a significant need gap are located in southern or western rural Indiana, as shown in Figure 4.5.

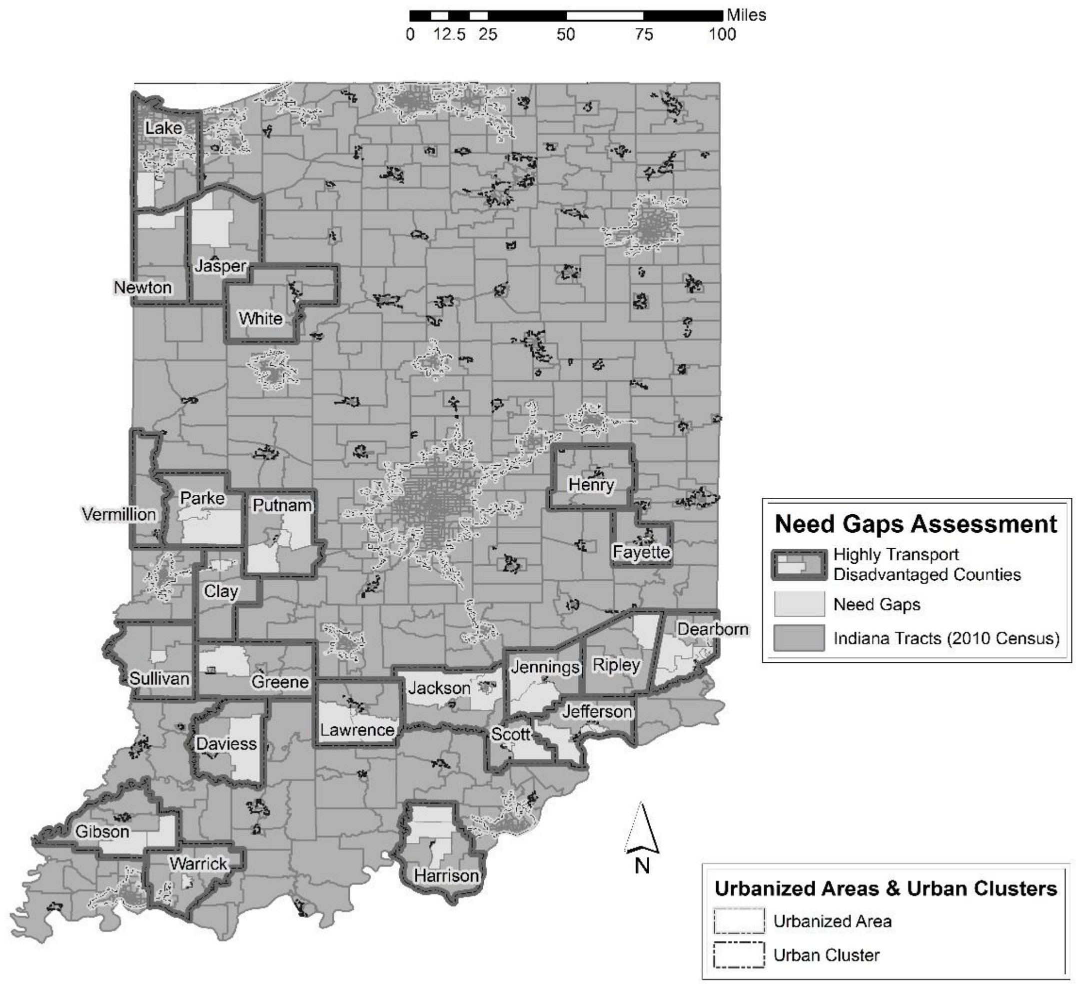

Figure 4.5 Results of the Need Gap Assessment, Tracts and Associated Counties

As Figure 4.5 illustrates, 23 out of the 92 counties in Indiana (i.e., 25% of the counties) have at least one census tract with a significant need gap. Fifteen percent of the population living within these tracts is 65 years old and older, 20% is 14 years old and younger, 4% is unemployed, and 2% lives below the poverty line. In addition, 6% of the households within these tracts do not own an automobile.

4.3.4 Outcome-Based Approach

Figure 4.6 shows the results of the outcome-based analysis at the tract level, as well as the urbanized areas and urban clusters.

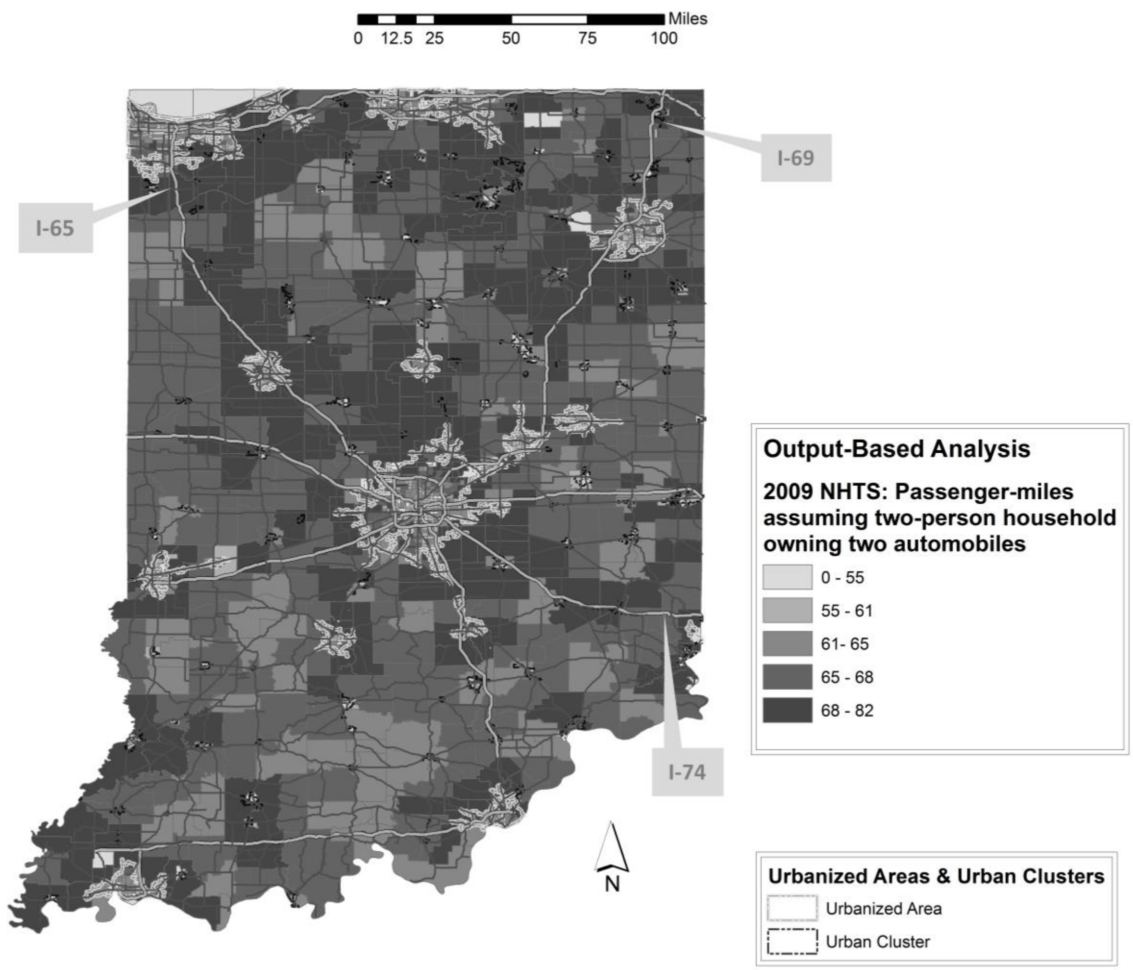

Figure 4.6 Outcome-Based Analysis Results by Tract

As Figure 4.6 illustrates, all urbanized areas exhibit lower trip lengths (0–61 miles), while the majority of rural areas exhibit higher trip lengths (61–82 miles). This is expected and in line with the literature (Pucher and Renne, 2005). The highest trip lengths are within rural areas across Indiana. In addition, it seems that tracts located near the main Interstates that pass through Indiana (such as I-65, I-69, and I-74) exhibit, in general, higher trip lengths. As expected, the

Indiana DOT reports a comparatively high annual average daily traffic (AADT; between 23,000 and 200,000 for 2011) on these Interstate facilities (Indiana Department of Transportation, n.d.). This might imply that individuals living in areas near an Interstate have chosen their house location considering, in part, factors pertaining to access to opportunities, such as employment. This finding might further imply limited employment and other opportunities in rural areas and the concentration of employment and other opportunities in the greater Indianapolis area. This implication is also supported by commuting data. For instance, in 2000 it was estimated that approximately 32% of the employees in Marion County commuted from other counties in Indiana (Census, 2000).

4.4 Concluding Remarks

The objective of this chapter was to establish comprehensive measures that can support the identification, evaluation, and quantification of transport disadvantage in U.S. rural and small urban communities, considering both data availability and the unique characteristics of the U.S. To achieve this objective, this component of the research framework developed a spatial multi-perspective approach to account for the three essential elements of transport disadvantage: accessibility, mobility, and realized travel behavior.

The empirical findings suggest that a great part of rural and small urban Indiana presents a low density of opportunities and that transport-disadvantaged residents of such areas might experience the impacts of low transit supply as well. In addition, the findings suggest that residents of rural and small urban areas travel longer distances on their day-to-day activities. Thus, based on the developed research framework, the next steps of the analysis call for an assessment of the available transportation options in the area and the evaluation of the potential of a ridership increase of the public transportation mode that is identified as the most promising that can further support the development and improvement of the particular mode. Focusing on passenger rail, the next two chapters present the implementation of the developed framework and the results of the analysis for the case study of the Hoosier State train.

CHAPTER 5. MODE ASSESSMENT

5.1 Introduction

One of the main goals of this dissertation is to explore whether passenger rail is the most advantageous mode for intercity travel in rural and small urban areas (as discussed in Chapter 1, Section 1.4). To achieve this goal, the second component of the developed framework involves the assessment of transportation modes available in an area for intercity travel, in view of the communities' long- and short-term transportation planning goals (shown highlighted in bold in Figure 5.1). As such, accounting for the different—and sometimes contradictory—expectations of the various stakeholders involved in transportation planning is imperative to this research component.

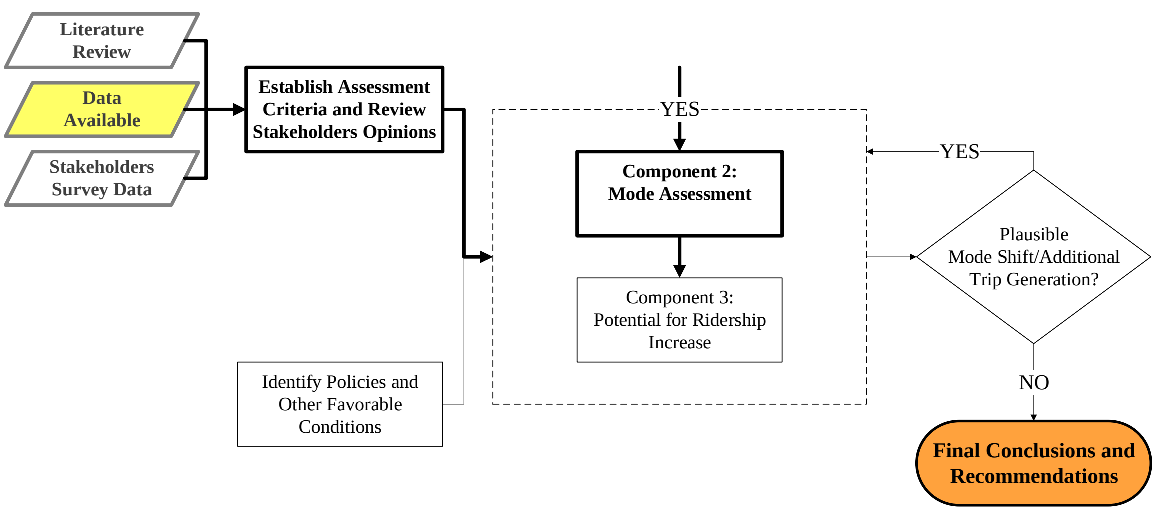

Figure 5.1 Component 2, Part of the Research Framework Flow Chart (from Figure 1.1)

To collect the required data and achieve the objectives of this research component, it was decided to conduct focus groups. Focus groups are "group discussions exploring a specific set of issues" (Barbour and Kitzinger, 1998, p. 4). The difference between focus groups and group interviews is that the focus groups explicitly use the interaction between the participants to generate data (Barbour and Kitzinger, 1998). There are several reasons for using this format.

Focus groups have been identified as a useful data collection tool to investigate complex behaviors and motivations (Morgan, 1993). Because transportation decision making is an inherently complex process that includes the evaluation of the various trade-offs involved, combining survey responses with focus group observations and secondary data (such as the long- and short-plans of the various agencies) can provide valuable insights on the matter. In addition, a focus group is a suitable tool to explore people's perspectives as they interact with one another and generally operate within a social context (Barbour and Kitzinger, 1998) and to investigate the degree of consensus (Morgan, 1993). Thus, in order to achieve a more realistic assessment of transportation modes in the case study area, focus groups were used to both solicit information pertaining to the stakeholders' perspectives regarding the various transportation modes and to explore the dynamics and the level of consensus among stakeholders.

Apart from the mode assessment, due to the unique empirical setting of the case study, a second goal of this component became to solicit information regarding the future efforts of the communities to help improve public transportation systems in Indiana generally and the Hoosier State train specifically. Given the funding provisions of the PRIIA 2008 (as discussed in Chapter 3), obtaining information regarding the future financial support of the line is important in order to realistically evaluate the feasibility of the continuation and improvement of the passenger train's services.

In view of the above, the two major goals of the focus groups were to evaluate the Hoosier State train and competing modes in view of the communities' long- and short-term plans and to solicit information regarding the future efforts of the communities to help improve public transportation systems in Indiana, both in terms of financial support and in terms of fostering a ridership increase. To achieve the latter, the specific objectives were as follows:

- Identify funding opportunities
- Identify optimal conditions for financially viable services
- Understand the role of a ridership increase in the continuation and improvement of the service
- Identify ways to foster a ridership increase
- Envision the role of other public (mass) transportation modes in the broader Indiana transportation system

5.2 Methodology

This section describes the methodology followed for this part of the research, from designing and conducting the focus group, to selecting and recruiting the participants, and to analyzing the data collected.

5.2.1 Participants' Selection and Recruitment Process

In view of the research goals stated above, the focus groups consisted of individuals and groups in Indiana that have influence over planning and decision making and/or influence over fostering a mode shift from automobile to public transportation for intercity trips. Participants who have an interest in the future of the Hoosier State train include elected officials, planning and operating agencies, economic development groups, transportation stakeholders, passenger rail advocacy groups, and other key stakeholders in Indiana and the five counties where an Amtrak station is located (i.e., Marion, Lake, Jasper, Tippecanoe, and Montgomery counties) (see Figure 5.2). A convenience sample was used. The individuals were selected either because of their involvement in the Hoosier State train's development since 2013 (e.g., state senators and representatives, community leaders), or based on their key position in target agencies (e.g., INDOT representatives, mayors, representatives from metropolitan planning organizations [MPOs]).

For the initial contact to invite participation, a number of well-connected individuals were recruited to help with personally contacting the potential participants in order to ensure the maximum response rate and participation. The participants were initially contacted via a personal email. Then, when the focus group meetings' candidate dates were selected, the participants who expressed an interest in the focus group were contacted via telephone. After the locations and dates of the meetings were finalized, the participants were asked to confirm their participation, and a participation confirmation was sent. Lastly, a reminder was sent to all confirmed participants 24 hours before the focus group meetings to ensure maximum participation.

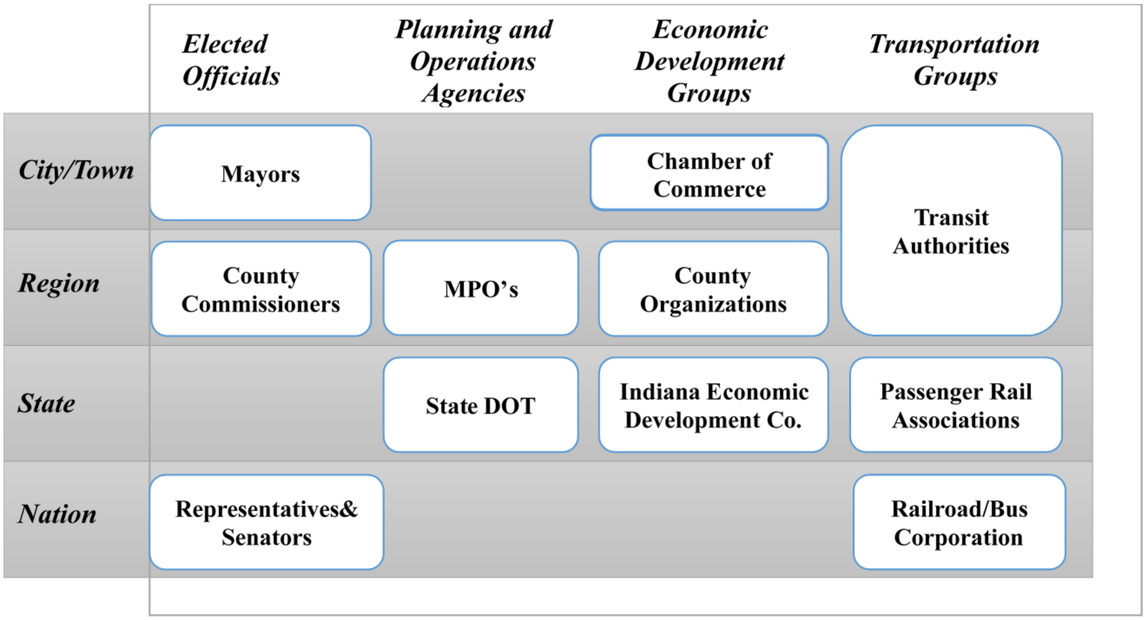

Figure 5.2 Target Groups Invited

Two focus group meetings were organized. The target size of each focus group was around 6 to 10 individuals (no less than 4 to 5 and no more than 12), as suggested by the literature (e.g., Krueger, 1994).

5.2.1.1 Recruitment Material

The first step in conducting a focus group is the initial contact to invite the individuals to participate in the focus group. For this, standard practices were followed, which included initially contacting the participant via email to provide a general description of the research, the general topic of discussion, and the importance of the individual's participation and opinion (Stewart and Shamdasani, 2014).

Thus, for the initial contact, a recruitment letter that provided more information on the discussion topics was distributed to the target individuals. Together with the recruitment letter, a pilot survey (see Appendix A.2) was distributed. This pilot survey aimed at providing context to the potential participants, preparing the participants who ultimately decided to participate, and soliciting initial information that was later used to design the material for the focus group meeting. The pilot survey was developed based on the same principles as the discussion guide (see the following section).

Note that all documents for the focus groups (including all recruitment materials) were reviewed and approved by the Purdue Research Board (IRB Research Project Number 1507016231; see Appendix A.3).

5.2.2 Focus Group Discussion

This section outlines the discussion topics and presents the discussion guide developed and used to guide the focus group meetings. The focus group meetings were designed to last approximately 120 minutes. The agenda distributed to the participants is presented in Appendix A.4, Doc. 1.

5.2.2.1 Discussion Topics

Both meetings were moderated by the author, who facilitated and prompted conversations based on the following five discussion topics:

- Long- and short-term planning goals of the communities and the different stakeholders involved
- Mode assessment in view of the planning goals identified
- Financial support and financial viability of the Hoosier State train
- Ridership increase
- Multimodal transportation

The main body of the discussion guide was divided into sections based on the topics summarized above (see Appendix A.4, Doc. 2). As suggested in the literature (see for example Edmunds, 2000; Litosseliti, 2003; Krueger, 1994), the focus group discussion began with welcoming the participants, briefly repeating the goals of the focus groups, clarifying the rules of the focus group, and providing other administrative information (see discussion guide, Appendix A.4, Doc. 2, I. INTRODUCTION). For the introductory part of the meeting, the participants briefly introduced themselves and provided their names, affiliations, and any other relevant information they wanted to share.

A combination of surveys and focus group discussions were used in this research, because this combination usually ensures more comprehensive and time-efficient data collection (Morgan, 1993). Thus, after the introductions were completed, the participants were guided through the first questionnaire using verbal instructions (see Appendix A.4, Doc. 2, II. TRANSPORTATION PLANNING GOALS-CRITERIA FOR ASSESMENT). The responses to this first survey were collected and summarized on-site and were subsequently used to identify the pertinent community goals that were to be used to complete the mode assessment, as per the methodology explained in Section 5.2.3. After that, a second questionnaire was distributed to the participants (similar to the one distributed during the recruitment procedure), and the participants were asked to complete it to ensure that their opinions on several predetermined topics were collected, even if the discussion did not cover those topics. Another purpose of this survey was to ensure that the opinions of all participants were captured in case a participant did not feel comfortable sharing his/her opinion on a specific topic with the focus group.

Upon completion of the second questionnaire, a discussion was prompted aiming to better understand the priorities of the stakeholders in relation to the goals of the community or the agency they represented. During the last part of this discussion, the participants were presented with a summary of their responses to the first questionnaire, specifically showing the top 5 to 7 planning goals provided by the participants. This was done to ensure that all participants agreed with the selected goals that would later be used as criteria in the multicriteria analysis (see Section 5.2.3).

The next part of the focus group aimed at collecting data pertaining to the perceived transportation mode performance, in view of the identified criteria (see Appendix A.4, Doc. 2, III. MODE ASSESSMENT BASED ON CRITERIA). For this part of the meeting, a survey technique was again used instead of attempting to collect data through a discussion, both to save time in data collection and to ensure that the unbiased opinion of each stakeholder was recorded.

The next part of the focus group (see Appendix A.4, Doc. 2, IV. FINANCIAL SUPPORT and V. RIDERSHIP INCREASE) involved an open-ended discussion of several topics guided by the moderator. The discussion was not structured, but rather the participants were presented with the following key topics and were encouraged to start a conversation based on what they considered to be most urgent:

- Public investments in the Hoosier State train
- Funding sources for operations, improvement, and expansion
- Optimal conditions for financially viable services
- Ridership increase
- The role of other public (or mass) transportation

Even though the discussion was not structured, the moderator kept these topics in mind and, when the conversation faltered, used these topics to prompt further discussion (refer to Appendix A.4, Doc. 2). The topics above can be categorized into two broad themes. The first theme includes issues pertaining to the public funding of the Hoosier State train. The part of the discussion focusing on this theme aimed to solicit stakeholders' opinions on the matter. The author prepared the following questions, among others, to prompt discussion on this theme:

1. What do you think about public investments in the Hoosier State train?

2. Where do you think that money for the operations, improvement, and expansion of the Hoosier State train should come from in general?

3. If we wanted to minimize the subsidy and aim for a financially viable passenger rail line, what circumstances/conditions do you think need to exist? What current circumstances/conditions do you think need to change? How do you foresee a passenger rail line becoming financially viable or nearly so?

The second theme involves topics related to increasing ridership and the role of other public transportation services. This part of the discussion was a brainstorming session to identify factors that can support an increase in ridership as well as suitable strategies and planning practices that can foster such an increase. The author prepared the following questions, among others, to prompt discussion on this theme:

1. If an increase in the Hoosier State train's ridership is the goal, how can we achieve that? Are there any ways we can foster an increase?

2. If we expect that the ridership will come from other modes of transportation (i.e., a mode shift), from which alternative modes would these riders come?

3. What role can other forms of public (or mass) transportation, such as intercity buses, play?

Finally, the focus group closed with an opportunity for the participants to debrief (Bloor, 2001) (see Appendix A.4, Doc. 2, VI. CLOSING).

5.2.2.2 Design of the Discussion Guide and Questions

Instead of the "topic guide" typically used to plan focus groups, a question-based method was used to develop the discussion guide to account for the inexperience of the moderator. A topic guide is a list of topics to be discussed during the focus group, while a question-based method would consist of a sequence of questions to be asked (Krueger, 1994). While there are many advantages to using a topic guide (such as a less "staged" discussion, looking more spontaneous), the question-based method ensures that the questions accurately reflect the intentions of the researcher, and—because more than one focus group was planned—eliminates any differences in the phrasing of the questions that might trigger different responses in different focus group meetings (Krueger, 1994). For the complete discussion guide, see Appendix A.4, Doc. 2.

As far as the wording of the questions is concerned, special attention was given to include only open-ended questions. Both dichotomous questions (e.g., with yes/no answers) and close-ended within a range questions (such as *to what extent, how much,* etc.) were avoided based on the suggestions of literature such as (Krueger, 1994; Litosseliti, 2003) and standard practice.

5.2.3 Multicriteria Evaluation

To evaluate the Hoosier State train and competing modes in light of the communities' long- and short-term plans, a standard multicriteria analysis was used. In transportation planning, it is often required that key decisions are made on the basis of a wide range of performance criteria that reflect the concerns and goals of all key stakeholders involved, such as transportation agencies, transportation system users, and society as a whole (Sinha and Labi, 2011). In addition, as highlighted in Chapter 4, contemporary transportation planning should focus on providing access to services, activities, and employment opportunities rather than on just providing connectivity among places. This planning shift requires abandoning the conventional systems evaluation practices, which are commonly roadway- and automobile-oriented, and embracing a multiobjective, multimodal, comprehensive, and people-oriented evaluation.

For the assessment of the existing transportation modes and future directions of the public transportation systems, under multiple criteria with different dimensions (monetary or not), multicriteria analysis is a commonly used tool. In this dissertation, for the purpose of identifying modes and/or infrastructures that should be prioritized for public funding based on the communities' and the agencies' transportation-related planning goals, a simple ranking and rating method is used. The alternatives considered are the Hoosier State train, passenger intermodal stations, highways, alternative fuel stations, and airports. This list is not intended to be exhaustive, but to reflect the most commonly subsidized transportation modes and infrastructures in the area.

Typically, a multicriteria analysis involves the identification, weighting, and scaling of the criteria, and the combination (or amalgamation) of each alternative in view of the alternative's performance in terms of the selected criteria (Sinha and Labi, 2011). For this research, the various transportation alternatives were rated using the rank-based value method. In the following sections, the choices made for each step are presented.

5.2.3.1 Identification

For this research, the criteria were identified through the first survey. Specifically, the participants were asked to review a pool of 20 planning goals and objectives related to the provision of transportation services and identify the five most important goals for them and/or the agency they represented. Table 5.1 shows the goals presented to the participants.

Table 5.1 Pool of Planning Goals for the Multicriteria Analysis

☐ Transportation safety (improve health, reduce transportation-related fatalities/injuries)	
☐ State of good repair (maintain or improve operating conditions, sustaining assets)	
Economic Competitiveness	☐ Enhance productivity and growth
	☐ Improve systems' performance (efficiency, travel time reliability)
	☐ Promote land-use patterns that foster community development
	☐ Promote the adoption of new transportation technologies
Quality of Life in Communities	☐ Enhance quality of life and community well-being
	☐ Improve accessibility, mobility, and connectivity
	☐ Expand transportation choices
	☐ Promote social equity
	☐ Promote environmental justice
Environmental Sustainability	☐ Promote energy efficiency and/or reduce energy use
	☐ Mitigate environmental impacts (including water quality/quantity, air pollution, noise, damage to cultural heritage)
	☐ Adapt to climate change
Public (or Mass) Transportation Specific and Multimodality	☐ Enhance economic attractiveness of systems (e.g., reduced costs for agencies)
	☐ Enhance financial viability
	☐ Improve services to maximize mobility, accessibility, and multimodality (e.g., reduced travel time, improved on-time performance, increased frequency, route expansion)
	☐ Increase ridership
	☐ Provide quality and affordable services
	☐ Encourage use of non-motorized modes (e.g., pedestrian and bicycle travel)

These 20 goals were selected based on a review of the transportation planning goals of INDOT as captured in the 2013-2035 Future Transportation Needs Report (INDOT, 2013), the U.S. DOT's 2014-2018 Strategic Plan (U.S. Department of Transportation, 2014), past literature such as Litman (2013b), and the feedback obtained from the pilot survey distributed to the participants. Because the goal was to be as comprehensive as possible, the participants were instructed to add to the list any other goals that they saw as important so that the moderator could bring such goals to the attention of the group. However, no additional planning goals were added by any participant in either of the two meetings.

5.2.3.2 Weighting

Following the suggestions of Dodgson et al. (2009), numerical weights can be directly assigned by the stakeholders, either with a simple prioritization or with point allocation. In this research, direct weighting through a ranking approach was chosen because it would be less time-consuming than point allocation. The final ranking of the criteria was determined by considering the initial order that resulted from the survey responses and the opinions expressed in the discussions before and after the participants were presented with the order of the top criteria. Different criteria were allowed to have the same importance. As per the rank-based value method, the final weights corresponded to the final ranking of the criteria (Sinha and Labi, 2011).

5.2.3.3 Scaling

This step is required because, in practice, different criteria are measured in different units. To solve this problem, this research used a common pre-established scale that reflected the degree to which development/improvement of the transportation mode or infrastructure using public funds was expected to advance or hinder progress toward the goal considered based on the participants' perceptions. Specifically, the participants rated the alternatives on a negative to positive visual analog scale (VAS) (refer to Appendix A.4, Doc. 4). The rating was then transformed to a pre-established 9-point rating scale (from -4 to 4) for the calculations.

5.2.3.4 Scoring

The participants were instructed to rate the Hoosier State train and potential alternative transportation modes and/or associated infrastructures with respect to each of the selected planning goals. They were further instructed for the rating to consider the degree to which development/improvement of the transportation mode or infrastructure using public funds was expected to advance or hinder progress toward each goal.

The final score for each alternative was calculated based on the following equation:

$$\sum_{j=1}^{J} w_j O_{ij} \tag{5}$$

where w_j was the weight of each criterion, O_{ij} was the average among the participants score given to each alternative i for each criterion j showing the degree to which the criterion would be achieved by funding the alternative j.

5.3 Focus Group Outcomes

The two focus group meetings were conducted in West Lafayette and Indianapolis during Fall 2015. The first meeting included 11 participants representing:

- local elected officials at the local and state levels,
- INDOT, specifically the passenger rail division of the multimodal program and the research and development program,
- the Indiana Passenger Rail Alliance (IPRA),
- Iowa Pacific Holdings, specifically the sales and marketing department and operations department,
- the Northwestern Indiana Regional Planning Commission (NIRPC), and
- community volunteers and members of Greater Lafayette Commerce.

The second meeting included 9 participants representing:

- local elected officials at the local level,
- INDOT, specifically the passenger rail division of the multimodal program (same representative as the first meeting) and the communications division,
- IPRA,
- Amtrak, specifically the state corridor division,
- Iowa Pacific Holdings, specifically the sales and marketing department (same representative as the first meeting),
- the Indiana Economic Development Corporation, and
- Greyhound Lines (the nation's largest intercity bus carrier [U.S. Department of Transportation et al., 2005]) and Barons Bus Lines (a new, small, family-owned and -operated intercity bus company).

Two individuals participated in both meetings; thus, the total number of stakeholders was 18. The following sections present the results of the multicriteria evaluation and summarize the key points that emerged from the focus group discussion.

5.3.1 Multicriteria Evaluation

The two focus group meetings produced two different sets of criteria based on the planning goals the participants prioritized. The criteria selected and the final hierarchical order resulting from the survey responses and the focus group discussions are presented in Table 5.2. The order was also used as a weight for the calculations. The scale used was from 5 to 1, with 5 being the most important criterion and 1 being the least important.

Table 5.2 Planning Goals Selected for the Multicriteria Analysis

Criterion/Goal	Order/Weights	
	1st meeting	2nd meeting
Enhance productivity and growth	5	-
Enhance quality of life and community well-being	5	-
Expand transportation choices	5	-
Improve accessibility, mobility, and connectivity	4	-
Improve services to maximize mobility, accessibility, and multimodality	3	4
Improving system performance	2	3
State of Good Repair	1	-
Transportation Safety	-	5
Enhance financial viability	-	1
Increase ridership	-	2

Based on the criteria above and the methodology presented in the previous section, the results of this analysis are shown in Table 5.3. The scores for the first focus group are reported as calculated, that is, on a scale between -100 to 100, with 100 being the highest score. The scores for the second focus group have been transformed to the same scale to allow an easier comparison. The actual scale for the second set of criteria was between -60 and 60. This difference is due to the different number of criteria used in the two sets.

Table 5.3 Results of the Multicriteria Analysis

Mode/Infrastructure	Performance Score	
	1st meeting	2nd meeting
Hoosier State train	80.82	77.78
Passenger multimodal facilities	58.18	36.11
Highways	40.27	48.70
Alternative fuel stations	31.55	22.04
Airports	27.00	45.37

For the above results, a score of a 100 is the highest score, denoting that all participants agreed that the development/improvement of the transportation mode or infrastructure using public funds would be expected to advance progress towards all selected community goals to the maximum degree. The scores for each criterion are shown in Figures 5.3 and 5.4.

Figure 5.3 Scores by Criterion, 1st Meeting

Figure 5.4 Scores by Criterion, 2nd Meeting

As seen in Table 5.3 and Figures 5.3 and 5.4, in both focus group meetings the Hoosier State train received the highest scores. This confirms that, based on the perceptions of the stakeholders who participated in the meeting, the funding spent on sustaining and improving the Hoosier State train is justified. Later discussions further highlighted this point.

5.3.2 Survey Results

Based on the responses of the participants to the on-site survey (see Appendix A.4, Doc. 3), most participants:

- believe that continuation and development of the Hoosier State line would advance progress towards community goals,
- agree that for the Hoosier State line to be financially viable, ridership must substantially increase,
- believe that discontinuing the train would significantly impact the mobility of Indiana residents, and
- support the idea of public investments in the line.

The participants' responses to the survey were in agreement with the focus group discussions, as outlined in the next section. For a summary of the responses to the survey, refer to Appendix A.5.

5.3.3 Findings from the Open Discussion

The discussions of both groups were recorded, and the discussions were analyzed based on the recordings, the personal notes of the author, and notes provided by the two volunteers who assisted in the focus group meetings. The following sections present the key findings of the meetings. The complete focus group report prepared based on the suggestions of Krueger (1994), Edmunds (2000), and (2014) can be found in the Appendix A1.

5.3.3.1 Financial Viability and Financial Support of the Hoosier State train

In both focus groups, the participants seemed to agree that a crucial goal for the Hoosier State train is to achieve more financially viable services, or services that would not need to be so heavily subsidized. Increasing ridership emerged as the single factor that could ensure financially viable services. However, the prevailing feeling was that a number of barriers currently prevent a significant increase in ridership. Specifically, many of the participants referred to the infrequency of the services (one trip per direction per day), the inconvenient schedule (early morning/late night), and the unreliability of the schedule.

Another point discussed was that residents are unaware of the services. Many of the participants felt that this is also a barrier to increasing ridership. Many of the participants also made the connection between improving services as a means to increase ridership and providing adequate funding to improve the infrastructure. Interestingly, in both meetings, but independently, the conversation reached the point where one participant observed that the problem before them is circular: on one hand a ridership increase is needed to provide evidence that the line can become financially viable and thus justify subsidization of the line, but on the other hand financial support is needed to improve the existing infrastructure and services in order to attract more riders.

One of the key research goals of the discussion was to solicit information regarding the plans of the state and the communities along the line to continue supporting the Hoosier State train in the future and/or to discuss alternative funding sources. All of the elected officials and some other stakeholders who participated in the meetings firmly believed that even though the communities have been supporting the line since 2013 and will continue to do so until 2017, this should be a temporary solution. In terms of where the funding should (or should not) come from, the participants offered a few ideas of various funding sources, but generally agreed that public funding is an important part.

Another idea that emerged from both meetings was the idea of passenger rail as a public utility that should receive public funding. Not all participants felt as strongly as others about this idea, but a few provided strong support for the idea. However, in the discussion a few skeptical comments were made pertaining to the return on investment and the extent of passenger rail utilization.

5.3.3.2 Ridership Increase

Apart from the barriers to increased ridership discussed above and the connections made between improving service and increasing ridership, a number of other factors that can increase ridership were discussed.

Representatives of Iowa Pacific Holdings (IPH) discussed their perspective and reported their attempts to foster such an increase in ridership. They also made it clear that this is one of their key goals. Apart from improving operational services, the key points in terms of marketing that IPH mentioned were improved onboard services, targeted advertisement, word of mouth, digital awareness, and public relations. Iowa Pacific Holdings also talked about a more targeted approach to advertising its services. Specific target population groups mentioned were university students and their parents, “millennials,” and senior citizens.

In view of the participants’ comments summarized in Appendix A.1, it might be inferred that the anticipated ridership increase is mainly expected to come from new demand. However, whether the source of the additional demand would be new demand for travel or a mode shift from automobile or alternative transportation modes (such as intercity buses) was not discussed to much extent. The potential of a mode shift to the Hoosier State train for business travel was briefly mentioned. Related to that were comments on the barriers to business travel, as discussed above. Other key factors and opportunities discussed that could be explored to support a ridership increase included i) economic development and investments by the private sector along the rail lines and specifically around train stations and ii) connectivity with other modes of transportation.

5.3.3.3 Multimodal transportation

Apart from the importance of system-wide connectivity and accessibility to the line, as highlighted above, the participants also discussed the importance of multimodality. In addition, participants representing different perspectives made the case that different mass transportation modes, whether state supported, such as the Hoosier State train, or privately owned, such as intercity buses, are not competing modes. Rather different modes can be complementary, even if they serve the same areas, because they aim to provide transportation options to Indiana residents.

5.3.3.4 Other Key Topics that Emerged

Many participants also highlighted the role that culture plays in both the adoption of public transportation services in general and passenger rail specifically and the willingness of stakeholders to financially support such services. Specifically, many of the participants discussed the fact that Indiana is an automobile-centered state. However, many of the participants also discussed the possibility of an ongoing shift in the culture and the transportation paradigm towards a more multimodal and less automobile-centered lifestyle. Another related subject was that one of the reasons for such a cultural shift in transportation culture is the perceptions of younger generations. A concern expressed in this regard was that these generations are less politically active than previous generations.

Another topic worth mentioning that was raised during the discussions included the perceived benefits of providing passenger rail services in the state and the importance of sustaining the line. The sentiment was that the Hoosier State train connects communities along the line and provides options to the communities' residents.

5.3.3.5 Future Directions

The discussions revealed that the stakeholders who participated in the focus groups viewed the Hoosier State train as a resource of the state, an asset that needs to be preserved. Moreover, most participants agreed that future efforts should be concentrated not only on sustaining the line but also on expanding the passenger rail services in the state.

5.4 Concluding Remarks

This research component proposed the use of focus group meetings to assess the transportation modes available in an area for intercity travel, in view of the communities' long- and short-term transportation planning goals, and accounting for the expectations of the various stakeholders involved in transportation planning. The feedback received by the participants, both at the end of the focus group meetings and through a feedback survey, verified the value of such meetings. Eleven of the 18 participants responded to the short feedback survey that was sent out. All 11 believed that focus groups such as the one in which they participated can facilitate collaboration among stakeholders and discussion of important topics related to public transportation systems while promoting the improvement of such systems. Most respondents (10 out of 11, with 1 remaining neutral) agreed that the focus group meeting was useful, and they would recommend the use of similar methods in the future.

In terms of the case study results, the research findings suggest that—based on the stakeholders' perceptions—continuing and improving the Hoosier State train services would be in line with the communities' transportation planning goals. A number of key topics that can help guide the future of the Hoosier State train were also discussed.

The next, and final, component of the research develops a methodology based on the technology acceptance model and accounting for a number of factors that affect the intention to use passenger rail services. The analysis aims to better understand the perceptions of users and potential users of the system. In addition, factors that affect decision making regarding the mode choice for intercity travel are explored.

CHAPTER 6. EVALUATION OF THE POTENTIAL FOR RIDERSHIP INCREASE

6.1 Introduction

This chapter presents the last component of the designed research framework (shown highlighted in bold in Figure 6.1). The main goal of this component is to explore the potential for an increase in public (mass) transportation ridership, with a focus on passenger rail, that can further support the continuation and development of public transportation systems. Such an increase might originate from either a mode shift from personal automobile and other competing public (mass) transportation modes or from the generation of additional travel. This chapter contains sections published in Pyrialakou and Gkritza (2016), reprinted here with permission from ASME (copyright ASME).

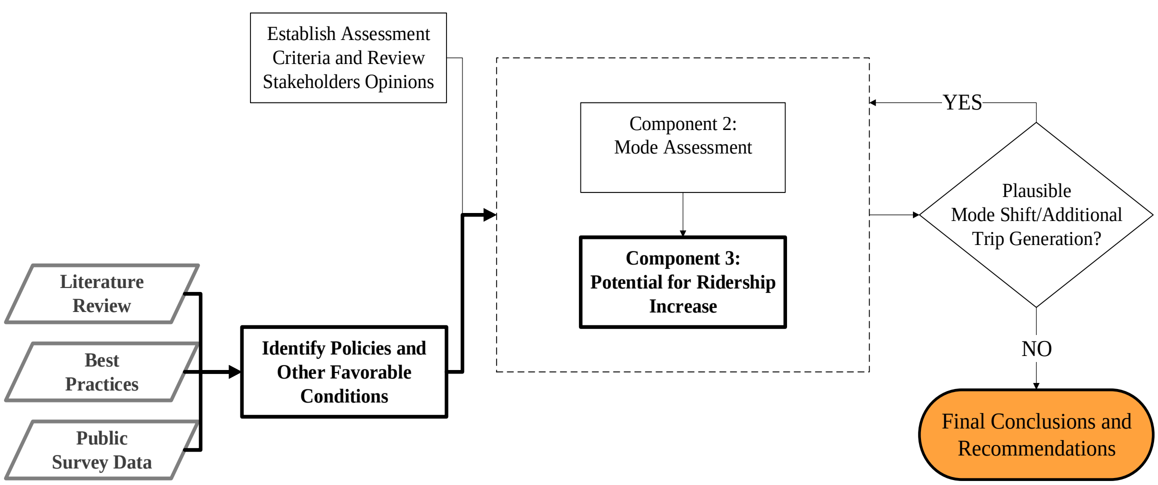

Figure 6.1 Component 3, Part of the Research Framework Flow Chart (Figure 1.1)

An ongoing shift in U.S. society's perceptions of and attitudes towards automobile use is identifiable in the literature. Statistics show that younger generations of Americans are inclined to drive less and use public transportation modes more frequently. Dutzik and Baxandall (2013) argue that this cultural change and the desire to drive less should be encouraged and supported via the development of a transportation network that can facilitate such changes. As the authors suggest, a revised transportation policy should, at minimum, prioritize a multimodal system that will provide more choices for a larger percentage of Americans, encourage authorities to reconsider automobile-oriented planning and zoning rules, and channel federal investment towards overlooked infrastructure systems, including passenger rail and transit systems. As discussed in Chapter 5, the stakeholders who participated in the focus groups conducted under this research echoed some of these sentiments to describe the state of passenger rail in Indiana today.

In any attempt to encourage the use of alternative modes, the identification and evaluation of available mode shift strategies is important. Buehler and Pucher (2012) propose that strategies that can be used to increase demand for public transportation fall into three main categories: expansion and improvement of public transportation services, promotion of attractive fares and convenient ticketing, and multimodal coordination of services and fares. Other policies that do not fit into these three categories but that may nevertheless encourage a mode shift can emerge. Examples include restricting automobile use, increasing automobile travel costs (through an increase in parking costs, tolls, etc.), or enacting land-use policies such as compact development and livable communities.

To evaluate policy and planning choices that attempt to foster a ridership increase and/or a mode shift from personal automobiles to alternative modes of transportation, such as the aforementioned policies, it is essential to understand the attitudes of individuals (users and potential users) towards the specific and competing modes. In other words, it is essential to understand the underlying mode choice mechanisms.

In view of the above, this last component of the dissertation aims to capture the thoughts of users and potential users of passenger rail regarding their mode choice decisions and their attitudes towards passenger rail. To achieve this, a theoretical model was designed to explore the attitudes and behaviors towards intercity passenger rail. This model was built based on the technology acceptance model (TAM) and accounted for a number of relevant theories and factors that might affect such attitudes and behaviors. The model was tested for the case study of the Hoosier State train in Indiana. In addition, a multiattribute attitude model that can be used to explore the reasoning behind mode choice decisions was estimated. This latter model can support the prioritization of policies and decision planning choices that can foster an increase in ridership on the Hoosier State train. To collect the data required for both analyses, a public opinion survey was conducted. The next section outlines the sample design and data collection efforts.

6.2 Sampling Methods and Data Collection

6.2.1 Sampling Methods

The original plan for the sample design was to collect a representative sample of Indiana residents. For the purposes of the case study, Indiana residents constituted the largest pool of users and potential users of the Indiana passenger rail system that could be reached. In addition, it was anticipated that Indiana residents would be the population group most affected by any changes in the Hoosier State train service because it was expected that most current users of the Hoosier State train belong to this population group. To achieve this plan, a random probability sample design was used, targeting all residents (18 years and older) of Indiana counties along the Hoosier State line.

For the purposes of this survey and in order to complete the sampling procedure more efficiently, a complex random sample was designed. The design first involved stratification of the population into five strata based on the five Indiana counties that have a station served by the Hoosier State train (see Figure 6.2).

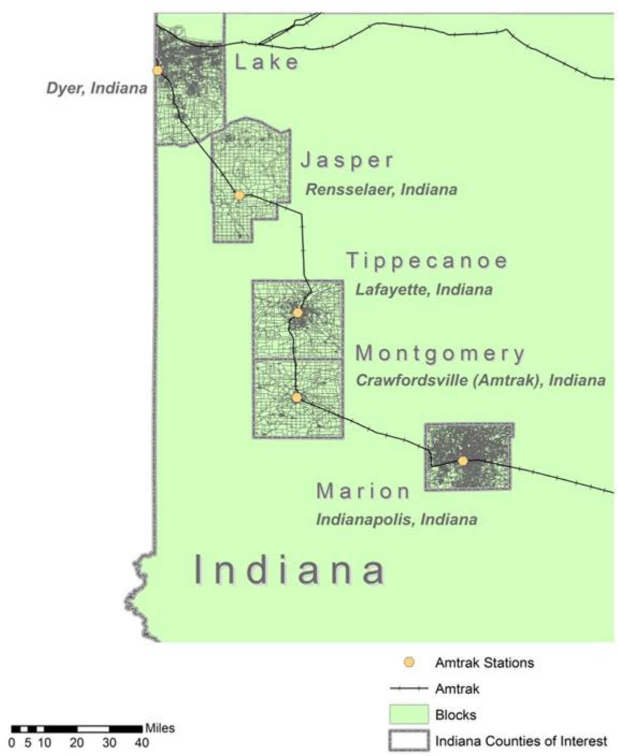

Figure 6.2 Sample Design, Strata

The population was stratified for two main reasons. First, through the stratification, estimates of known precision for each county could be obtained. Second, based on initial data collected pertaining to the population size and the Hoosier State ridership for each county, it was safe to assume that the variances in the relevant data to be collected would vary by county. The ratio of ridership to total population was considered to be an indicator of the data variability, under the assumption that larger ratios would correspond to larger variances in the data (Table 6.1). As seen in Table 6.1, the corresponding ratios vary significantly. The assumption that the residents' responses vary by county of residence also makes an intuitive sense, because residents of different counties have different experiences with the Hoosier State train. For example, the access to/from the station might be better or worse, the arrival/departure times might be more or less convenient, and the destinations that can be accessed are different.

Table 6.1 Demographic and Ridership Characteristics of the Areas

County	County	Population (residents 18% over)[a]	Ridership (Trips/FY)[b]	Ratio (Trips/Residents)
1	Marion County	676,888	32,125	0.0475
2	Lake	368,732	2,257	0.0061
3	Jasper	24,884	1,847	0.0742
4	Tippecanoe	137,063	25,805	0.1883
5	Montgomery	28,985	5,488	0.1893

[a]Based on 2010 Census Data
[b]Values from CDM Smith (2013)

Subsequently, equal random samples (i.e., all having the same sample size) were drawn from each stratum. An optimal allocation that would result in different sample sizes for each stratum based on the estimated variance was considered, but the equal random sample design was chosen instead. This choice was made in order to ensure that residents of counties with relatively small populations would be represented in the sample.

Even though an in-person survey would be preferred, this was not a feasible option due to budget and time limitations and due to the fact that only one person was administering the survey. Though the costs involved and the expected non-response rates were recognized, a phone/mail-based survey was chosen as an alternative. Aiming at a sample size of at least 150 responses, 1,000 records that included mailing addresses and/or landline phone numbers were obtained.

However, it was expected that most of the selected individuals would not be familiar with the services of the Hoosier State train. For this reason, the plan was that the sample would be enriched with individuals that have experience with and/or stronger opinions regarding the

Hoosier State train. Thus, to reach passengers of the Hoosier State train, an onboard survey was scheduled. To reach individuals with strong opinions about the Hoosier State train and/or passenger rail in Indiana, a web-based (online) survey was distributed through newsletters of the Indiana Passenger Rail Alliance and other media; for example, an invitation was posted to a Facebook page supporting the Hoosier State train called Hoosiers for the Hoosier State[3]. Individuals who responded to the online survey distributed via these channels were expected to be more informed on issues pertaining to the Hoosier State train. However, it was also anticipated that these individuals would have mostly positive opinions, because they were reached through advocacy groups. The resulting sampling methods for both the onboard survey targeting current riders and the web-based survey targeting individuals with strong opinions of passenger rail were non-probability (i.e., the probability of representation in the sample was unknown). For the onboard survey consecutive sampling was used, in which all riders of the Hoosier State train at the time of data collection who were more than 18 years old and who hadn't had responded to the survey before were invited to participate in the survey. For the web-based survey a self-selection sampling was used. The survey was distributed openly, and anyone interested could respond to it.

6.2.2 Data Collection

The administration of the survey was completed personally by the author for all of the different data collection methods. Few responses were collected via the phone- and mail-based surveys during the data collection period (spread out between Spring 2015 and Fall 2016). As Table 6.2 shows, the mail-based survey had a very low responses rate, which might indicate a selection bias toward those residents who did respond. The phone-based survey had the anticipated response rate. However, what was unexpected was that a large percentage of the residents could not be reached, at least during the study period. Thus, the number of collected responses through this method was very low as well.

Data collection for the onboard survey was scheduled for five days over two weeks (see Table 6.3). Permission from Amtrak to conduct the survey was obtained in advance with a request for "temporary permit to enter upon Amtrak property" and the completion of a contractor safety and security awareness training session. As seen in Table 6.2, the final onboard data set included 421 responses. Based on the daily ridership and an estimation of the eligible survey

[3] https://www.facebook.com/savethehoosierstate/?fref=ts

population (excluding persons younger than 18 years old and individuals who had already completed the survey once), the response rate was around 70%.

Table 6.2 Data Collected by Survey Type and Estimated Response Rate

	Target Population	**Sample Size**	**Approximate Response Rate**
Onboard Survey	Hoosier State train riders	421	70% of eligible passengers
Web-Based Survey	Supporters of the Hoosier State train	38	Unknown
Phone-Based Survey	Indiana residents with a landline telephone	18	10% based on the population reached (i.e., who answered the phone call)
Mail-Based Survey	Indiana residents	15	2.5%

Table 6.3 presents the schedule of the onboard survey administration and the number of responses collected for each trip. For this survey, the data were collected on board the Hoosier State train. The questionnaires were distributed to all eligible passengers who boarded the train after the train departed from each station. The responses were collected during the trip before the passengers disembarked from the train.

Table 6.3 Onboard Data Collection Schedule and Responses Collected

Day	**Date**	**Departure Station**	**Arrival Station**	**Responses**
Friday	10/9/15	Indianapolis	Chicago	58
Friday	10/9/15	Chicago	Indianapolis	35
Sunday	10/11/15	Indianapolis	Chicago	70
Sunday	10/11/15	Chicago	Indianapolis	40
Wednesday	10/14/15	Indianapolis	Chicago	30
Wednesday	10/14/15	Chicago	Indianapolis	31
Friday	10/16/15	Indianapolis	Chicago	50
Friday	10/16/15	Chicago	Indianapolis	36
Sunday	10/18/15	Indianapolis	Chicago	28
Sunday	10/18/15	Chicago	Indianapolis	43

6.3 Methodology

To explore the attitudes and behaviors of Indiana residents towards intercity passenger rail that might affect the future usage of such services, a theoretical model was built based on the technology acceptance model and accounting for a number of relevant theories and other factors that might affect such attitudes and behaviors. In addition, a multiattribute attitude model was estimated to explore the reasoning behind mode choice decisions. This section presents the methods used in terms of theoretical model design, survey instrument design, and data analysis.

6.3.1 Theoretical Model Design

6.3.1.1 Technology Acceptance Model

6.3.1.1.1 Theoretical Basis

The technology acceptance model was first introduced by Davis (Davis, 1986, 1989; Davis et al., 1989). Since then, a number of models have been developed based on this basic model, with various factors and/or relationships among factors being modified or added. The literature has thoroughly discussed the evolution of the TAM (see, for example, the discussion of Venkatesh et al., 2007).

The TAM is, in essence, an extension or adaptation of the theory of reasoned action by Ajzen and Fishbein (Ajzen and Fishbein, 1980; Fishbein and Ajzen, 1975), which aimed to explore the acceptance (or adoption) of a system. However, through the decades, researchers have explored the role that many factors can play in an individual's attitudes and behaviors, as far as the adoption of a system is concerned, and have attempted to combine a number of existing theories with the TAM. Venkatesh et al. (2003) provide a thorough discussion and documentation of all the different combinations and models that the literature has proposed.

Notwithstanding the usefulness of these theoretical models, they might or might not be relevant and/or applicable to every field of research. Transportation mode choice is a topic for which such behavioral models have been widely explored and tested. The effects of many factors have been extensively studied (such as habit and behavior). Nevertheless, the technology acceptance model has rarely been employed to investigate the use of public transportation, specifically passenger rail. To the author's knowledge, only one such study has been conducted (Chen and Chao, 2011). However, a number of variations of the TAM have been used to explore the adoption of transportation innovations, such as electric bicycles (Wolf and Seebauer, 2014) and innovative ticketing, toll collection, and information/check-in services (Chen et al., 2007; Mallat et al., 2008; Lu et al., 2009).

The core of the theoretical model proposed in this dissertation is Davis's technology acceptance model. Some additions to this basic model have been made for this analysis. For example, the factor of enjoyment as a determinant of behavioral intention to use the passenger rail services in the future is explored. In addition, the proposed theoretical model integrates elements of the theory of planned behavior. Section 6.3.2.2 describes the developed theoretical model in more detail and presents the elements included in the model together with the supporting literature.

6.3.1.1.2 Model Estimation

To test the proposed model, a structural equation modeling (SEM) framework was employed. The analysis of the data proceeded in three steps. First an exploratory factor analysis (EFA) was performed to investigate the structure of the data. Based on the results of the EFA, a *measurement model* was then estimated using a confirmatory factor analysis (CFA). Finally, a *structural model* was developed to test a number of hypotheses and investigate the goodness of fit of the model. Note here that a full model was used instead of a composite model. The EFA was conducted using IBM SPSS and the CFA and SEM were conducted using IBM SPSS Amos. The specific estimation methods and modeling choices are presented in Section 6.5.1.

The convergent and discriminant validity and reliability of the constructs of the theoretical model were assessed using the CFA. Based on the results of the EFA and CFA, two SEMs were estimated. The modeling procedures followed, and the results are presented in Section 6.5.1. To assess the convergent and discriminant validity and reliability, the average variance extracted (AVE) was estimated and the square root of the AVE was compared to the inter-construct correlations; to assess the reliability, the composite reliability (CR) was estimated, based on Hair et al. (2010).

Finally, the goodness of fit of both the measurement and the structural models was evaluated using a number of absolute and relative fit measures. In this dissertation, based on the suggestions of Hu and Bentler (1999), Blunch (2008), and Hooper et al. (2008), the main measures discussed are the chi-square (χ^2) statistic, the comparative fit index (CFI), and the root mean square error of approximation (RMSEA) and p of close fit (PCLOSE). The results of these and a number of other absolute, relative, and parsimony fit indices are reported in Appendix C.

<u>Absolute Fit Measures</u>

The chi-square (χ^2) statistic is among the most popular methods for evaluating the goodness of fit of a model. Nevertheless, for a large sample size, the χ^2 will be significant in almost every case (i.e., the null hypothesis will be rejected). It is noted here that in the SEM, the χ^2 test follows a "reverse" procedure, on the basis of which the null hypothesis states that the model tested is true. Thus, it is suggested by the literature that for SEM additional fit indexes should be explored. The statistics is based on the sample size and the minimum fitting function ($C=(n-1)F_{min}$). In addition to chi-square, the chi-square divided by the degrees of freedom (χ^2/DF), which is a relative or normalized χ^2, is also frequently used as a fit measure.

The RMSEA is a well-established measure based on the non-central χ^2 distribution with a non-centrality parameter. It is estimated as follows:

$$\mathbf{RMSEA} = \sqrt{\frac{\max[\chi^2 - DF, 0]}{DF(N-1)}} \qquad (6)$$

where N is the sample size.

In addition to the RMSEA, the PCLOSE measure, which corresponds to the p-value for a one-sided test with null hypothesis, H_0, that RMSEA is smaller than 0.05, is commonly utilized.

Relative Fit Measures

The CFI is a relative fit measure that accounts for the degrees of freedom. The index compares the χ^2 of the proposed model to the χ^2 of a null or independence model (i.e., the model with no correlation among the indicators) based on the following equation:

$$\mathbf{CFI} = \frac{(\chi^2 - DF)_{ind} - (\chi^2 - DF)_{prop}}{(\chi^2 - DF)_{ind}} \qquad (7)$$

6.3.1.2 Multiattribute Attitude Model

Apart from the data collected to test the theoretical model discussed above, additional data were collected in order to estimate a multiattribute attitude model. This model was intended to better explain the mode choice decisions in the system of interest and support a prioritization of the policy and planning choices aiming to foster a mode shift towards the Hoosier State train.

This model is based on the idea that an individual's attitude towards an object is shaped by his/her *beliefs* about the object that are relevant to the evaluation and the implicit *evaluative responses* pertaining to those beliefs. This theory can be outlined as follows (Fishbein and Ajzen, 1975, pp. 29):

1. An individual holds many beliefs about a given object, i.e., the object may be seen as related to various attributes such as other objects, characteristics, goals, etc.
2. Associated with each of these attributes is an implicit evaluative response, i.e., an attitude.
3. Through conditioning, these evaluative responses are associated with the attitude object.
4. These conditioned evaluative responses summate.
5. On future occasions, the attitude object will elicit this summated evaluative response, i.e., the overall attitude.

Based on the above, *attributes* can be defined as qualities or features that characterize an object and that are considered during an evaluation. The questions used to solicit information for this part of the analysis were designed following the suggestions of Solomon (2009) based on Fishbein's theory (Fishbein, 1976, 1967).

The following attributes were considered:

- Cost
- Travel time
- Comfort
- Safety
- Amenities (Wi-Fi, food, etc.)
- Flexibility of travel (ability to go wherever one chooses)
- Convenient/flexible schedule
- Reliability (not being late)
- Ease of traveling (minimize the effort required to travel)

Focusing on intercity train, the competing modes of transportation selected for this analysis included personal vehicle (driving alone and carpooling), intercity bus, and airplane. This list includes all the available competing modes serving the study area. To achieve a comparison, the Hoosier State train passengers were asked to provide their opinion about all the transportation modes listed above. Both the selected attributes and the competing modes were chosen based on the pilot survey results.

Based on Fisbein's multiattribute model, the overall attitude towards an object can be estimated using the following index:

$$\boldsymbol{A_j = \sum_{i=1}^{n} b_{ij} a_i} \qquad (8)$$

where A_j = attitude toward object *j* (transportation mode herein), b_{ij} = individual's belief regarding the extent to which object *j* is associated with an attribute *i*, a_i = evaluative aspect of attribute *i* (i.e., the importance weight given to each attribute), and *n* = the limited number of attributes that the person will consider (herein *n* = 9).

In this application of the model, the presence of attribute i (b_{ij}) was rated on a scale of 1 (poor) to 5 (excellent), and the evaluation of attribute i (a_i) was rated on a 5-point importance scale, from (1) not important at all to (5) extremely important. The results of this index can be used to guide a prioritization of the policy and planning choices aiming to foster a mode shift towards the Hoosier State train.

6.3.2 Questionnaire Design and Theoretical Model

6.3.2.1 Pilot Survey

In the early stages of the research for this component, it became evident that a pilot survey should be conducted before the survey instrument was finalized. The purpose of the pilot survey was to assess the data collection instrument and ensure the relevance and appropriateness of the proposed set of questions. The target population of the pilot survey included residents of the greater West Lafayette/Lafayette area who might have a strong opinion about Hoosier State line, either due to their expertise or due to their involvement with the service (either as supporters or as users). Collected data were used to explore methodological issues in order to finalize the proposed methodology and framework of the study. Questions solicited information pertaining to the perceived ease of use and usefulness of the passenger rail services, the attitudes and other factors that affect the respondent's behavior toward transit, and factors that affect an individual's mode choice.

The pilot survey was designed based on previous literature (as outlined in the following section) and initial speculations regarding the correlations between the various elements that can influence mode choice behavior and attitudes and behaviors towards public transportation. The pilot survey instrument is included in Appendix B.3.

A few pilot interviews were completed with selected individuals (n = 5), the opinions of whom could provide valuable insights for this study, and a qualitative analysis was conducted to investigate the results in order to finalize the survey instrument and the hypotheses to be tested (as outlined in the next section). The summary and key findings are outlined in Appendix B.3. Based on the results of the qualitative analysis, the questions to be included in the survey instrument were revised. For example, additional questions were added to explore factors that emerged during the pilot surveys, and for some existing questions the wording was improved.

6.3.2.2 Survey Instrument and Theoretical Model

As described above, the basis of this model is the TAM. However, a number of additional factors were explored based on extended technology acceptance models, such as the one proposed by Venkatesh and Davis (2000), and other applied research (e.g., Pagani, 2004; Bruner and Kumar, 2005; Chtourou and Souiden, 2010; Chen and Chao, 2011). Furthermore, it was decided to explore some factors based on the feedback received from the pilot surveys. Finally, the proposed theoretical model integrates elements from the theory of planned behavior (Ajzen, 1991).

Table 6.4 outlines the initial hypotheses and the supporting literature for each hypothesis. In addition, the table shows the target of each question in the questionnaire as far as the main body of the technology acceptance model is concerned. To find a specific question, refer to the survey instrument in Appendix B.1. Note that the codes have been indicated on this copy of the survey for convenience/clarity.

Table 6.4 Hypotheses Proposed, Corresponding Supporting Literature, and Target Questions

Hypothesis	Supporting Literature*	Target Questions
H1: Perceived usefulness has a positive effect on the intention to use passenger rail.	Davis, 1989; Davis et al., 1989; Chen and Chao, 2011	Usefulness 1-6; Using in the future 1-3
H2: Perceived ease of use has a positive effect on the intention to use passenger rail.	Davis, 1989; Davis et al., 1989; Chen and Chao, 2011	Ease 1-7; Using in the future 1-3
H3: Enjoyment has a positive effect on the intention to use passenger rail.	Pagani, 2004; Bruner and Kumar, 2005; Chtourou and Souiden, 2010	Your thoughts 6-8; Using in the future 1-3
H4: Enjoyment has a positive effect on perceived usefulness.	Pagani, 2004; Bruner and Kumar, 2005; Chtourou and Souiden, 2010	Your thoughts 6-8; Usefulness 1-6
H5: Enjoyment has a positive effect on the attitude towards passenger rail.	Pagani, 2004; Bruner and Kumar, 2005; Chtourou and Souiden, 2010	Your thoughts 6-8; Your thoughts 1-4
H6: Perceived ease of use has a positive effect on perceived usefulness.	Davis, 1989; Davis et al., 1989; Chen and Chao, 2011	Ease 1-7; Usefulness 1-6
H7: Perceived behavioral control has a positive effect on the attitude towards passenger rail.	Ajzen, 1991	External factors 1-8; Your thoughts 1-4
H8: Social norm has a positive effect on the attitude towards passenger rail.	Ajzen, 1991	Usage and personal network 1-3; Your thoughts 1-4
H9: Perceived behavioral control has a positive effect on the social norm; social norm has a positive effect on the perceived behavioral control.	Ajzen, 1991	External factors 1-8; Usage and personal network 1-3

Table 6.4 Hypotheses Proposed, Corresponding Supporting Literature, and Target Questions (Continued)

Hypothesis	Supporting Literature*	Target Questions
H10: Social norm has a positive effect on the intention to use passenger rail.	Ajzen, 1991	Usage and personal network 1-3; Using in the future 1-3
H11: Attitude towards passenger rail has a positive effect on the intention to use the passenger rail.	Ajzen, 1991; Chen and Chao, 2011	Your thoughts 1-4; Using in the future 1-3
H12: Perceived behavioral control has a positive effect on the intention to use the passenger rail.	Ajzen, 1991; Chen and Chao, 2011	External factors 1-8; Using in the future 1-4
H13: Social norm has a positive effect on the perceived usefulness.	Venkatesh and Davis, 2000	Usage and personal network 1-3; Usefulness 1-6
H14: Perceived usefulness has a positive effect on the attitude towards passenger rail.	Davis, 1989; Davis et al., 1989; Chen & Chao, 2011	Usefulness 1-6; Your thoughts 1-4
H15: Habitual private mode use has a negative effect on the perceived behavior control.	Bamberg et al., 2003; Chen and Chao, 2011	Which mode 1-2; External factors 1-8
H16: Habitual private mode use has a negative effect on attitude toward public transit.	Bamberg et al., 2003; Chen and Chao, 2011	Which mode 1-2; Your thoughts 1-4
H17: Habitual private mode use has a negative effect on the intention to use passenger rail.	Bamberg et al., 2003; Chen and Chao, 2011	Which mode 1-2; Using in the future 1-3
H18: Experience has a positive effect on the attitude towards the passenger rail.**		Experience 1-5; Your thoughts 1-4
H19: The positive direct effect of social norm on perceived usefulness will attenuate with increased experience.	Venkatesh and Davis, 2000	Experience 1-5; (Usage and personal network 1-3; Usefulness 1-6)
H20: The positive direct effect of social norm on the intention to use passenger rail will attenuate with increased experience.	Venkatesh and Davis, 2000	Experience 1-5 (Usage and personal network 1-3; Using in the future 1-3)

* This table includes only key studies supporting each question; the list is not exhaustive.
** Venkatesh & Davis (2000) proposed that there are only indirect effects on the intention to use the system, though they discuss how the intention becomes stronger with continuous experience. The theoretical model designed in this dissertation proposes that there is also a direct effect on the intention.

In light of the initial hypotheses outlined above, Figure 6.3 presents the structural diagram of the theoretical model to be tested. Specifically, the figure presents the latent variables that correspond to the factors that were expected to affect the intention to use the rail services in the future and the links between the factors, which show the hypothesized directions of the relationships. Latent variables have had many definitions over the years; for this dissertation, the simple and broad definition of Bollen (2002) is adopted, in which a latent variable is a variable “for which there is no sample realization for at least some observations in a given sample” (Bollen, 2002, p. 612). The indicators (or manifest variables) through which this dissertation attempts to capture these latent variables are discussed in Section 6.5. Figure 6.3 also includes the codes of the hypotheses outlined in Table 6.4.

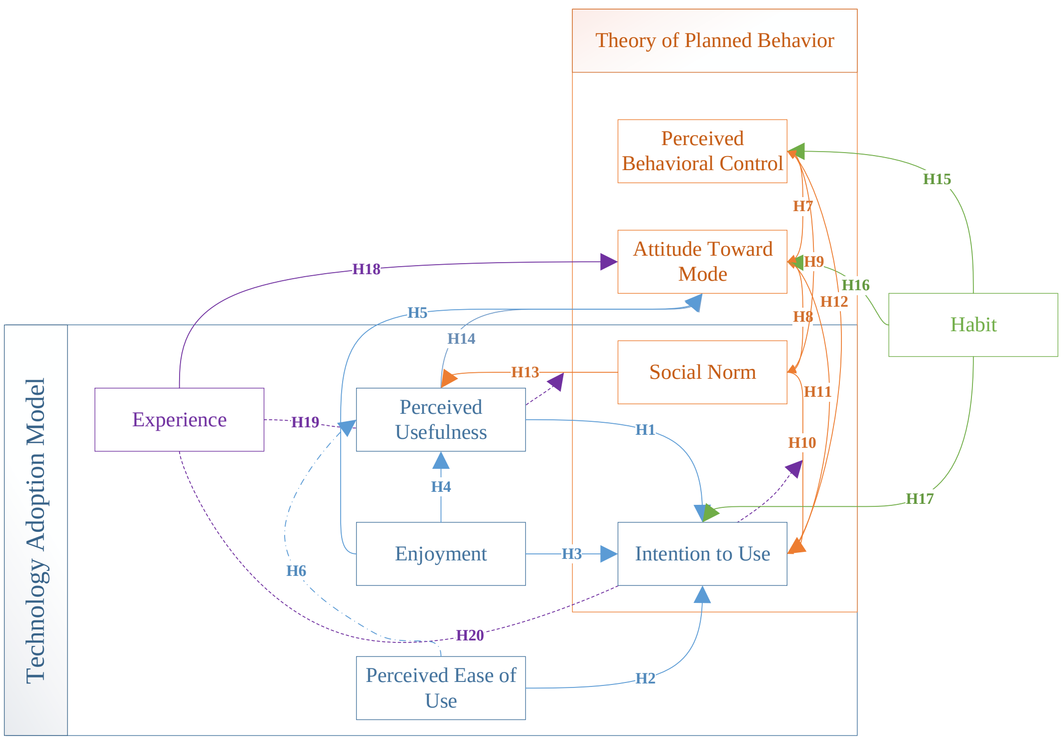

Figure 6.3 Structural Diagram of the Designed Model

In the main body of the diagram, the factors of perceived usefulness (PU) and perceived ease of use (PEU) are shown; these factors are the key elements of a TAM. Based on the initial qualitative study conducted through the pilot survey, it was hypothesized that there is no straight link between the PEU and the PU (as the theoretical model suggests). In addition, the factor “experience” was included based on the pilot study results as well as the proposed extended TAM (TAM2) (Venkatesh and Davis, 2000). The factor “enjoyment” was also included, based on both the feedback from the pilot survey and consultation of recent research and applications that suggest that enjoyment is becoming a major factor contributing to the intention to use a system (Bruner and Kumar, 2005; Chtourou and Souiden, 2010; Pagani, 2004). Another large part of the proposed theoretical model is the theory of planned behavior (Ajzen, 1991). Factors included based on this theory were perceived behavioral control, the attitude towards the mode, and the social norm. Finally, the element of “habit” was added because both the literature (for example, Bamberg et al., 2003) and the preliminary qualitative analysis of the pilot survey results suggested that this can potentially be a strong factor affecting both the intention to use the system and the actual usage behavior.

6.3.2.3 Final Instrument and Question Design

Based on the theoretical framework summarized above, the final instrument was designed to include 10 sections:

1. Information pertaining to the origin and destination of travel, as well as previous usage information
2. Perceived ease of using the Hoosier State train
3. Perceived usefulness of the train
4. Beliefs about the Hoosier State train related to perceived enjoyment during the trip
5. Opinions of others in the respondent’s personal network (or social norms)
6. External factors that might affect usage
7. Intended future use
8. Habitual automobile-related behavior
9. Mode choice decisions (data for the *multiattribute attitude model*)
10. Socioeconomic and demographic information

The questions for Sections 1 through 7 of the survey instrument were designed based on the literature cited in Section 6.3.1. All questions for Section 1 in the instrument were designed to collect data regarding one (or more) of the factors to be tested, which are outlined in the previous section.

Section 6 of the questionnaire attempted to solicit information pertaining to perceived behavioral control. The questions were designed based on the suggestions of Fishbein and Ajzen (2011) and aimed to capture the power of specific factors to facilitate or impede the future usage of the services, as well as the belief that the control factor is present. The questions for Section 8 were designed following the suggestions of Bamberg et al. (2003) to solicit information pertaining to habitual mode usage behavior. The questions for Section 9 were designed following the suggestions of Solomon (2009), which themselves are based on Fishbein's theory (Fishbein, 1976, 1967), to collect data for the multiattribute attitude model. Finally, socioeconomic and demographic questions were included in order to test for variations in the attitudes and behaviors towards passenger rail among different socioeconomic and demographic groups.

The final survey instrument is included in Appendix B.1. Note that all documents for both the survey and the pilot survey (including recruitment materials and survey instruments) were reviewed and approved by the Purdue Research Board (IRB Research Project Numbers 1502015762 and 1503015896; see Appendix B.2).

6.4 Data Description and Exploratory Analysis

6.4.1 Onboard Survey Data Description

An exploratory analysis was conducted to summarize the responses of the Hoosier State train riders and investigate differences based on socioeconomic and demographic characteristics and levels of use of the Hoosier State train. A descriptive analysis was completed to identify any existing patterns in the data. It was hypothesized that there would be some differences across different sociodemographic groups, both in the attitudes towards the Hoosier State train and the intention to use the train in the future. Differences in proportions were tested using a standard two-tailed test of proportions, with null hypothesis H_0: $p_1 = p_2$ (or H_0: $p_1 - p_2 = 0$) versus alternative hypothesis H_A: $p_1 \neq p_2$.

The z-statistic, assumed to follow a normal distribution, is as follows:

$$\boldsymbol{Z} = \frac{(\hat{p}_1 - \hat{p}_2) - 0}{\sqrt{\hat{p}(1-\hat{p})(\frac{1}{n_1} + \frac{1}{n_2})}} \qquad (9)$$

where $\hat{p}_1$ is the proportion for sample 1, $\hat{p}_2$ is the proportion for sample 2, and $\hat{p}$ is the overall (or combined) proportion.

In addition, a correlation analysis was conducted utilizing the Spearman's rank correlation coefficient to investigate the directions of associations between a number of factors that might affect the attitudes of the riders towards the Hoosier State train as well as their intention to use the train in the future. The Spearman correlation is used because the data explored herein are ordinal data resulting from a 5- or 7-point Likert scale.

The administered questionnaire included more than 50 questions designed to solicit information that corresponds to the 10 instrument sections outlined in Section 6.3.2.3. The results of the analysis, focusing on some key variables, are presented and discussed below.

First, the main passenger flows between the stations along the Hoosier State line were explored (Table 6.5).

Table 6.5 Origin-Destination Matrix (out of 403 responses)

from\to	***Ind.***	***Craw.***	***Laf.***	***Rens.***	***Dyer***	***Ch.***	***Total***
Indianapolis	0.0%	0.0%	0.0%	0.2%	1.5%	26.5%	28%
Crawfordsville	0.0%	0.0%	0.0%	0.0%	0.0%	5.7%	6%
Lafayette	0.0%	0.0%	0.0%	0.0%	0.2%	19.6%	20%
Rensselaer	0.2%	0.0%	0.0%	0.0%	0.0%	1.5%	2%
Dyer	0.5%	0.0%	0.2%	0.0%	0.0%	0.5%	1%
Chicago	19.6%	5.4%	15.8%	1.5%	0.7%	0.0%	43%
Total	20%	5%	16%	2%	2%	54%	100%

As expected, most of the survey respondents' trips were from (43%) or to (54%) Chicago. The major pair flows are Indianapolis-Chicago and Lafayette-Chicago. Another result worth noting is where the riders live. Based on the responses provided (398 responses), approximately 42% of the respondents live in counties with a station, 27% live in other Indiana counties, and 31% of the respondents do not live in Indiana. For the 42% of the respondents living in a county with a station, Figure 6.3 presents the percentages living in each county.

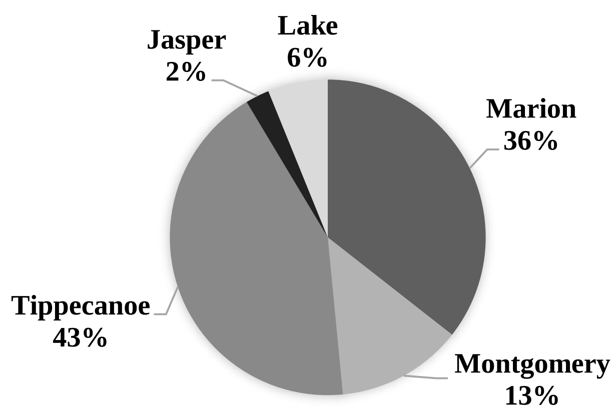

Figure 6.4 Riders by Place of Residence

Of the 42% of respondents who live in a county with a station, 11% do not live in the same city as the station. An interesting observation pertaining to the composition of the riders is that individuals who have no access to an automobile are overrepresented compared to the average U.S. population (Figure 6.5).

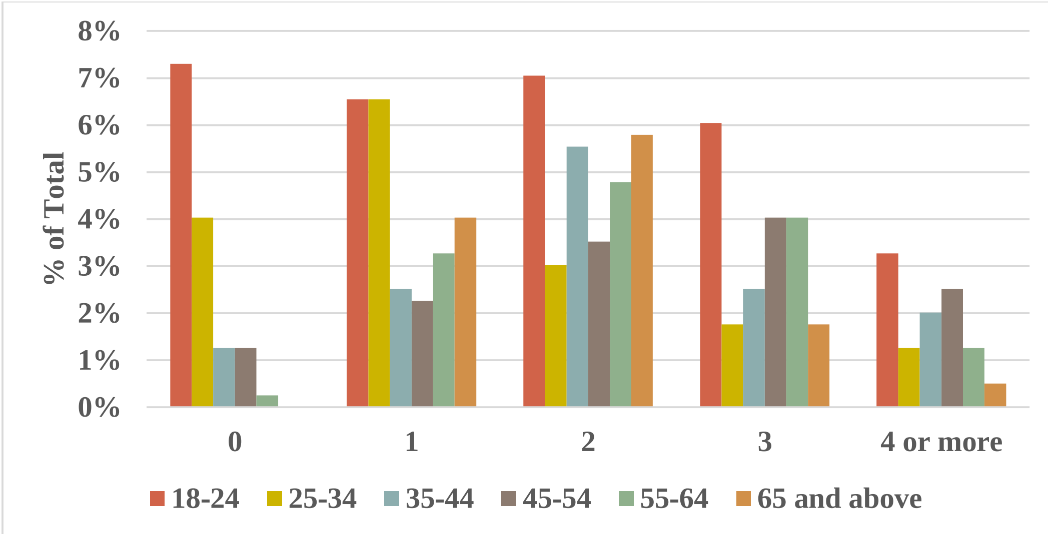

Figure 6.5 Number of Automobiles the Household has Access to by Age Group

As Figure 6.5 shows, approximately 14% of the riders surveyed do not have access to an automobile. For comparison, the 2009 National Household Travel Survey (NHTS) shows that 3.2% of Indiana residents have zero vehicles in their household, while the corresponding national statistic is 6% (Federal Highway Administration, 2009). Note that the NHTS percentage refers to automobile ownership, while the information collected in this survey refers to automobile access, and thus the ownership statistic is expected to be smaller than the corresponding access-related statistic. The results suggest that most of these individuals are between 18 and 25 years old.

Turning to some key socioeconomic variables, the descriptive analysis suggested that there were no obvious patterns related to education, income, employment, or number of children in the household. However, it was found that the distributions of some of the responses of older individuals (65 years and above) are noticeably different from those of all other age groups (see Table 6.6).

Riders of the Hoosier State train were of various ages, but most riders tended to be in the younger age groups. Approximately 30% of the respondents were between 18 and 24 years old, while only approximately 13% of Indiana residents older than 18 years old belong to this age group (see Figure 6.6).

Table 6.6 Ease of Use and Intention to Use by Age

	18-24 (31%)	**25-34** (16%)	**35-44** (14%)	**45-54** (13%)	**55-64** (14%)	**> 65** (12%)
Ease of Use ***(Traveling with the Hoosier State train is easy for me)***						
Strongly Disagree	1.63%	0.00%	1.82%	0.00%	0.00%	4.26%
Disagree	1.63%	1.52%	1.82%	3.70%	0.00%	6.38%
Neutral	7.32%	12.12%	14.55%	11.11%	14.81%	17.02%
Agree	48.78%	48.48%	40.00%	55.56%	53.70%	40.43%
Strongly Agree	40.65%	37.88%	41.82%	29.63%	31.48%	31.91%
Total	100%	100%	100%	100%	100%	100%
Intention to Use ***(I intend to travel with the Hoosier State train in the next month)***						
Strongly Disagree	11.48%	21.54%	27.27%	22.64%	22.22%	36.96%
Disagree	30.33%	26.15%	41.82%	45.28%	35.19%	34.78%
Neutral	26.23%	21.54%	14.55%	13.21%	29.63%	17.39%
Agree	18.85%	18.46%	9.09%	9.43%	5.56%	6.52%
Strongly Agree	13.11%	12.31%	7.27%	9.43%	7.41%	4.35%
Total	100%	100%	100%	100%	100%	100%

For example, Table 6.6 shows that a relatively large percentage of older people perceive traveling with the Hoosier State train to be difficult. Approximately 10% of older individuals responded that they disagree or strongly disagree with the statement that the train is easy to use, while only 3.5% of respondents younger than 65 years old gave the same response. These percentages were statistically significantly different at less than a 1% level. Along the same lines, older people are less likely to travel by train in the near future, based on their responses. The proportions of respondents older than 65 years old and younger than 65 years old who stated that they disagree or strongly disagree with the statement that they intend to use the services in the next month were found to be statistically significantly different at less than a 5% level. However, Table 6.6 shows that younger individuals (younger than 34 years old) are more likely than other groups to travel by train more frequently. Approximately 32% of younger individuals responded that they agree or strongly agree with the statement, while only 15% of respondents older than 34 years old gave the same response. These percentages are statistically significantly different at less than a 0.01% level.

In addition, some small differences between men and women were found in the intention to use the Hoosier State train in the future (see Table 6.7). The percentages of female and male respondents were approximately the same.

Table 6.7 Intention to Use by Sex

	Intention to Use ***(I intend to travel with the Hoosier State train in the next month)***			Intention to Use ***(I expect to travel with the Hoosier State train in the foreseeable future)***	
	Female (51%)	**Male** (49%)		**Female** (51%)	**Male** (49%)
Strongly Disagree	24.26%	18.42%		5.42%	6.88%
Disagree	38.12%	31.05%		6.90%	5.29%
Neutral	20.79%	21.05%		16.26%	20.11%
Agree	9.41%	16.84%	*	40.89%	38.62%
Strongly Agree	7.43%	12.63%	·	30.54%	29.10%
Total	100%	100%		100%	100%

*, · Significantly different proportions at 5%, 10% level, respectively

As Table 6.7 shows, more men than women indicated on the survey that they intend to travel by train within the next month. However, at a longer time horizon the difference between men and women becomes statistically insignificant. In fact, slightly more women responded that they expect to travel by train in the foreseeable future.

Another interesting finding pertains to the differences between individuals who traveled using the Hoosier State train one or more times in 2014 and those who did not travel using the train at all during the same year (see Table 6.8).

Table 6.8 Perceived Behavioral Control and Intention to Use for Past Users and Non-Users of the Train in 2014

	Behavioral Control ***(There are numerous factors outside of my control that could prevent me from using the Hoosier State train)***			**Intention to Use** ***(I intend to travel with the Hoosier State train in the next month)***		
	Non-users (64%)	Users (36%)		Non-users (64%)	Users (36%)	
Strongly Disagree	6.32%	13.14%	*	28.35%	10.00%	***
Disagree	23.32%	27.74%		37.80%	29.29%	·
Neutral	28.85%	27.01%		18.90%	23.57%	
Agree	32.02%	29.20%		9.45%	19.29%	**
Strongly Agree	9.49%	2.92%	*	5.51%	17.86%	***
Total	100%	100%		100%	100%	

***, **, *, · Significantly different proportions at 0.1%, 1%, 5%, 10% levels, respectively

Note: The comparison here refers to users and non-users during the year 2014 exclusively and does not reflect current usage frequency or familiarity with the services.

This finding suggests that individuals who have used the services in the past might be more likely to use the services again in the future. The result also suggests that individuals who did not use the services in the previous year perceive more barriers to using the services in the future. This finding may be due to one-time visitors (who did not have the chance to take the train in 2014 and might not be able to take the train in the future), but when the results are filtered to include only Indiana residents, the differences in the responses to both questions remain similar.

Finally, we explore the correlation coefficients among a number of variables. Table 6.9 presents some of the most noteworthy results. All variables included are categorical variables, and thus low correlation coefficients were anticipated. Nevertheless, the estimated Spearman's ρ is significantly different from zero in many of the explored pairs, indicating that some relatively strong associations between the various factors might be present. Table 6.10 includes the corresponding questions for the variables examined.

Table 6.9 Spearman's Rank Correlation Coefficient

	Ease	**Useful**	**Attit.**	**Habit**	**Contr.1**	**Contr.2**	**Int1**	**Int2**	**Int3**
Ease	1.00								
Useful	0.59**	1.00							
Attit.	0.38**	0.53**	1.00						
Habit	0.11*	0.04	0.07	1.00					
Contr.1	0.43**	0.50**	0.34**	0.01	1.00				
Contr.2	-0.12*	-0.15**	-0.08	-0.02	-0.21**	1.00			
Int1	0.15**	0.15**	0.06	-0.17**	0.19**	-0.06	1.00		
Int2	0.13**	0.15**	0.07	-0.20**	0.14**	-0.06	0.90**	1.00	
Int3	0.34**	0.42**	0.37**	-0.02	0.35**	-0.12*	0.38**	0.39**	1.00

** Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level (2-tailed)

Table 6.10 Corresponding Survey Questions

Code	**Survey Question**
Ease	Traveling with the Hoosier State train is easy for me.
Useful	I find the Hoosier State train useful for my traveling purposes.
Attitude	I dislike-like traveling on the Hoosier State train.
Habit	Whether I go to work or go shopping, I almost always travel by car.
Contr.1	If I wanted to, I could easily travel using the Hoosier State train.
Contr.2	There are numerous factors outside of my control that could prevent me from using the Hoosier State train.
Int1	I have plans to travel with the Hoosier State train in the next month.
Int2	I intend to travel with the Hoosier State train in the next month.
Int3	I expect to travel with the Hoosier State train in the foreseeable future.

The positive correlation between the perceived ease of use and usefulness of the services was anticipated. Individuals who find traveling on the Hoosier State train difficult are also expected not to find the services useful. However, the correlations between many other factors are noteworthy. For example, the relatively strong positive correlation between the first perceived behavioral control indicator (Control1) and the perceived ease of use and usefulness of the services is suggestive. This finding may indicate that there is a positive association between the individual's perception that he/she is in control of his/her travel using the Hoosier State train (or, in other words, that the individual can easily travel by train if he/she wants to) and the perceived usefulness or ease of use of the services. In addition, it is verified that an individual's habit of using a personal automobile for his/her main trips is negatively correlated with his/her intention to use the train in the future, especially for short-term plans. The correlation results suggest that there is a negative association between an individual typically using a personal automobile for commuting and other regular activities and his/her intention or plan to travel using the Hoosier State train within the next month. On the other hand, the correlation coefficient between "always driving" and the intention to use the train in the "foreseeable future" is not significantly different from zero.

6.4.2 Mail-, Telephone-, and Web-based Survey Data Description

Given that a very small sample was collected from the mail-, telephone-, and web-based survey (as discussed in Section 6.2.2), a quantitative analysis of the data would not yield statistically meaningful results. Section 6.4.2 briefly presents some descriptive statistics and the key findings of a qualitative analysis.

From the residents' sample (mail- and phone-based surveys), it was found that even though 85% of the respondents were aware of the Hoosier State train, only 33% of them had ridden the train in the past and none had plans to travel with the train in the next month. Nevertheless, as Table 6.11 shows, 45% of the respondents expected to use the services in the foreseeable future.

From the web-based surveys, it was found that all of the respondents were aware of the Hoosier State train and a majority (55%) of them had ridden the train. In addition, 29% of them stated that they intended to use the services in the next month, and 68% expected to use the services in the foreseeable future.

Table 6.11 Intention to Use the Hoosier State Train in the Future by Sample Group

	Intention			
	(I intend to travel with the Hoosier State train in the next month)		***(I expect to travel with the Hoosier State train in the foreseeable future)***	
	Residents	**Supporters**	**Residents**	**Supporters**
Disagree	84.85%	52.63%	33.33%	15.79%
Neutral	12.12%	18.42%	21.21%	15.79%
Agree	3.03%	28.95%	45.45%	68.42%
Total	100.00%	100.00%	100.00%	100.00%

Another interesting finding pertains to the different perceptions regarding the ease of use and usefulness of the services between the residents of Indiana who responded to the survey and the supporters of passenger rail, as shown in Table 6.12.

Table 6.12 Ease of Use and Usefulness by Sample Group

	Ease ***(Traveling with the Hoosier State train is easy for me)***		**Usefulness** ***(I find the Hoosier State train useful for my traveling purposes)***	
	Residents	**Supporters**	**Residents**	**Supporters**
Disagree	15.15%	18.42%	33.33%	15.79%
Neutral	30.30%	18.42%	27.27%	21.05%
Agree	54.55%	63.16%	39.39%	63.16%
Total	100.00%	100.00%	100.00%	100.00%

As Table 6.12 shows, more than half of the respondents for both sample groups believed that the Hoosier State train is easy to use. However, while approximately 40% of the residents responded that they find the Hoosier State train useful for their traveling purposes, 63% of the passenger rail supporters responded the same. As anticipated, the supporters of the Hoosier State train find the services more useful than the general population.

Turning to the socioeconomic and demographic composition of the respondents, a noteworthy finding is the differences between the age distributions of, on the one hand, the riders of the Hoosier State train and, on the other hand, the few supporters of passenger rail and the residents of Indiana who responded to the survey (Figure 6.6).

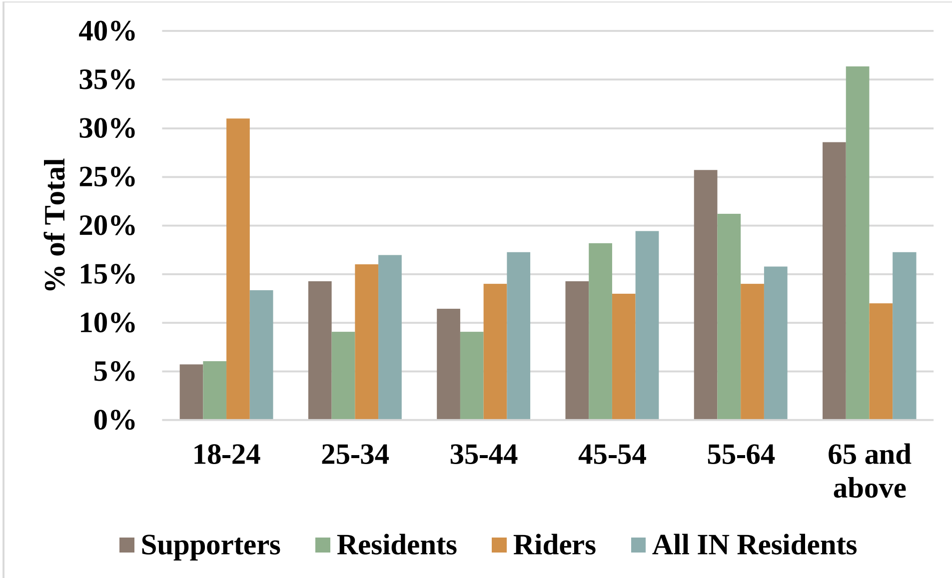

Figure 6.6 Age Distribution of Respondents by Target Group and all Indiana Residents (based on U.S. Census Bureau, 2010 Census)

As Figure 6.6 shows, most of the supporters of the Hoosier State train and the residents who responded to the survey were older than 45 years old, while most of the riders were younger. For the passenger rail supporters, this might be a result of self-selection (i.e., mostly older individuals chose to respond to the survey) or a result of population characteristics (most supporters of passenger rail in Indiana are in general older than 45 years old). For the residents of Indiana who responded to the survey, this finding might again be a result of self-selection, or it may be an indication that it is more difficult today to reach younger populations through landline telephones (i.e., younger individuals might not have a landline phone or might not respond to phone calls, either because they screen their calls or because they spend more time outside of their homes).

Another difference that should be noted relates to automobile access. As discussed in Section 6.4.1, approximately 14% of the riders surveyed reported that they do not have access to an automobile. The corresponding percentages are 6% for the supporters of passenger rail, which is also the national average, and 0% for the residents who responded to the survey. The fact that all residents who responded to the survey had access to at least one automobile is not surprising, because only approximately 3% of Indiana residents do not have access to an automobile, as noted in the previous section; if the survey respondents were a representative sample of Indiana residents, of the 33 residents who responded to the survey, approximately 1 resident would not have access to an automobile.

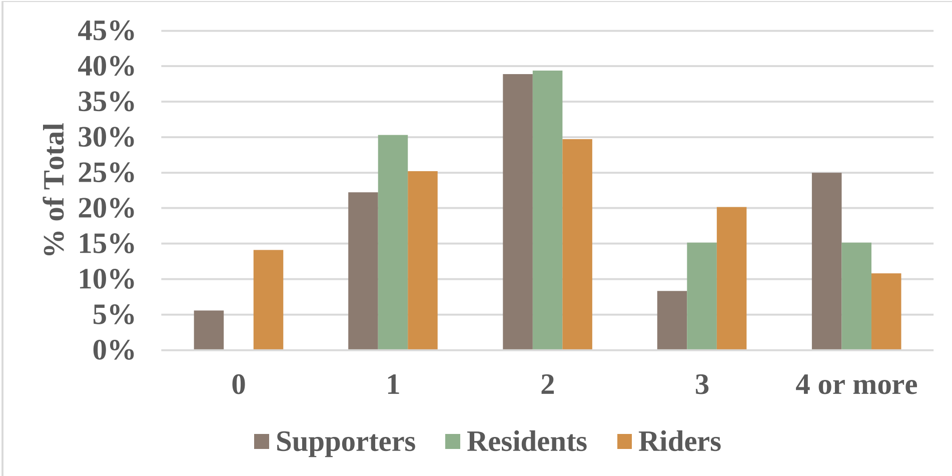

Figure 6.7 Respondents' Access to Automobile by Target Group

Even though the findings summarized above are valuable to some degree, it is again emphasized that the samples of the passenger rail supporters and Indiana residents are very small. Therefore, the samples cannot be considered representative of the target groups, and the comparisons discussed in this section do not necessarily have statistical significance.

6.5 Onboard Survey Model Results

This section presents the results of the modeling efforts completed using the responses of the riders of the Hoosier State train. In Section 6.5.1 the results of testing the theoretical model are presented. This analysis aims to provide a better understanding of the riders' attitudes towards passenger rail and explore the effects of various factors on the intention to use the services in the future. In Section 6.5.2, the results of the multiattribute attitude model are presented. This model explores factors affecting the mode choice decisions of the riders in terms of the choice between passenger rail and other competing transportation modes.

6.5.1 Hypotheses Testing through the Use of Structural Equation Modeling

As stated in Section 6.3, a three-part approach was used to test the hypotheses outlined. Initially an EFA was conducted. The findings of this EFA suggested that the theoretical structure shown in Figure 6.3 cannot be tested as is. When all the latent factors included in this model were accounted for, the *face validity* of the model, i.e., the "extent to which a measure appears to be measuring what it is supposed to be measuring" (Cramer and Howitt, 2004, p.63), suffered and the factor structure was not adequate. There were a lot of cross-loadings (i.e., variables having large factor loadings onto more than one factor) and variables that did not load onto any of the factors. Therefore, it was decided to test two models, one based on the extended technology acceptance model and one based on the planned behavior theory. This section outlines the results of the SEM for these two models. The details for the EFA and CFA can be found in Appendix C. Before presenting the results, this section outlines the steps completed to prepare the data set.

6.5.1.1 Data Preparation

A complete data set without missing values is required for the estimation of a SEM. Therefore, data screening was performed prior to modeling to ensure that there are no issues with the data set and no missing values. First, a case screening was performed, in which the data were screened case by case to check for survey responses with many unanswered questions. During this step, all responses for which more than 10% of the questions were unanswered (approximately 5 out of the 45 main body questions) were removed from the data set. These included a total of 32 responses. Thus the final data set included 389 responses.

The data set was also checked for passive or unengaged responses. For this step, variables that would be used to estimate the latent variables were screened based on the variability of the responses (i.e., whether an individual's responses to questions differed sufficiently or whether the individual responded to all questions in a similar manner or appeared to follow a pattern). For example, an indicator of an unengaged response would be a completed survey for which the respondent marked "strongly disagree" to most of the questions in one section. There was no evidence of such responses.

Furthermore, outliers in the data were identified through an exploration of the descriptive statistics of the variables. Only one variable, which was designed to capture the number of times riders used the Hoosier State train in the year 2014 ("history"), presented two outliers, but the cases were not suspicious, and thus the data were kept in the data set. The variables were then screened for missing data, and the missing data were imputed based on the median value for all categorical variables and the mean value for the "history" variable. Lastly, the normality of the data was assessed through an exploration of the kurtosis of the variables and skewness, where applicable. Variables that had a kurtosis value greater than 2 (or smaller than -2) were identified (refer to Appendix Table C.1). The analysis did not reveal significant issues, in that a non-normal distribution was anticipated for the variables identified through this process.

In addition, a number of new variables were constructed. First of all, based on the suggestions of Fishbein & Ajzen (2011), a variable capturing the perceived behavior control was estimated using the questions designed to solicit information regarding the power of specific factors to facilitate or impede the future use of the services and information regarding the belief that the control factor is present. The final variable was constructed based on the responses to the questions shown in Table 6.13.

Table 6.13 Perceived Behavioral Control Components

Code	Question	Scale
BC1	*How likely is it that you can reach a desired destination using the Hoosier state train?*	1 through -5
BC2	*Being able to reach a desired destination would make it easier for me to use the Hoosier State train.*	-2 through -2
BC3	*How likely is it that the Hoosier State schedule will be convenient for your travel purposes?*	1 through -5
BC4	*Having a convenient train schedule would enable me to use the Hoosier State train.*	-2 through -2
BC5	*How likely is it that you can reach your destination on time using the Hoosier state train?*	1 through -5
BC6	*Being able to reach my destination on time would enable me to use the Hoosier State train.*	-2 through -2

The variable capturing the perceived behavioral control (BC) was estimated as follows:

$$\boldsymbol{BC = \sum c_i p_i} \qquad (10)$$

where c_i is the belief that the factor is present, assessed through questions BC1, BC3, BC5 and rated on a scale of 1 through 5, with 1 being “very unlikely” and 5 being “very likely”;
and p_i is the power of factor i, assessed through questions BC2, BC4, BC6 and rated on a scale of -2 through 2, with -2 being “strongly disagree” and 2 being “strongly agree”. The variable was then normalized on a scale of 0 to 1.

In addition, a set of new variables pertaining to the habitual mode use behavior was estimated. One variable for each of the following transportation alternatives was estimated: car, bus, train, bicycle, walking, and other. The variable was a discrete value between 0 and 10 and resulted from the summation of the number of responses to the corresponding questions, following the suggestions of Bamberg et al. (2003). Based on these variables, a variable that corresponded to non-motorized modes was estimated (as a summation of bicycle and walking). The variable pertaining to automobile usage was then re-estimated by subtracting the calculated value from 10, so that it corresponds to an expected positive effect on the future use of the services. For the same reasons, the variable corresponding to the question that directly solicited information regarding the use of personal automobile for personal travel was recoded.

6.5.1.2 Technology Acceptance Model

The latent factors explored for this model were perceived usefulness (Use), perceived ease of use (Ease), enjoyment (Fun), habitual behavior (Habit), social norm (SN), intention to use (Int), and an additional factor that emerged from the EFA related to social consciousness (SC). Table 6.14 shows the specific variables included in the model. For the EFA, a maximum likelihood method was used because this approach had been used in SPSS Amos for the CFA. In terms of the rotation, a PROMAX rotation was used because it was anticipated that there would be some correlation between the factors based on the structure of the data. This was later verified by the results. The extraction was based on eigenvalues with values greater than one, and coefficients smaller than 0.30 were suppressed so that factor loadings smaller than 0.30 would not be displayed in the output and thus obstruct the interpretation of the results. The final pattern matrix can be seen in Appendix Table C.2.

Table 6.14 Variables Included in the Technology Acceptance Model

Code	**Question**
Latent Factor: Perceived Ease of Use	
Ease7	Traveling with the Hoosier State train is easy for me.
Ease6	It is easy for me to travel with the essentials for my trip purposes (carry-on luggage, etc.).
Ease1	My interaction with the ticketing system of the Hoosier State train (Amtrak) is easy and understandable.
Ease5	It is easy for me to access the platform at the Hoosier State train station.
Ease2	My interaction with the information (display) system (such as electronic information boards and other systems providing real-time trip information) of the Hoosier State train (Amtrak) is easy and understandable.
Latent Factor: Enjoyment	
Fun1	Traveling on the Hoosier State train is: *Boring : Fun*
Fun2	Traveling on the Hoosier State train is: *Unpleasant : Pleasant*
Fun3	Traveling on the Hoosier State train is: *Painful : Enjoyable*
Latent Factor: Intention to Use in the Services in the Future	
Int1	I have plans to travel with the Hoosier State train in the next month.
Int2	I intend to travel with the Hoosier State train in the next month.
Int3	I expect to travel with the Hoosier State train in the foreseeable future.

Table 6.14 Variables Included in the Technology Acceptance Model (Continued)

Code	**Question**
Latent Factor: Perceived Usefulness Combined with Perceived Behavioral Control	
BC_Recode	Indicator of perceived behavior control, constructed, as explained above
BC7	If I wanted to, I could easily travel using the Hoosier State train.
Usef1	Using the Hoosier State train would enable me to reach my destination faster.
Usef6	I find the Hoosier State train useful for my traveling purposes.
Usef2	Taking the Hoosier State train would make my trip safer.
Latent Factor: Habitual Behavior	
Hab1_tr	Indicator for auto-dependence, as explained above
Hab_nonmot	Indicator for use of non-motorized modes (walking and biking), as explained above
Hab_auto	Whether I go to work or go shopping, I almost always travel by car. (Recoded from agree to disagree)
Latent Factor: Social Norm	
SN2	Most people who are important to me think that I should use the Hoosier State train.
SN3	People who use the Hoosier State train are people like me.
Latent Factor: Social Consciousness	
Hatt1	If more people used the Hoosier State train, it would be good for the environment.
Hatt2	If more people used the Hoosier State train, it would contribute to the reduction of traffic congestion in the State.

The validity of the final structure was tested, and there were no concerns regarding *convergent validity* (i.e., “the extent to which a measure is related to other measures which have been designed to assess the same construct” [Cramer and Howitt, 2004, p.38]), *discriminant validity* (i.e., “the extent to which a measure of one construct is less strongly related to measures of other constructs than measures of the same one” [Cramer and Howitt, 2004, p.52]), or *face validity*. The factor structure was acceptable. Finally, there were no concerns about the adequacy of the data, as explored through the use of the Kaiser-Meyer-Olkin (KMO) statistic, or about the reliability of the factors, as assessed through the use of Cronbach’s alpha. For the results of the above measures, refer to Appendix Tables C.3 through C.6.

For the CFA, a model was designed and tested using the latent factors identified in the EFA. The model can be found in Appendix Figure C.1, and the model fit metrics are provided in Appendix Table C.7. Table 6.15 shows the results of the validity testing.

Table 6.15 Validity Testing for the CFA of the Technology Acceptance Model

			Factor Correlation Matrix with Square Root of the AVE on the Diagonal				
	CR	**AVE**	**SC**	**Int**	**Habit**	**SN**	**Attitude**
SC	0.835	0.721	0.849				
Int	0.846	0.666	0.045	0.816			
Habit	0.844	0.651	0.006	0.119	0.807		
SN	0.915	0.845	0.307	0.166	0.172	0.919	
Attitude	0.788	0.572	0.519	0.252	0.096	0.545	0.756

Attitude is a second-order factor based on perceived ease of use, perceived usefulness, and enjoyment, as seen in Figure 6.8. The results for the CR show a reliable model (i.e., all values are greater than 0.7), and the results for the AVE show that there is no evidence of convergent validity issues (i.e., all values are greater than 0.5). The thresholds considered are based on the suggestions of Hair et al. (2010). In addition, the square root of the AVE is greater than the inter-construct correlations; thus, there is no evidence of discriminant validity issues.

After completing the CFA, the structural model was estimated. Table 6.16 presents the structural parameter estimates (unstandardized values), and Table 6.17 presents a number of key goodness of fit test results.

Table 6.16 Structural Parameter Estimates for the Technology Acceptance Model

Path			**Estimate**	**Stand. Estimate**	**S.E.**	**C.R.**	**P**
SC	→	**Attitude**	0.310	0.388	0.050	6.164	***
SN	→	**Attitude**	0.253	0.427	0.037	6.772	***
Attitude	→	**Ease**	1.000	0.612			
Attitude	→	**Fun**	1.235	0.548	0.151	8.181	***
Attitude	→	**Use**	1.186	1.020	0.129	9.182	***
Attitude	→	**Int**	0.751	0.287	0.215	3.496	***
Habit	→	**Int**	0.036	0.088	0.022	1.661	.097
SN	→	**Int**	0.046	0.030	0.101	0.460	.646
SC	→	**Int**	-0.238	-0.114	0.136	-1.756	.079
Ease	→	**Ease7**	1.000	0.908			
Ease	→	**Ease6**	0.865	0.775	0.050	17.337	***
Ease	→	**Ease1**	0.680	0.587	0.056	12.158	***
Ease	→	**Ease5**	0.930	0.671	0.065	14.411	***
Ease	→	**Ease2**	0.707	0.534	0.065	10.813	***
Fun	→	**Fun3**	1.000	0.924			
Fun	→	**Fun2**	0.784	0.821	0.040	19.527	***
Fun	→	**Fun1**	1.048	0.765	0.059	17.824	***
Int	→	**Int2**	1.000	0.966			
Int	→	**Int1**	0.992	0.932	0.048	20.591	***
Int	→	**Int3**	0.414	0.443	0.045	9.104	***

Table 6.16 Structural Parameter Estimates for the Technology Acceptance Model (Continued)

Path			Estimate	Stand. Estimate	S.E.	C.R.	P
Use	→	**BC_Recode**	0.301	0.725	0.023	13.087	***
Use	→	**BC7**	1.034	0.618	0.092	11.209	***
Use	→	**Usef1**	0.991	0.452	0.121	8.217	***
Use	→	**Usef6**	1.000	0.736			
Use	→	**Usef2**	0.959	0.624	0.085	11.322	***
Habit	→	**Hab1_tr**	1.000	0.958			
Habit	→	**Hab_nonmot**	0.626	0.823	0.039	16.044	***
Habit	→	**Hab_auto**	0.289	0.597	0.024	11.897	***
SN	→	**SN1**	1.000	0.848			
SN	→	**SN2**	1.165	0.985	0.073	16.037	***
SC	→	**HAtt1**	1.000	0.725			
SC	→	**Hatt2**	1.265	0.957	0.131	9.675	***

Table 6.17 Goodness of Fit Measures for the Technology Acceptance Model

NPAR	χ^2	DF	P	**χ^2/DF**	**Threshold Considered**
58	384.541	218	0.000	**1.764**	**< 3**
NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	**CFI**	**Threshold Considered**
0.918	0.905	0.963	0.956	**0.962**	**> 0.90**
	RMSEA	LO 90	HI 90	**PCLOSE**	**Threshold Considered**
	0.044	0.037	0.052	**0.898**	**RMSEA < 0.1** **PCLOSE > 0.05**

The thresholds considered were taken from Hu and Bentler (1999).

As both the absolute and relative indexes shown in Table 6.17 suggest, the proposed model has a good fit. For the other goodness of fit measures, refer to Appendix Table C.8. Figure 6.6 depicts the final estimated model with standardized path coefficients.

Based on the results shown in Table 6.16 and Figure 6.8, a number of the hypotheses stated in Section 6.3.2.2 can be tested. First, habitual behavior seems to significantly affect the intention to use the passenger rail system in the future (standardized β=0.088, t=1.661). From the factor loadings to the latent variable capturing the habitual behavior, it can be inferred that the habit of using an automobile contributes the most to the latent variable. Because the variable has been recoded, the positive coefficient denotes that the more the respondent relies on a personal automobile for his/her trips, the less he/she is expected to use passenger rail services in the future. Therefore, the results of this model support the corresponding hypothesis (H17, Table 6.4). However, the results suggest that the social norm does not significantly affect the intention to use the passenger rail system in the future (standardized β=0.030, t=0.460). Therefore, there is not enough evidence to support the corresponding hypothesis (H10, Table 6.4).

In addition, the effects of the main elements of a TAM, i.e., the perceived ease of use and usefulness of the system, were explored through a second-order factor. This modeling decision was made based on the best model fit and to ensure face validity. The first-order factors considered were the latent variables of perceived ease of use, usefulness, and enjoyment. The second-order factor constructed from these first-order latent variables was a second-order latent variable that essentially captures the overall attitude of the respondent towards the passenger rail services, in that it captures how easy to use, useful, and fun to use the respondent believes the passenger rail services to be. The findings suggest that there is evidence to support the corresponding hypotheses that the perceived usefulness, ease of use, and enjoyment significantly affect the intention to use the passenger rail services in the future (H1, H2, and H3 in Table 6.4). This can be inferred from the fact that the second-order latent variable "attitude" has a significant positive effect on intention to use the passenger rail services in the future (standardized β=0.282, t=3.496) and from the fact that all three first-order factors are significantly and positively associated with this "attitude" variable (ease of use: standardized β=0.612, usefulness: standardized β=1.020, enjoyment: standardized β=0.548). The results also suggest that the perceived usefulness followed by the perceived ease of use have the strongest influence, as anticipated.

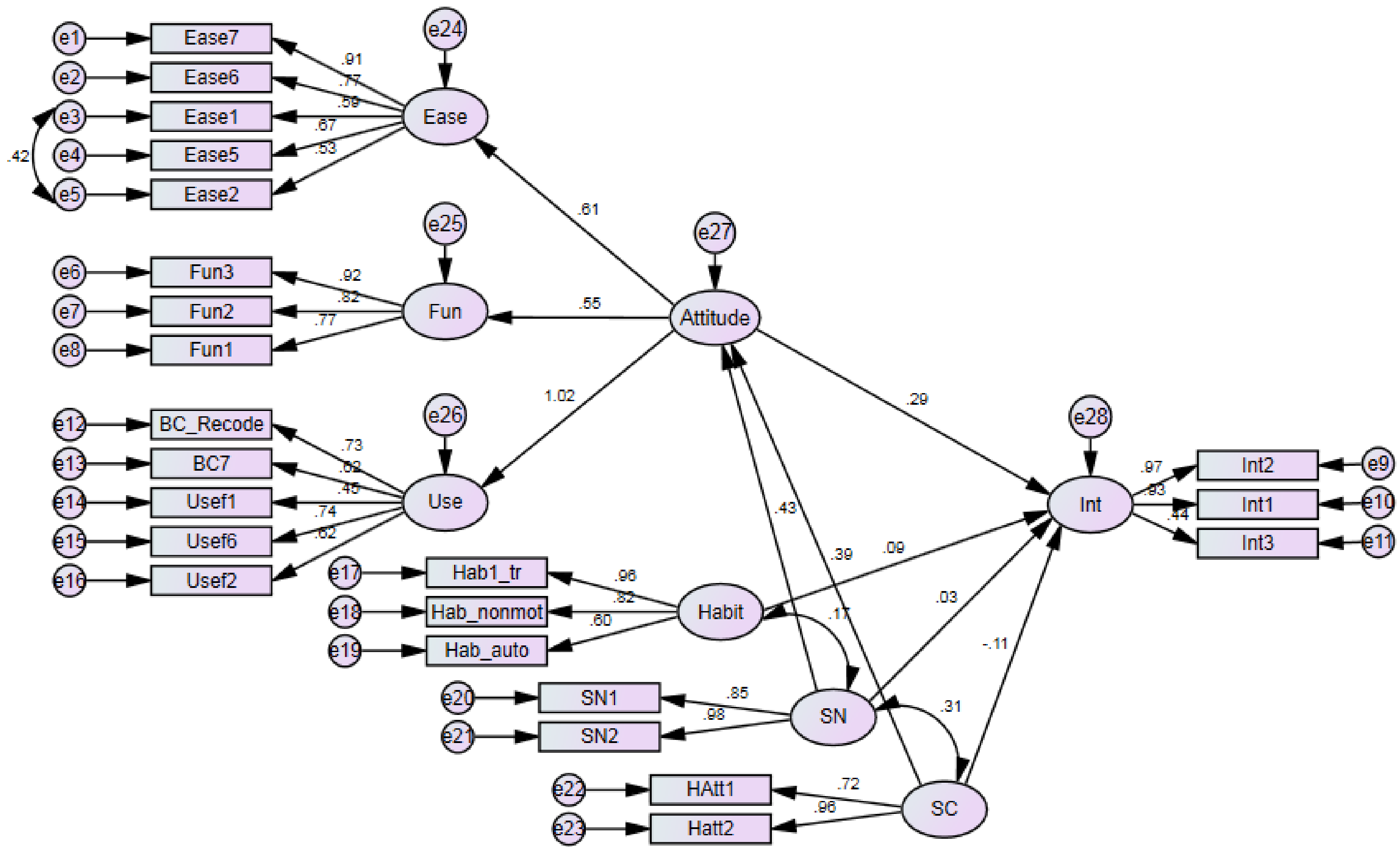

Figure 6.8 Final SEM for Technology Acceptance Model

6.5.1.3 Model Based on the Theory of Planned Behavior

A similar methodology was followed to design and test the second model, which aims to test the hypotheses related to the theory of planned behavior. This section presents the key results of this model. The complete results of the EFA, CFA, and SEM can be found in Appendix C.3.

Table 6.18 shows the specific variables included in this model. For the EFA, a maximum likelihood method was used again because this approach had been used in SPSS Amos for the CFA. In terms of the rotation, a PROMAX rotation was used because it was again anticipated that there would be some correlation between the factors based on the structure of the data. This was later verified by the results. A fixed number of five factors was used for the extraction. The final pattern matrix can be seen in Appendix Table C.9.

Table 6.18 Variables Included in the Planned Behavior Model

Code	**Question**
HST	How many times approximately did you travel using the Hoosier State train last year?
Latent Factor: Intention to Use in the Services in the Future	
Int1	I have plans to travel with the Hoosier State train in the next month.
Int2	I intend to travel with the Hoosier State train in the next month.
Int3	I expect to travel with the Hoosier State train in the foreseeable future.
Latent Factor: Habitual Behavior	
Hab1_tr	Indicator for auto-dependence, as explained in Section 6.5.1.1
Hab_nonmot	Indicator for use of non-motorized modes (walking and biking), as explained in Section 6.5.1.1
Hab_auto	Whether I go to work or go shopping, I almost always travel by car. (Recoded from agree to disagree)
Latent Factor: Social Norm	
SN1	Most people who influence my behavior think that I should use the Hoosier State train.
SN2	Most people who are important to me think that I should use the Hoosier State train.
SN3	People who use the Hoosier State train are people like me.
Latent Factor: Attitude	
Hatt3	Using the Hoosier State train is a __ idea for me. – *Bad : Good*
Hatt4	I __ traveling on the Hoosier State train. – *Dislike : Like*
Hatt5	Traveling on the Hoosier State train is: *Inconvenient : Convenient*
Latent Factor: Perceived Behavioral Control	
BC_Recode	Indicator of perceived behavior control, constructed, as explained in Section 6.5.1.1
BC7	If I wanted to, I could easily travel using the Hoosier State train.

The validity of the final structure was tested, and there were no concerns regarding convergent validity, discriminant validity, or face validity. The factor structure was acceptable, and there were no concerns about the adequacy of the data as explored through the use of KMO statistics. For the results of this exploration, refer to Appendix Tables C.10 through C13.

For the CFA and the SEM, a model was designed and tested using the latent factors identified in the EFA. The model can be found in Appendix Figure C.2, and the model fit metrics are provided in Appendix Table C.14. Table 6.19 presents the results of the validity testing.

Table 6.19 Validity Testing for the CFA of the Planned Behavior Model

			Factor Correlation Matrix with Square Root of the AVE on the Diagonal				
	CR	**AVE**	**Att**	**Intention**	**Habit**	**SN**	**BControl**
Att	0.783	0.548	0.740				
Intention	0.846	0.666	0.148	0.816			
Habit	0.843	0.650	0.028	0.118	0.806		
SN	0.821	0.625	0.456	0.173	0.175	0.791	
BControl	0.704	0.546	0.646	0.207	0.092	0.529	0.739

The CR results show a reliable model (i.e., all values are greater than 0.7), and the AVE results suggest that there is no evidence of convergent validity issues (i.e., all values are greater than 0.5). The thresholds considered are the same as for the previous model, based on the suggestions of Hair et al. (2010). In addition, the square root of the AVE is greater than the inter-construct correlations; thus, there is no evidence of discriminant validity issues.

After completing the CFA, the structural model was estimated. Table 6.20 presents the structural parameter estimates (unstandardized values), and Table 6.21 presents a number of key goodness of fit test results.

Table 6.20 Structural Parameter Estimates for the Planned Behavior Model

Path			**Estimate**	**Stand. Estimate**	**S.E.**	**C.R.**	**P**
Att	→	**HST**	1.070	0.119	0.505	2.119	0.034
Habit	→	**Intention**	0.026	0.065	0.020	1.306	0.191
SN	→	**Intention**	0.064	0.042	0.095	0.678	0.498
Att	→	**Intention**	-0.018	-0.010	0.140	-0.126	0.899
BControl	→	**Intention**	1.071	0.163	0.597	1.795	0.073
HST	→	**Intention**	0.057	0.302	0.009	6.289	***
Sex	→	**Intention**	0.313	0.133	0.111	2.806	0.005
Edu	→	**Intention**	-0.195	-0.171	0.054	-3.608	***

Table 6.20 Structural Parameter Estimates for the Planned Behavior Model (Continued)

Path			Estimate	Stand. Estimate	S.E.	C.R.	P
Intention	→	**Int2**	1.000	0.965			
Intention	→	**Int1**	0.994	0.933	0.043	23.394	***
Intention	→	**Int3**	0.415	0.442	0.045	9.169	***
Habit	→	**Hab1_tr**	1.000	0.959			
Habit	→	**Hab_nonmot**	0.624	0.822	0.039	15.930	***
Habit	→	**Hab_auto**	0.289	0.596	0.024	11.854	***
SN	→	**SN1**	1.000	0.864			
SN	→	**SN2**	1.120	0.965	0.059	18.904	***
SN	→	**SN3**	0.502	0.440	0.056	8.993	***
Att	→	**Hatt3**	1.000	0.826			
Att	→	**Hatt4**	0.993	0.711	0.079	12.626	***
Att	→	**Hatt5**	1.089	0.676	0.090	12.134	***
BControl	→	**BC_Recode**	1.000	0.820			
BControl	→	**BC7**	3.195	0.650	0.336	9.510	***
Age	→	**BC_Recode**	-0.001	-0.010	0.005	-0.251	0.802
Habit	↔	**SN**	0.323	0.144	0.109	2.976	.003
SN	↔	**Att**	0.242	0.456	0.035	6.816	***
SN	↔	**BControl**	0.071	0.518	0.010	7.295	***
Att	↔	**BControl**	0.079	0.642	0.010	8.180	***

Table 6.21 Goodness of Fit Measures for the Planned Behavior Model

NPAR	χ^2	DF	P	χ^2/DF	**Threshold Considered**
45	302.793	126	0.000	**2.403**	**< 3**
NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	**CFI**	**Threshold Considered**
0.894	0.872	0.936	0.921	**0.935**	**> 0.90**
	RMSEA	LO 90	HI 90	**PCLOSE**	**Threshold Considered**
	0.060	0.051	0.069	**0.027**	**RMSEA < 0.1** **PCLOSE > 0.05**

The thresholds considered were taken from Hu and Bentler (1999).

As most of the absolute and relative indexes shown in Table 6.21 suggest, the proposed model has a relatively good fit. The RMSEA is below 0.1 but larger than 0.05 (value of 0.06). This is an acceptable value based on the literature and suggests a fair fit (Hu and Bentler, 1999; Hooper et al., 2008). For the other goodness of fit measures, refer to Appendix Table C.15. Figure 6.9 depicts the final estimated model with standardized path coefficients.

The variable HIST is an indication of past usage and experience with the passenger rail services. This variable was used as a mediator (i.e., an intermediate variable between the causal and outcome variables). The effects of mediation were tested using a bootstrapping technique. Based on the results shown in Table 6.20 and Figure 6.9, a number of the hypotheses stated in Section 6.3.2.2 can be tested.

The estimates show that the effects of perceived behavior control on the intention to use the passenger rail services in the future is significantly positive (stand. $\beta=0.163$, $t=1.795$). Thus, the findings support the corresponding hypothesis (H12 in Table 6.4). However, there is not enough evidence to support the hypotheses that social norm, attitude, and habit significantly influence the intention to use the passenger rail services in the future (H10, H11, and H17 in Table 6.4). The findings pertaining to habit contradict the results of the first model. However, it can be noted that when the model did not account for the control factors of age, education, and sex, the results of the two models were in agreement.

Furthermore, there was evidence that there were significant positive associations between perceived behavioral control and social norm (H9 in Table 6.4), perceived behavioral control and attitude towards passenger rail (H7 in Table 6.4), and social norm and attitude (H8 in Table 6.4). There was no strong evidence to support the mediation hypothesis that the positive direct effect of social norm on the intention to use the passenger rail services in the future attenuates with increased experience (H20 in Table 6.4).

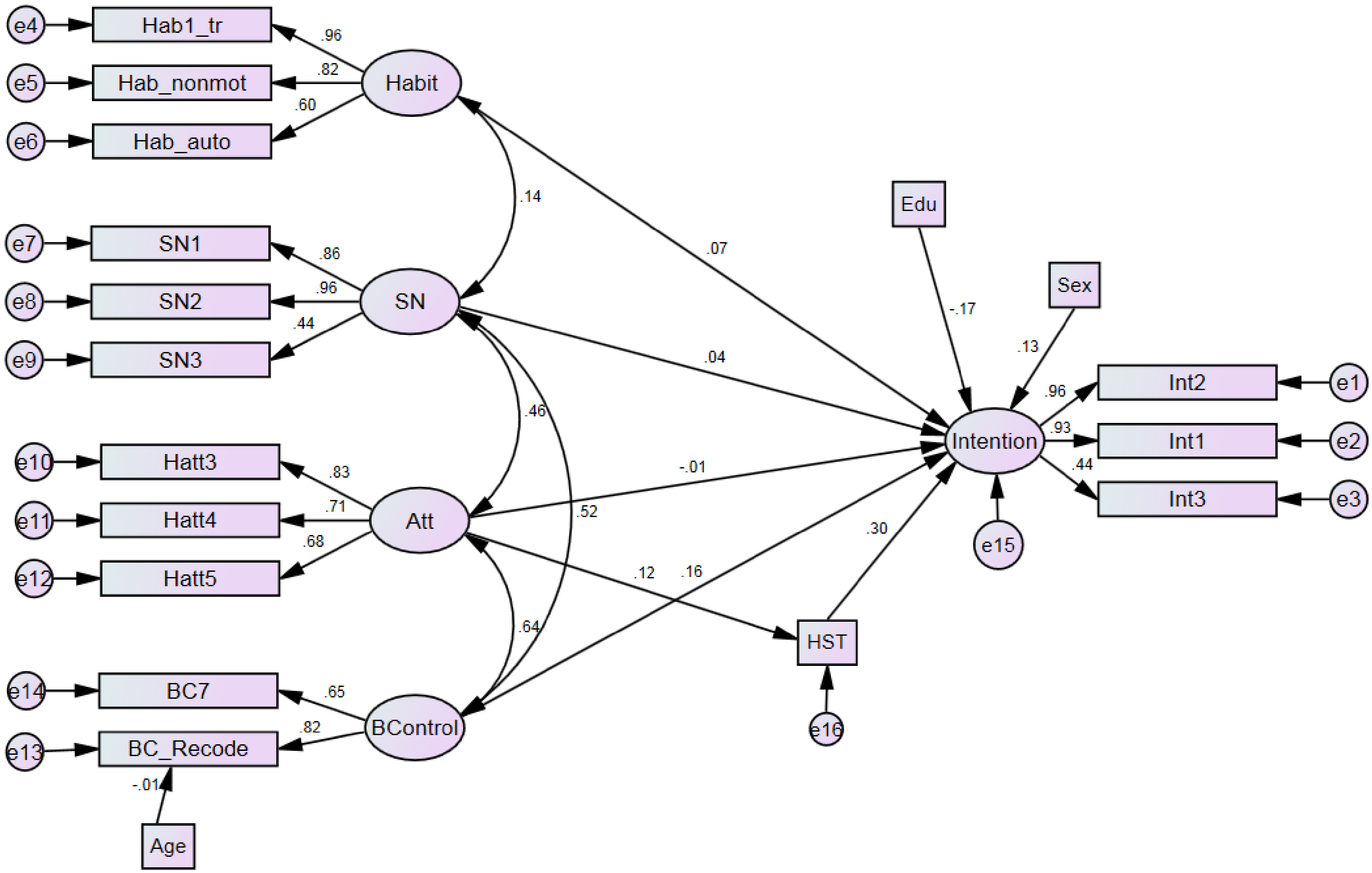

Figure 6.9 Final SEM for the Planned Behavior Model

6.5.2 Multiattribute Attitude Model

Table 6.22 presents the results of the multiattribute attitude model. Specifically, the total average score (Total Rank) that corresponds to the estimated index *(Eq. 8)* is reported, as well as the decomposed scores for each attribute. The decomposed scores, also presented in Figure 6.10, can be used to identify the attributes for which intercity passenger rail outperforms the competing modes and the attributes for which it lags behind the competing modes based on riders' beliefs. Table 6.23 presents the average scores for individuals' beliefs (a_{ij}), which correspond to the importance or relevance of each attribute for mode choice decisions. Based on the scales considered (refer to the data and methodology section for a description), the higher the value of the index, the more attractive the mode (or the more favorable the attitude towards the mode).

Table 6.22 Multiattribute Attitude Model Scores

	Drive Alone	***Train***	***Carpool***	***Air***	***Intercity Bus***
Total Rank	**138.59**	**135.15**	**120.05**	**119.94**	**107.20**
Safety	12.95	15.40	12.41	14.95	11.55
Reliability	19.92	15.73	16.83	15.58	13.90
Convenience	17.98	10.56	14.17	11.09	10.24
Ease of Use	14.16	13.83	12.58	11.29	10.90
Flexibility	17.69	11.20	13.96	12.13	10.41
Cost	11.19	17.57	13.61	9.79	16.33
Travel Time	18.11	14.75	16.49	19.11	12.07
Comfort	17.93	17.80	14.83	14.81	11.00
Amenities	10.29	13.96	9.58	12.37	8.12

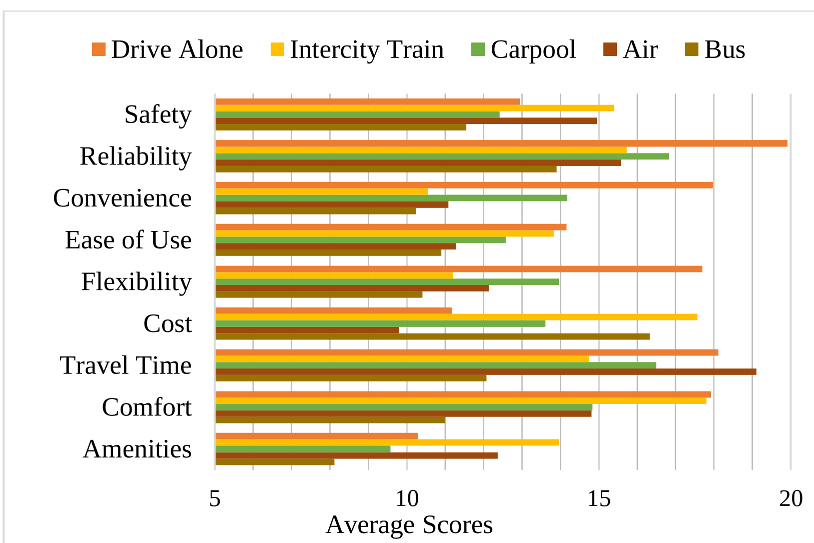

Figure 6.10 Average Scores per Attribute

Table 6.23 Average Importance Rating of the Attributes

	Rank	***Mean Score***	***St. Dev.***	***Min***	***Max***
Safety	*1*	4.20	0.90	1	5
Reliability	*2*	4.13	0.79	2	5
Convenience	*3*	3.94	0.84	1	5
Ease of Use	*4*	3.93	0.86	1	5
Flexibility	*5*	3.88	0.88	1	5
Cost	*6*	3.79	1.00	1	5
Travel Time	*7*	3.73	0.92	1	5
Comfort	*8*	3.67	0.87	1	5
Amenities	*9*	3.23	1.09	1	5

It is anticipated that intercity passenger rail would rank relatively high based on the estimated index because the sample consisted of riders who had already chosen the Hoosier State train for their trip. However, the results indicate that driving alone is—even among Hoosier State train riders—perceived as the most attractive choice.

For the decomposed rating, Figure 6.10 shows that intercity passenger rail received high scores related to safety, comfort, amenities, and ease of use, but especially low score related to travel time, flexibility, convenience, and reliability. At the same time, as Table 6.23 suggests, some of the attributes perceived as the weak points of passenger rail are among the most important factors for the riders (i.e., reliability, flexibility, and convenience).

Another significant point is that cost and travel time, which are typically considered the most important factors in mode choice decisions, play a less important role than other factors according to the responses to this survey. This result can be due to selection bias (i.e., we only observe the opinions of riders of the Hoosier State train). It might also be related to the types of trips commonly served by the Hoosier State train; even though trip purpose was not collected, it is speculated that only a very small percentage of the respondents' trips were commuting trips, for which time and cost are highly important. For rural areas, this result seems to be in line with the international literature. As Jackson et al. (2012) found, for rural services factors such as comfort and reliability might be the most important factors for passengers, and speed might be a secondary factor.

6.6 Concluding Remarks

This chapter presented the analysis completed under the last component of the research framework. The development of a theoretical model to explore attitudes towards passenger rail and the expected effects of various factors on the intention to use the services in the future was described. The data collection efforts and a description of the collected data were also presented. Finally, the data collected from onboard surveys were used to estimate two structural equations models, through which a number of the initial hypotheses could be tested.

The next chapter assembles the conclusions of this dissertation based on the findings of the three components outlined in this and the previous two chapters. The final chapter also closes the dissertation with remarks on the study, policy and planning implications, and the limitations and future directions of this research.

CHAPTER 7. CONCLUSIONS, LIMITATIONS, AND RECOMMENDATIONS

7.1 Conclusions

This dissertation work stemmed from an increasing need for public transportation research, especially in rural and small urban areas, which are at a disadvantage because of the lack of a nationwide public transportation network. The focus has been on assessing public transportation options for intercity travel in U.S. rural and small urban areas. This dissertation has attempted to address the following three questions:

4. Is investment in public transportation in U.S. rural and small urban communities crucial to reaching the communities' long- and short-term goals, and is this investment viable in light of key issues relevant to the communities?
5. Is passenger rail and/or HSR the most advantageous public transportation mode in such areas?
6. What conditions should be fostered and how can these conditions be encouraged to promote the development and use of passenger rail/HSR?

To address these topics, a three-part research framework was developed that involves assessing transport disadvantage in an area, evaluating the existing transportation modes, and investigating the potential for a ridership increase that can further support the improvement and expansion of public transportation systems. To illustrate this framework, the case study of Indiana and the Hoosier State train was used. This research aimed to provide a practice-ready, well-documented, and easy-to-use framework that can support planning and policy decisions, as well as the transportation supply decisions of transportation providers. At the same time, this research aimed to contribute to the evaluation of the passenger rail systems that have been proposed in the U.S., especially the Midwest. This chapter assembles the conclusions of this dissertation based on the findings of each component and closes the dissertation with remarks on the study, policy and planning implications, and the limitations and future directions of this research.

7.1.1 Methodological Contribution

Chapters 4 to 6 presented the methodologies used to approach the three-part framework developed in this dissertation (see Figure 1.1) and the results of the case study conducted. The findings of all three chapters verify that the structure of the framework makes it suitable to achieve the goals of this dissertation. In addition, the findings suggest that the specific approaches proposed for each of the three components of the framework can contribute to the assessment of public transportation options for intercity travel in U.S. rural and small urban areas.

The first component of the framework attempted to provide an answer to the question of whether there is a need for changes to the provision of public transportation in U.S. rural and small urban areas. The evidence provided by this analysis can be used as a first step to assess whether investment in public transportation in such areas is crucial to reaching the communities' long- and short-term goals, especially in light of the goal of providing equitable transportation options and mitigating transport disadvantage. In terms of the methodology developed, the review of the literature and research methods suggests that, from a planning point of view, both process-based and outcome-based measures should be utilized to assess the transport disadvantage of areas and/or population groups. Given this finding, this first part of the research framework proposed a spatial multi-perspective approach to account for the three essential elements of transport disadvantage: accessibility, mobility, and realized travel behavior. The approach was developed considering the data availability within the U.S. as well as the unique settings of U.S. communities. Nevertheless, due to the easily replicable measures proposed and the basic census and geographical data used pertaining to the available opportunities, the approach can be adapted to explore transport disadvantage in any area in the U.S. or elsewhere with similar characteristics, i.e., automobile-dependent rural areas with limited transportation choices and few available opportunities scattered over a relatively large area. Similar census and opportunity-related geographical data are typically collected in many countries and regions and should be easily accessible to the researcher.

The proposed methodology for the second component of the framework involves the assessment of the transportation modes available in an area for intercity travel in view of the communities' long- and short-term transportation planning goals. In addition, the methodology involves the exploration of the stakeholders' expectations and opinions towards passenger rail and competing intercity modes. This component was, in part, intended to provide further evidence to help address the question of whether investment in public transportation in U.S. rural and small urban communities is crucial to reaching the communities' long- and short-term goals and whether such an investment would be a viable option in light of key issues relevant to the community. In addition, this component was designed to help address the question of whether passenger rail and/or HSR would be the most advantageous public transportation mode in such communities. The results of this component can provide some insights into which conditions could be fostered and how those conditions could be encouraged to promote the development and use of passenger rail/HSR from a policy and planning perspective.

To gather data for the second component, a focus group approach using a combination of surveys and discussion techniques was employed. The feedback received from the participants, both at the end of the focus group meetings and through a subsequent feedback survey, verified the value of such meetings. Standard multicriteria evaluation techniques were used with the focus group data to conduct the mode assessment, which was the main goal of the chapter (see Chapter 5). The potential of such techniques has been well-recognized in the literature and in practice. For this dissertation, the findings suggest that similar techniques can provide valuable insights for a high-level evaluation of the available modes in an area. Such techniques can be used to verify that public investments are justified in light of the communities' goals and/or to draw attention to investments that are not expected to advance the communities' goals or that could even hinder such goals.

The third component of this framework focuses on evaluating the potential for a mode shift or an increase in passenger rail ridership through an understanding of individuals' mode choice decisions and the prevailing attitudes towards passenger rail. This component aims to provide further evidence on whether passenger rail and/or HSR is the most advantageous public transportation mode in rural and small urban areas. The main focus of this component is to explore the conditions that should be fostered and the ways those conditions can be encouraged to promote the development and use of passenger rail/HSR. To achieve its goals, this component utilizes a theoretical background drawn from consumer science and psychology.

Specifically, to better understand mode choice decisions, a multiattribute attitude model was tested. In addition, to explore attitudes towards passenger rail and future usage intention, a theoretical model based on the theory of technology acceptance and accounting for a number of other relevant factors was developed and tested. Data were collected to test these models through the design and administration of a public opinion survey. Even though such models have been developed and tested in many fields, transportation research has yet to take a full advantage of them. At the same time, as transportation options increase with technological advancement and the phenomenon of globalization, more and more people view mode choice as another consumer decision. The findings of this dissertation verify that the development and testing of such theoretical persuasion and behavior models can provide valuable insights that can be used to guide policy and planning decisions aiming to increase the ridership of public transportation modes, including passenger rail.

7.1.2 Empirical Contribution

For the Indiana case study, the findings of the first component suggest that a great part of rural and small urban Indiana presents a low density of opportunities and that certain disadvantaged groups (such as elderly and low-income people) experience the impacts of low public transportation supply. Residents of rural and small urban areas travel longer distances in their day-to-day activities. These results thus imply that a “forced” realized mobility is imposed upon disadvantaged groups in these areas to access the nearby opportunities. Thus, the analysis suggests that rural and small urban Indiana would benefit considerably from the improvement and expansion of public transportation. Especially for intercity travel, which is the focus of this study, the available transportation options in such areas are very limited, and as discussed in Chapter 1, seem to be decreasing.

The findings of the second component of this dissertation verify that, based on the stakeholders’ perceptions, improving the Hoosier State train’s services would be in line with the communities’ goals. The results of the analysis further suggest that investment in public transportation and specifically in passenger rail in Indiana would be crucial to reaching the communities’ long- and short-term goals. Because passenger rail is currently the only public (mass) transportation mode for intercity land travel supported by the state, its continuation and further advancement would most certainly benefit Indiana, especially in terms of multimodality, accessibility and connectivity, and economic development. In addition, the results of the second component suggest that, based on the stakeholders’ opinions, such investments would address key concerns of Indiana communities. Furthermore, stakeholders perceive passenger rail to be the most advantageous transportation mode that can be developed for intercity travel in the area. Finally, during the focus group meetings, a number of key topics that can help guide the future of the Hoosier State train were also discussed (presented in Section 7.1.3).

The findings discussed so far do not necessarily provide evidence that rural and small urban areas would benefit from the continuation and improvement of the Hoosier State train, because in the focus groups no participants specifically represented rural areas. A representative from the Indiana Farm Bureau, for example, might have provided such representation. However, as explained in Chapter 3, some of the cities served by the Hoosier State train are parts of small urbanized areas. For example, as was highlighted by the participants during the focus group meetings, Crawfordsville (Montgomery County), which is a small urban area, has not been served by any other mass transportation modes (such as intercity buses) for many years. This concern regarding whether the existing passenger rail services can benefit rural and small urban areas in Indiana was further explored in the third component.

The findings of the third component of this dissertation provide further evidence that the continuation and development of the Hoosier State train can benefit rural and small urban areas in Indiana. Specifically, the results of the onboard survey revealed that a large percentage of the Hoosier State train riders are not residents of the counties with a station but rather traveled to a station from other counties in Indiana, such as Bartholomew, Boone, Clinton, Grant, Hancock, Howard, Knox, Lawrence, Morgan, Shelby, Wabash, and Wayne, which generally consist of mixed rural and small urban areas, and counties such as Greene, Owen, Pulaski, Putnam, and Tipton, which are predominantly rural (Ayres et al., 2012).

This finding was not anticipated, but it further supports the claim that rural and small urban areas in proximity to the stations can benefit from the services that passenger rail provides. It is worth mentioning that many of the areas identified as having need gaps (Chapter 4) are in close proximity to the stations (see Figure 7.1). Therefore, it is expected that such areas can benefit from the Hoosier State train service. This conclusion becomes even more evident when one examines the sociodemographic characteristics of the riders. As concluded from the analysis in Chapter 6, a relatively large percentage of riders have no access to an automobile. In addition, many older individuals (one of the key demographic groups at risk of transport disadvantage) are using the services. From Figure 7.1, it can also be inferred that future development of the suggested rail lines, including the HSR-designated corridors, such as Indianapolis to Cincinnati, Ohio, and Indianapolis to Louisville, Kentucky (MWRRI, 2007), can help further alleviate transport disadvantage in rural and small urban areas in Indiana because the proposed corridors would pass near many of the areas with a needs gap.

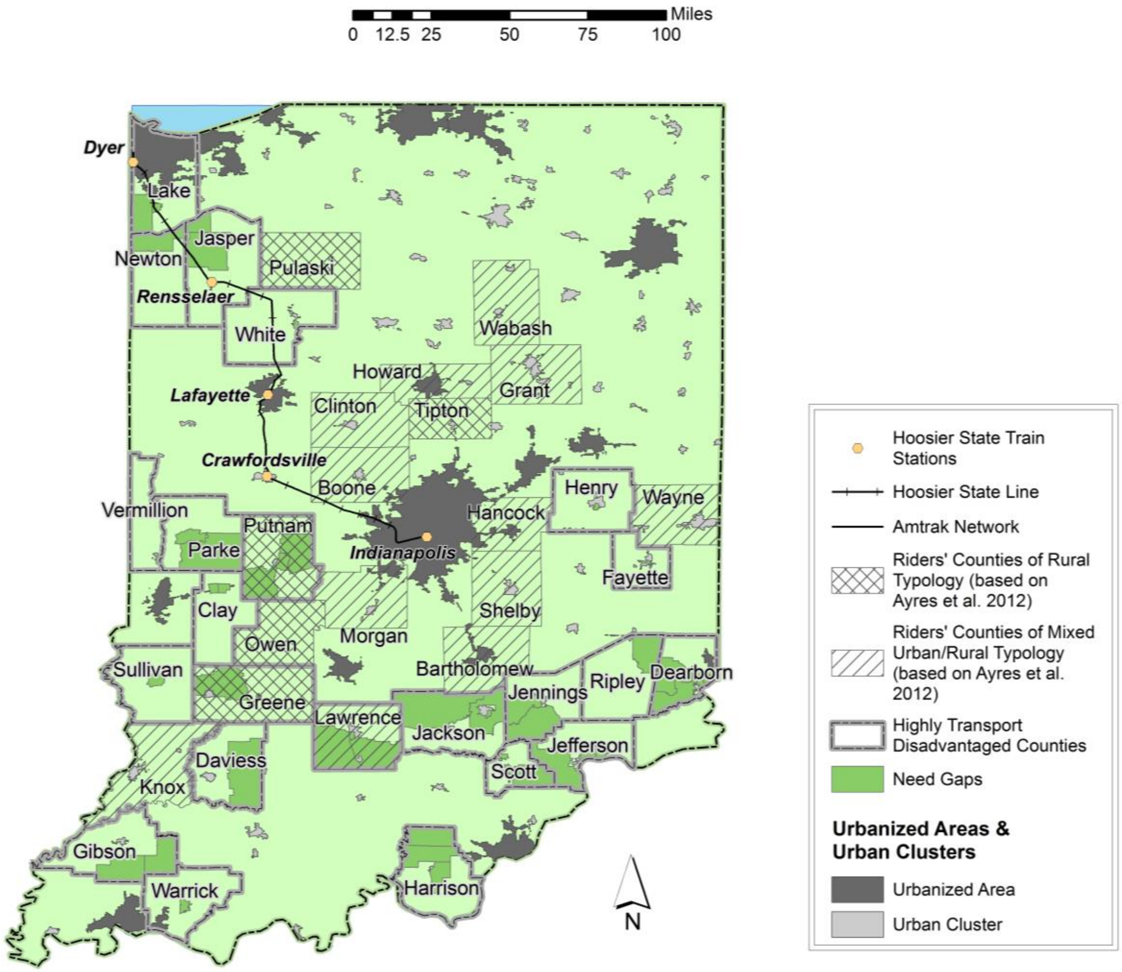

Figure 7.1 Areas with the Potential to Benefit from the Hoosier State Train

Finally, based on a theoretical model proposed to explain the intention of passengers to use the passenger rail services in the future, a number of hypotheses were made. Some of these hypotheses could be tested with data from the onboard surveys conducted on the Hoosier State train. The findings suggest, as anticipated, that the perceived ease of use and usefulness of the passenger rail services have a strong influence on the intention to use the services in the future. Interestingly, the habitual behavior regarding personal automobile use was found to hinder passengers' intention to use passenger rail services in the future. This finding seems to be in line with the results of the multiattribute attitude model, suggesting that the most desirable transportation option for intercity trips among the riders of the Hoosier State train was driving alone (even though the respondents had chosen the train for that particular trip).

The methodology used for the third component also allowed a number of conditions favorable to increased ridership to be identified (as presented in Section 7.1.3).

7.1.3 Policy and Planning Implications

This dissertation has attempted to advance the national research pertaining to public transportation for intercity travel and provide a framework that can support planning and policy decisions at the community as well as at the state level. The proposed approach of the first component incorporates accessibility measures based on the availability, type, and distribution of opportunities that are important for ensuring quality of life in order to locate areas that have limited accessibility. In addition, based on the designed mobility measures, it is possible to identify areas where transportation need is expected to be relatively high based on the existence and size of various transport-disadvantaged socioeconomic and demographic population groups. Furthermore, the need for public transportation can be explored by combining the results of the mobility and accessibility approaches. This information regarding the accessible opportunities within an area and the location of specific population groups can support planning and policy decisions to allocate funds and resources at both the community and state level. For instance, the information resulting from this approach can help policymakers decide whether the operation of transit should be financially supported or whether additional opportunities should be attracted to an area (utilizing planning tools such as land use and providing incentives for development). In addition, this information can be used to aid transport providers' supply decisions regarding, for instance, the areas that would benefit the most from a new bus route or prolonged hours of operation or whether to implement fixed-route versus demand-response transit. Furthermore, the developed tools can help mitigate social disadvantage, because—as discussed in Chapter 4—transport disadvantage can be a driving factor of social disadvantage. For instance, areas can be identified that are most in need of social support or that can benefit from specific infrastructure such as clinics, schools, and parks.

The last part of the first component focused on realized travel behavior. The proposed approach can provide useful information on residents' travel behavior as shaped by their mobility limitations and the accessibility limitations of their areas. The value of such an analysis is twofold. First, the results can corroborate the implications of the accessibility analysis or suggest that further research is required. Second, combining the accessibility, mobility, and realized travel behavior approaches, an indication of any "forced" mobility as well as "forced" automobile ownership can be obtained. That is, in areas with a high need index and low accessibility levels, it can be expected that part of the high realized mobility through automobiles may be “forced”. Overall, the proposed approach can support the planning and policy efforts of rural and small- or medium-sized urban communities and provide a deeper understanding of the transport disadvantage within certain areas and among specific population groups.

While a number of areas in Indiana that should be considered for improved public transportation services were identified, further analysis is needed to investigate the specific needs of such areas.

From the analyses of the second and third components, a number of key conclusions emerged that can help guide policy and planning decisions in the study area. For example, it was highlighted that for the Hoosier State train to be a financially viable service, an increase in ridership should be achieved. Apart from the marketing effort, it was evident that a number of improvements to the train services as well as system-wide improvements can foster such an increase. It was also found that, from a planning point of view, improving the reliability, convenience, and flexibility of the line is expected to produce the most benefits. However, because providing a more flexible schedule (e.g., through more frequent service) would be difficult to achieve[4], issues of reliability and convenience of schedule should be prioritized. In addition, accounting for the demand both from cities with a passenger rail station and from surrounding communities could further increase ridership while improving the accessibility of Indiana’s communities and the mobility of its residents by providing riders with easier access to a passenger rail line.

In addition, the results of the models developed for the third component of the framework highlighted how the perceived ease of use and usefulness of the services can affect the intention to use the Hoosier State train in the future. These findings also highlight the importance of improvements to the system for achieving easy-to-use, reliable, and convenient services. Also of interest for understanding the factors affecting the use of passenger rail could be the variables that were excluded from the model at the exploratory analysis stage. For example, the variables pertaining to access to the stations and parking availability did not seem to contribute to the latent variable proposed to capture the perceived ease of use. While this result could imply that these factors do not affect the perceived ease of use of the system, the exclusion from the latent variable could also indicate that these factors affected the perceived ease of use of the system differently

[4] As was highlighted during the focus group, such an attempt would require the coordination of all parties, including Amtrak and the freight owners of the railways (the most involved of which is CSX), and a substantial investment to provide greater capacity on the corridor.

across the respondents due to the respondents' individual experiences with the system. For example, parking may be inadequate at some stations and thus may contribute to the perceived ease of use of the Hoosier State train, but for other stations adequate parking might not necessarily make the services easier to use. Based on the descriptive statistics of the data and considering that both parking availability and access to the station significantly differ depending on the rider's station of origin, the latter seems plausible. Therefore, improving access to the stations system-wide through multimodal coordination and ensuring that adequate parking is available close to the stations to account for out-of-city demand might further foster a ridership increase.

Finally, marketing efforts to foster a more positive perception of passenger rail in an automobile-dominated environment should be continued, as highlighted in the focus group discussions and verified by the findings of the model, which suggested that habitual automobile usage can play a significant role in passengers' future intention to use the train services in the future.

7.2 Limitations and Future Directions

When attempting to replicate the framework outlined in this dissertation, some limitations should be taken into consideration. First, note that because this approach focuses on rural and small urban areas, it is not suitable to identify transport disadvantage within urban settings without proper modification. The measures proposed in Chapter 4 have been designed in the context of the expected scarcity of opportunities and limited public transportation services within rural and small urban areas. Furthermore, the lack of comprehensive individual-based data or at least cross-tabulated data that can relate two or more characteristics of interest (such as the number of households that are below the poverty line, rent their homes, or have a mortgage, and own a vehicle) is a recognized limitation of this analysis. At the same time, the use of the NHTS estimates might compromise the accuracy of the results of the outcome-based approach. These estimates were computed based on a limited sample, and certain assumptions had to be made for the computation (such as the average household size and the average number of automobiles in a household). Depending on the actual demographic and automobile ownership characteristics of the population, the actual travel patterns within an area might differ from these estimations. In any case, without additional empirical data collected using survey and travel diary techniques, the accuracy of this approach cannot be fully assessed. Such detailed data could also provide additional information to support the estimation of an unequal weighting scheme to be used in the construction of the transport need index.

Additional data from other sources could also be used to improve the analysis. Because there is a lack of a comprehensive, detailed public transportation database for intercity travel, additional data may need to be collected through transit providers. Similarly, the lack of detailed public transportation supply data that can provide geospatial information regarding the routes and schedules of intra- and intercity bus services is another potential shortcoming of this analysis. Along the same lines, temporal variations in transportation supply (such as differences between weekend and weekday services or on-peak/off-peak service provisions) have not been considered. However, collecting and using such additional data would probably limit the scope of the study to the county or area level, while the approach proposed in this dissertation is more suitable for exploration at the state (or larger) level. Finally, an investigation of the evolution of accessibility, mobility, and realized behavior using the approach developed in this dissertation and pertinent data from previous years could also be of interest from a planning perspective.

As for the mode assessment, the sample employed for the focus group meetings was a convenience sample. As such, unbiased responses cannot be ensured. However, maximum effort was spent to ensure a wide variety of participants from different backgrounds and, in some cases, from agencies ostensibly competing with the Hoosier State train. Furthermore, in order to ensure that the stakeholders' opinions were accurately reflected and were not influenced by peer pressure, on-site surveys were used to rate the modes for the multicriteria analysis and to collect responses to a number of topics also discussed during the meeting. Nevertheless, it can be seen that the results of the mode assessment differed between the first and second meetings. Because focus groups are designed for the collection of qualitative data, this is anticipated. In practice, to ensure a more comprehensive evaluation, the administration of additional focus group meetings to collect data from more participants is suggested.

Another potential limitation is the use of the ranking-based method to identify the weights used in the multicriteria analysis. The weights resulting from this method might indicate significantly different levels of relative importance. For example, the most important criterion (ranked as 5 in this application) is considered to be 5 times more important than the least important criterion (ranked as 1 in this application). Even though this is a well-established method, it is possible that criteria with low weights may not contribute significantly to the final performance assessment, which might be a shortcoming. A sensitivity analysis could be used to assess the impacts of using different weights in the multicriteria analysis. In addition, for future applications, different weighting methods such as point allocation could be used instead to ensure a more accurate representation of the stakeholders' perception of the importance of each criterion.

As for the public opinion survey, the response rate of the random sample was very small, and the goal of collecting a representative sample of Indiana residents through mail- and telephone-based surveys was not achieved. For the theoretical model tested, the data collected were only from current riders of the Hoosier State train, and, because the survey was distributed onboard, the sample was not a probability sample. However, special attention was paid to the data collection design to ensure a sample that was representative of the riders: data were collected over a relatively long period of time (two weeks), and a high response rate was achieved. For future research, it is suggested that an internet panel of respondents be utilized. The challenge with this approach, however, is ensuring that the participants are residents of specific areas. Based on the data collected for this dissertation, the theoretical structure of the model (shown in Figure 6.3) could not be tested as is. Therefore, it was decided to test two separate models, one based on the extended technology acceptance model and one based on the planned behavior theory. For this reason, only some of the initial hypotheses could be tested.

In terms of additional future research, as discussed in previous chapters, exploring the developments regarding the Hoosier State train is a unique opportunity to assess whether this new, innovative public-private partnership model is effective for this and similar short rail corridors. The onboard survey was conducted in Fall 2015, when the new services began. Since then, the Hoosier State train partners have been working on improving the services, and there is some indication that these efforts have been reflected in the ridership numbers. For example, the Hoosier State train's on-time performance has been improving recently and reached 93.9% in February 2016[5]. A follow-up survey of riders' opinions of the Hoosier State train, which would explore the changes in riders' opinions and capture any changes in ridership, could verify some of the conclusions of this dissertation and provide further insights. In addition, in such a follow-up study riders' opinions before and after the establishment of the services can be compared, the reasons for any changes in opinions can be determined, the factors that most contributed to the changes can be identified, and ultimately the potential impact of future planned improvements on ridership can be assessed. Specific "best practices" can also be reviewed through existing case studies (for example, Innovative Practices for Increased Ridership [FTA, n.d.]), and relevant

[5] https://www.amtrak.com/hoosier-state-train&mode=perf&overrideDefaultTemplate=OTPPageHorizontalRouteOverview

questions can be included in the questionnaire to assess the potential of these practices to increase ridership.

Lastly, a connectivity and accessibility analysis can be conducted to identify areas where accessibility/connectivity can be improved. Specific factors that can be assessed include, among others, parking availability; the availability, quality, and accessibility of alternative transportation modes (such as shuttle services or buses) to/from the train stations; and the availability of multimodal intra- and intercity connections along the line.

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APPENDICES

Appendix A Focus Group Documentation

A.1 Findings from the Open Discussion

The discussions of both groups were recorded, and the discussions were analyzed based on the recordings, the personal notes of the author, and notes provided by the two volunteers who assisted in the focus group meetings. What follows is the complete focus group report prepared based on the suggestions of Krueger (1994), Edmunds (2000), and Stewart and Shamdasani, (2014).

A.1.1 Financial Viability and Financial Support of the Hoosier State train

In both focus groups, the participants seemed to agree that a crucial goal for the Hoosier State train is to achieve more financially viable services, or services that would not need to be so heavily subsidized. Increasing ridership emerged as the single factor that could ensure financially viable services. However, the prevailing feeling was that a number of barriers currently prevent a significant increase in ridership. Specifically, many of the participants referred to the infrequency of the services (one trip per direction per day), the inconvenient schedule (early morning/late night), and the unreliability of the schedule. Some participants also mentioned the issue of operational efficiency in relation to the financial viability of the services.

A.1.1.1 Ridership and Financial Viability

- *"This is step one: to make it more viable as other communities have, where rail becomes a critical part of transportation, that helps greatly to grow the footprint of this community."*
  (Author's note: financially viable service is perceived as a crucial goal.)
- *"I think that that's linked in my mind to the ridership increase situation, where if we have the ability to make it more attractive, when more riders use the service, then it's going to enhance the financial viability of the system."*
  (Author's note: financial viability is linked with an increase in ridership.)
- *"You have to get the consumers there to have something viable."*
  (Author's note: financial viability is linked with an increase in ridership.)

- *"From a ridership's stand point [..] I don't think we are going to be able to turn the dial as much as I would have liked to have seen because of all these barriers that we have. But we need to see something."*
  (Author's note: financial viability is linked with an increase in ridership.)
- *"The goal is […] for that [the subsidy per passenger] to be noticeably reduced; and that would be noticeable reduced based on efficiencies and based on increased ridership."*
  (Author's note 1: financial viability is linked with an increase in ridership.
  Author's note 2: the participant pointed out that improving service efficiency would also contribute to more financially viable services.)

A.1.1.2 Perceived Existing Barriers

- *"The hours are dictated with the slot of the long distance train. It is not a schedule that is ultimately desirable."*
  (Author's note: the inconvenient schedule was a concern.)
- *"The other thing I find in talking to people here about using Amtrak is the inconvenient hours."*
  (Author's note: the inconvenient schedule was a concern.)
- *"The number one complaint is the 6 AM departure from Indianapolis."*
  (Author's note: the inconvenient schedule, and specifically the early departure from Indianapolis, was a concern.)
- *"In a route like this, you really need three trains a day in each direction to generate the volume of ridership even approaching economic viability. […] So that people can do rational trip planning, whether it's for business or pleasure. […] Wherever you start on the system, on a route this short, under of 200miles, you really need to be able to go out to your destination and back within the course of the day. On routes that have this kind of service, you can approach economic viability. On routes where you got one this way-one that way, […] it is always a struggle, just from that factor of trip planning."*
  (Author's note: the limited frequency of the service was a concern.)

- *"The way it stands right now […] I think it's tough for anybody who wants to travel between the two cities, or anything in between, for business, to do that, because it is so unpredictable. […] You have to get that reliability in there, so that they will rely on that [the service] more heavily."*
  (Author's note: the unreliability of the service was a concern.)
- *"And remember we have all this deadhead problem too, where the Iowa Pacific is stuck on the back of the Cardinal and brought back down and back and forth."*
  (Author's note: operational difficulties were a concern.)

A.1.1.3 Lack of Public Awareness

Another point discussed was that residents are unaware of the services. Many of the participants felt that this is also a barrier to increasing ridership. Some of the relevant comments were as follows:

- *"There is lack of information about the presence of that option. We have a very big deficiency in marketing. […] I don't know where we are (to tell you the truth) or where we want to go. There has to be some way to market where we are right now and where we want to go, and then put a lot of emphasis on how to get there."*
  (Author's note: insufficient marketing was an issue that the participant linked with the lack of public awareness.)
- *"It is amazing that people have no clue that this ever existed."*
  (Author's note: the lack of public awareness in that past was identified as a marketing challenge by the participant.)
- *"If they don't know that it's there they are not going to use it."*
  (Author's note: the lack of public awareness was a concern.)

A.1.1.4 Ridership Increase, Infrastructure Improvement, and Funding

Many of the participants also made the connection between improving services as a means to increase ridership and providing adequate funding to improve the infrastructure. Interestingly, in both meetings, but independently, the conversation reached the point where one participant observed that the problem before them is circular: on one hand a ridership increase is needed to provide evidence that the line can become financially viable and thus justify subsidization of the line, but on the other hand financial support is needed to improve the existing infrastructure and services in order to attract more riders. The following are among the statements pertaining to this topic:

<u>Group 1:</u>

- *"Iowa Pacific Holdings can do everything possible to make the ride pleasing within their control. The next obstacle becomes improving the infrastructure to get us there [i.e., to improved efficiency and increased ridership]; and that is to be polite a very large elephant in the room"*
  (Author's note: the participant connected, on the one hand, improving the existing infrastructure as a means to increase ridership and, on the other hand, the implications of these improvements for securing funding.)
- *"We are talking about relatively manageable sums of money that if spent will have this huge payback."*
  (Author's note: the participant commented on the perceived return on investment.)
- *"I think the PR side of thing is going to be critical to keep it going, but the greatest PR that we can have is [...] the ridership increasing."*
  (Author's note: the participant commented that well-utilized services are important for securing funding.)
- *"It's a chicken and an egg thing. How do you justify spending on increased frequencies if ridership is low? On the other hand, ridership will always be low if there aren't sufficient frequencies. It's a balancing act and it requires a little bit of vision, […] as opposed to rearguard action for what is."*
  (Author's note: the participant identified the perceived relationship between increasing ridership and increasing investment.)

<u>Group 2:</u>

- *"You are not going to have more riders until we have perhaps a larger commitment by the state from its budget, to kind of get the thing rolling at the level that the average consumer wants for you."*
  (Author's note: the participant identified the perceived relationship between increasing ridership and increasing investment.)

- *"It always comes down to money. And without it, this service and other services just don't run as well.*
  (Author's note: the participant believed that there is a need for investment to improve services.)
- *"This almost becomes a chicken-and-egg relationship. [...] If you build it, it's going to have the results, but with what it is now, it isn't so great, so they think why should I put money on it. But, put money in it and it would be better."*
  (Author's note: the participant identified the perceived relationship between increasing ridership and increasing investment.)

A.1.1.5 Public Investment and Funding Sources

One of the key research goals of the discussion was to solicit information regarding the plans of the state and the communities along the line to continue supporting the Hoosier State train in the future and/or to discuss alternative funding sources. All of the elected officials and some other stakeholders who participated in the meetings firmly believed that even though the communities have been supporting the line since 2013 and will continue to do so until 2017, this should be a temporary solution. Some of the relevant comments were as follows:

<u>Group 1</u>

- *"I think first and foremost we have to remove our locals' role in this [funding]."*
  (Author's note: the participant believed that local funding should be discontinued.)
- *"From a local standpoint we view [the funding of the services] in the context of economic development and quality of life. With that being said, it's not something that we can continue forever."*
  (Author's note: the participant believed that local funding should be discontinued, even though the investment has been justified so far.)
- *"We want to a part of it. We appreciate what the state has done and it was important that we played an active role in it, but, like everything else, there would have to be a time that we would not still be doing that"*
  (Author's note: the participant believed that local funding should be discontinued, even though the investment has been justified so far.)

- *"We are certainly willing to continue that for a while, and if we saw (quite frankly) additional investments being made [..] we would be more willing then to continue that knowing that there was hope for the future that there would be even better."*
  (Author's note: the participant identified the potential for continuing support to the line with local funds if additional investments are secured.)

Group 2

- *"The public investment on the local side is a little tricky to be honest. We have invested pretty heavily over the last few years. […]. We [local communities] are on borrowed time now. We have to see this, in the next couple of years, really take off or, I don't know if we can continue to fund [the services]. It's tough, people want results."*
  (Author's note: the participant believed that local funding should be discontinued.)
- *"INDOT's goal is to get just state funding [unintelligible] because it is a state resource."*
  (Author's note: the participant believed that state funds exclusively should be pursued.)

In terms of where the funding should (or should not) come from, the participants offered a few ideas of various funding sources, but generally agreed that public funding is an important part.

- *"So yes, public investment in the Hoosier State train is needed […]; it is needed, I don't care if it takes a penny out of my paycheck, it is needed."*
  (Author's note: the participant believed that public funds should be pursued.)
- *"NIRPC's commission passed a resolution of support for the Hoosier State train when it was very much in question what was going to be happening […] but the support was contingent on that whatever funding comes from the state does not come out of the public mass transit fund, because it is hard enough to maintain what relatively little we have, without making things harder, you know, endangering, the larger picture (at least in our region) of people being able to get around day to day to support this service."*
  (Author's note: the participant believed that public funds should be pursued mainly from the state, not from the public mass transit fund.)

- *“Find the right mix between tax supported and users supported, and always trying to shift those numbers, but that’s what it comes down to.”*
  (Author’s note: the participant believed that public funds should be pursued; the need for balance between subsidies and revenues was highlighted.)

A.1.1.6 Passenger Rail as a Public Good

Another idea that emerged from both meetings was the idea of passenger rail as a public utility that should receive public funding. Not all participants felt as strongly as others about this idea, but a few provided strong support for the idea. However, in the discussion a few skeptical comments were made pertaining to the return on investment and the extent of passenger rail utilization. For example, some of the related comments were as follows:

- *“It [the Hoosier State train] needs to be viewed as an asset of the state. […] And then we need to invest accordingly, which means there has to be a value to that investment.”*
  (Author’s note: the participant suggested that passenger rail be viewed as an asset of the state, and the participant believed that public funds should be pursued.)
- *“You have to treat it [the Hoosier State train] as a public good, that’s what it is. The addition of public transit/passenger rail is a public good, just like a highway. If that’s the way of thinking, it becomes a whole different conversation.”*
  (Author’s note: the participant views passenger rail as a public good.)
- *“So I am assuming there is no break-even point then, when we are looking at the millions of millions of dollars that would be required to be invested in order to make this a viable option. […] In terms of understanding the decision making process in our discussion with our constituents, we need to have an idea of what are our projections for how many Hoosier constituents would be using the line.”*
  (Author’s note: the return on investment and the potential for low overall utilization by the public were concerns.)

A.1.2 Ridership Increase

Apart from the barriers to increased ridership discussed above and the connections made between improving service and increasing ridership, a number of other factors that can increase ridership were discussed.

A.1.2.1 Efforts by Iowa Pacific Holdings

Representatives of Iowa Pacific Holdings (IPH) discussed their perspective and reported their attempts to foster such an increase in ridership. They also made it clear that this is one of their key goals. Apart from improving operational services, the key points in terms of marketing that IPH mentioned were improved onboard services, targeted advertisement, word of mouth, digital awareness, and public relations. Some of the related comments made on these topics by the representatives of IPH and other participants were as follows:

- *"What we want to attain is the maximum ridership and adoption from all of the communities along the route."*
  (Author's note: increased awareness and ridership are IPH's goals.)
- *"To make it successful [...] you need frequency, capacity, and dependability"*
  (Author's note: the IPH representative believed that operational characteristics play an important role in increasing ridership.)
- *"Customer service is a very high priority, and customer service isn't just selling a ticking and saying this is where you sit down."*
  (Author's note: customer service is a high priority for IPH.)
- *"We have found [...] that digital awareness and public relations is the best way to get that adoption."*
  (Author's note: the IPH representative believed that digital awareness and public relations can be effective ways to attract riders.)
- *"Word of mouth is the best form of advertisement." "Digital awareness is very important." "Digital awareness is the new word of mouth."*
  (Author's note: the IPH representative believed that digital awareness and "word of mouth" can be effective ways to attract riders.)

Iowa Pacific Holdings also talked about a more targeted approach to advertising its services. Specific target population groups mentioned were university students and their parents, "millennials," and senior citizens. Specific comments regarding targeted advertising and ways to attract target groups were as follows:

- *"Advertising has changed; it is so fragmented. So, it is targeting the desired communities, focusing on how to reach those communities, for example the university students, which is a huge opportunity here."*
  (Author's note: market fragmentation is a consideration in marketing efforts.)
- *"We are taking a look at student pricing, we are taking a look at what kind of flexibility we can employ in motivating students, putting together some kind of loyalty opportunity for students."*
  (Author's note: students are a key segment of the target market.)
- *"We've got a generation of millennials that really don't want a car, they want to be green, they want modes of transportation, they want buses, they want trains. The international student population at Purdue, that's huge for them, because that's what they've used to. So, I think the funding is important in all modes of transportation, not necessarily just the Hoosier State".*
  (Author's note: millennials and international students are a key segment of the target market because of cultural preferences that are potentially favorable to passenger rail.)
- *"Do not discount the senior citizens because a lot of riders are the senior citizens."*
  (Author's note: senior citizens are a key segment of the target market.)

A.1.2.2 Other Barriers, Key Factors, and Opportunities for Ridership Increase

In view of the comments summarized above, it might be inferred that the anticipated ridership increase is mainly expected to come from new demand. However, whether the source of the additional demand would be new demand for travel or a mode shift from automobile or alternative transportation modes (such as intercity buses) was not discussed to much extent. The potential of a mode shift to the Hoosier State train for business travel was briefly mentioned. Related to that were comments on the barriers to business travel, as discussed above. Other comments included the following:

- *"The convention business is something that's extremely important to downtown Indianapolis: meetings, and conventions, and the corporations that reside in downtown Indianapolis. And it's all about access, and it's all about frequency. And my perception is that there is a barrier right now, to that, because of the location and access of the train station."*
  (Author's note: access to the Indianapolis station and low frequency of service were perceived as barriers to attracting riders for business trips.)

Other key factors and opportunities discussed that could be explored to support a ridership increase included i) economic development and investments by the private sector along the rail lines and specifically around train stations and ii) connectivity with other modes of transportation. Some of the relevant comments are reported below:

- *"I feel that with public investments too, if you are getting businesses like commerce or anybody else, it's also going to boost, like, getting the word out to the employees and the people around, so that kind of also goes hand in hand with the businesses [that] are putting in their investments. They're going to also be promoting it because there going to want to see returns."*
  (Author's note: economic development and support by the private sector are viewed as opportunities to increase ridership.)
- *"Connectivity to other modes is another way [to increase ridership]. […] It's a way that you also show support for the service. You are acknowledging that it's there and then you are also providing that connection."*
  (Author's note: system-wide connectivity can be an opportunity to increase ridership.)
- *"Not only the service itself, but it's how you might be getting to and from the service is what really makes it or breaks it."*
  (Author's note: accessibility to the line can be an opportunity for or a barrier to increased ridership.)
- *"Especially millennials or older folks who don't want to drive, then [a well-connected mass transportation network] really becomes an attractive service. You get precisely that last mile to the train station."*
  (Author's note: system-wide connectivity can be an opportunity to increase ridership in terms of the last-mile problem.)

A.1.3 Multimodal transportation

Apart from the importance of system-wide connectivity and accessibility to the line, as highlighted above, the participants also discussed the importance of multimodality. In addition, participants representing different perspectives made the case that different mass transportation modes, whether state supported, such as the Hoosier State train, or privately owned, such as intercity buses, are not competing modes. Rather different modes can be complementary, even if they serve the same areas, because they aim to provide transportation options to Indiana residents. Some of the relevant comments were as follows:

- *"The train is a spine of a network. You get to these towns and you have transit and/or intercity bus that can take to more rural areas. You have a network [...] of connectivity, it works really well."*
  (Author's note: system-wide connectivity and multimodality are seen as goals to pursue.)
- *"I need the highway, just as much as I need the Amtrak, just as much as Amtrak needs the buses. And that's just it; not being a separated community but being a cohesive, and know that we all need each other. And I think that's the problem, that we're so separated."*
  (Author's note: system-wide connectivity and multimodality are seen as goals to pursue.)
- *"Providing access from the airport to the city center [of] Indianapolis would really give a boost to all the intermodal transportation in the region."*
  (Author's note: system-wide connectivity and multimodality are seen as goals to pursue.)
- *"Here is my competitor; it's not a competitor, to me it's just another person in the transportation community that has something to offer you, to try to get you where you need to get to. [...] It's all about options."*
  (Author's note: multimodality is seen as a goal to pursue; different modes are not perceived as competing with passenger rail.)
- *"I think a lot of us in the bus industry feel that way; we want to complement the railroads."*
  (Author's note: multimodality is seen as a goal to pursue; different modes are not perceived as competing but rather as complementary.)

A.1.4 Other Key Topics that Emerged

A.1.4.1 The Role of Transportation Culture

Many participants also highlighted the role that culture plays in both the adoption of public transportation services in general and passenger rail specifically and the willingness of stakeholders to financially support such services. Specifically, many of the participants discussed the fact that Indiana is an automobile-centered state. However, many of the participants also discussed the possibility of an ongoing shift in the culture and the transportation paradigm towards a more multimodal and less automobile-centered lifestyle. Some comments on this topic were as follows:

- *"The public perception is positive, but getting that message out that there are other opportunities to travel versus the car [is the challenge]. I mean, Indiana is a very car-friendly [car]-centered state, so changing some of the older perceptions is inherently important.*
  (Author's note: the automobile-centered culture of Indiana is a concern.)
- *"I think culture is a very important aspect. […] The way Europeans look at transportation is how they grew up with those modes of transportation, compared to how Americans look at it."*
  (Author's note: the automobile-centered culture of Indiana is a concern.)
- *"This is a very car-centered state, and it is going to remain a very car-centered state until the economic impacts […] will change that. The bottom line is, there is a sweet spot for passenger rail in this mix."*
  (Author's note: the automobile-centered culture of Indiana might be a concern, but it is not necessarily a barrier.)
- *"It's very hard to get from one place to another in Indiana, unless you are able and willing to drive yourself in your own car. You can't even fly between any two cities in Indiana anymore; and the bus routes are going away."*
  (Author's note: automobile-oriented development might be a concern from a "people" perspective.)
- *"I think in Indiana—INDOT included very much so—there has been a little paradigm shift in regard to looking at viable options; and I think that INDOT has shown that it's not just roads and bridges."*
  (Author's note: the participant believed that a paradigm shift away from automobile-oriented planning is occurring.)
- *"From a state of Indiana perspective, we've gone from a cumulative investment outside of the South Shore corridor of 120,000 over a 10-year period of time to 6 million dollars over 2 years. That is huge. At the same time, increasing public mass transit funding too by almost 2 million dollars."*
  (Author's note: the participant believed that a paradigm shift away from automobile-oriented planning is occurring.)
- *"What we want to do as a state is provide the people who live here options to go from A to B."*
  (Author's note: the participant views multimodal transportation as a goal to pursue.)

- *"It comes out of INDOT's budget, which is a vote of confidence from INDOT […] saying ok, we have rail as an option."*
  (Author's note: the participant believed that a paradigm shift away from automobile-oriented planning is occurring.)

A.1.4.2 The Role of Younger Generations in the Shift in Transportation Culture

Another related subject was that one of the reasons for such a cultural shift in transportation culture is the perceptions of younger generations. A concern expressed in this regard was that these generations are less politically active than previous generations. Some of the relevant comments are as follows:

- *"That's ultimately a conversation that has to be had within the tourism and transportation industries: the people that are driving a lot of the success or failure of businesses are young people."*
  (Author's note: younger generations are believed to drive the successes/failures of transportation systems.)
- *"Public opinion is shifting, we know that, it's a generational thing, we see it shifting back towards public transportation. The challenge, though, is that […] the group that is shifting it is not very politically active, it doesn't have much influence on the system."*
  (Author's note: younger generations drive the shift in transportation culture. However, their underrepresentation in public involvement and politics is a concern.)
- *"For those of us in elected office, that's tough. You are constantly watching that. But we do see a shift."*
  (Author's note: younger generations' underrepresentation in public involvement and politics is a concern.)

A.1.4.2 Benefits of Passenger Rail in Indiana

Another topic worth mentioning that was raised during the discussions included the perceived benefits of providing passenger rail services in the state and the importance of sustaining the line. The sentiment was that the Hoosier State train connects communities along the line and provides options to the communities' residents. Key comments included the following:

- *"Modern rail service basically connects any two points along that corridor."*
  (Author's note: interconnectivity is a benefit to the communities along a rail line.)
- *"When we were discussing whether or not the train was going to continue… had the decision been made to terminate service, that decision only would have been made because we had other options. […] At that point we believed that the Hoosier State was the best option to provide transportation services between the communities along the route."*
  (Author's note: the lack of comparable alternatives played a role in the decision not to discontinue the Hoosier State train.)
- *"We are not asking rail to become the number one mode of transportation; it's just an option, it's just a modality that needs to be there, it needs to be maintained."*
  (Author's note: passenger rail is viewed as an integral part of Indiana's future multimodal transportation network.)

A.1.5 Future Directions

The discussions revealed that the stakeholders who participated in the focus groups viewed the Hoosier State train as a resource of the state, an asset that needs to be preserved. Moreover, most participants agreed that future efforts should be concentrated not only on sustaining the line but also on expanding the passenger rail services in the state.

Some general comments related to this conclusion are as follows:

- *"We have this resource and we haven't promoted it to the point where everybody wants to ride it."*
  (Author's note: the participant believed that further promotion of the services to increase their utilization should be pursued.)
- *"What we are doing is hedging our bets for the future. We can't just say we have what we have and we are done. This is a start."*
  (Author's note: the participant advocated the continuation and development of passenger rail in Indiana.)
- *"We would like to see an elevation of what rail means to the state; not take away anything that already exists, but just elevate something that we already have".*
  (Author's note: the participant advocated the continuation and development of passenger rail in Indiana.)

- *"It all comes down to these transportation options. […] We compete with other parts of the U.S., basically compete with the rest of the world. Part of that is competing as a place where people want to live. […] Part of what makes younger people want to stay […] is the provision of modern, effective public transportation, and intercity rail being part of it."*
  (Author's note: the provision of public transportation services, including passenger rail, can contribute to more competitive and desirable Indiana communities.)

A.2 Pilot Survey

Name: *Click here to enter text.*
Organization: *Click here to enter text.*
Position within the Organization: *Click here to enter text.*

This is a pilot questionnaire that will help us better prepare the material to be discussed in the focus group that will be conducted as part of a project focusing on the evaluation of the current services and potential of public transportation in U.S. rural and small urban areas, with a focus on Indiana.

Before attending the focus groups discussion, please review the following questionnaire and prepare to discuss the questions raised.

If you choose to complete this questionnaire in advance and share it with us, please note that your responses will not be anonymous. However your responses will be confidential, and will not be published or shared with anyone outside of the research team. Any publishable information collected from this part of the study will be reported at an aggregated manner and the responses will not be linked with you, though they might be linked with the agency you represent.

There are no physical, psychological, social, economic, legal, or other expected risks to participating in this pilot survey; it is expected that the information you will share will be your and your agency's official public position on the matter.

If you are able to complete this survey in advance, please answer the following questions to the best of your knowledge and return the completed copy at vdp@purdue.edu or at the return address provided.

1. Please list and describe (with no more than one sentence each) 3-5 short-term planning goals and 3-5 long-term planning goals related to public transportation provisions that you or your agency has.
   Click here to enter text.

2. Please list any passenger transportation mode (public or private) and/or infrastructure that you or your agency believes that its (or their) development/improvement will advance progress towards the above goals?
   Click here to enter text.

3. Please explain why or why not the continuation and development/improvement (such as increased frequency, enhanced reliability, and additional amenities) of the Hoosier State line would advance progress towards the above goals.
   Click here to enter text.

4. In view of the goals stated in the first question, please answer the following questions:
   i. My agency believes that a mode shift from automobile to alternative transportation modes for intercity trips in Indiana is important.
      Strongly Disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly Agree ☐

   ii. My agency is interested in and attempts to foster a mode shift from automobile to alternative transportation modes.
      Yes ☐ No ☐ Maybe ☐

iii. My agency supports the idea of public investments in the Hoosier State train
Strongly Disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly Agree ☐
Briefly explain why or why not: *Click here to enter text.*

iv. My agency has provided financial support for the continuation of the Hoosier State train in the past.
Yes ☐ No ☐ I am not sure ☐

v. My agency is planning on financially supporting the continuation and/or improvement of the Hoosier State train in the future.
Yes ☐ No ☐ Maybe ☐

vi. My agency believes that in order for the Hoosier State line to be a financially viable transportation option, the ridership should be substantially increased.
Strongly Disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly Agree ☐

vii. My agency believes that a mode shift from automobile to the Hoosier State train is vital for the continuation of the line.
Yes ☐ No ☐ Maybe ☐

viii. My agency believes that a possible discontinuance of the Hoosier State train will have significant impacts in the mobility of Indiana's residents.
Strongly Disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly Agree ☐

ix. My agency believes that in case of discontinuance of the Hoosier State train, there are other public transportation alternatives that can absorb the ridership of the Hoosier State line, without hindering progress towards the goals stated in question 1.
Yes ☐ No ☐ Maybe ☐
If yes/maybe, please state which: *Click here to enter text.*

x. My agency has provided financial support for the development/improvement of other transportation modes and/or infrastructures in the past.
Yes ☐ No ☐ I am not sure ☐
If yes, please state which: *Click here to enter text.*

xi. My agency is planning on financially supporting the development/improvement of other transportation modes and/or infrastructures in the future.
Yes ☐ No ☐ Maybe ☐
If yes/maybe, please state which: *Click here to enter text.*

5. Please let us know if you have any other comments that you would like us to take into consideration in the preparation of the material for the focus group discussion.
Click here to enter text.

A.3 Purdue Institutional Research Board Approval

PURDUE
UNIVERSITY

HUMAN RESEARCH PROTECTION PROGRAM
INSTITUTIONAL REVIEW BOARDS

To:	KONSTANTINA GKRITZA HAMP
From:	JEANNIE DICLEMENTI, Chair Social Science IRB
Date:	07/14/2015
Committee Action:	**Exemption Granted**
IRB Action Date:	07/14/2015
IRB Protocol #:	1507016231
Study Title:	A Comprehensive Assessment of Transit in U.S. Rural and Small Urban Areas: A Focus Group

The Institutional Review Board (IRB) has reviewed the above-referenced study application and has determined that it meets the criteria for exemption under 45 CFR 46.101(b)(2) .

If you wish to make changes to this study, please refer to our guidance "**Minor Changes Not Requiring Review**" located on our website at http://www.irb.purdue.edu/policies.php. For changes requiring IRB review, please submit an **Amendment to Approved Study** form or **Personnel Amendment to Study** form, whichever is applicable, located on the forms page of our website www.irb.purdue.edu/forms.php. Please contact our office if you have any questions.

Below is a list of best practices that we request you use when conducting your research. The list contains both general items as well as those specific to the different exemption categories.

General

- To recruit from Purdue University classrooms, the instructor and all others associated with conduct of the course (e.g., teaching assistants) must not be present during announcement of the research opportunity or any recruitment activity. This may be accomplished by announcing, in advance, that class will either start later than usual or end earlier than usual so this activity may occur. It should be emphasized that attendance at the announcement and recruitment are voluntary and the student's attendance and enrollment decision will not be shared with those administering the course.
- If students earn extra credit towards their course grade through participation in a research project conducted by someone other than the course instructor(s), such as in the example above, the students participation should only be shared with the course instructor(s) at the end of the semester. Additionally, instructors who allow extra credit to be earned through participation in research must also provide an opportunity for students to earn comparable extra credit through a non-research activity requiring an amount of time and effort comparable to the research option.
- When conducting human subjects research at a non-Purdue college/university, investigators are urged to contact that institution's IRB to determine requirements for conducting research at that institution.
- When human subjects research will be conducted in schools or places of business, investigators must obtain written permission from an appropriate authority within the organization. If the written permission was not

submitted with the study application at the time of IRB review (e.g., the school would not issue the letter without proof of IRB approval, etc.), the investigator must submit the written permission to the IRB prior to engaging in the research activities (e.g., recruitment, study procedures, etc.). This is an institutional requirement.

Category 1

- When human subjects research will be conducted in schools or places of business, investigators must obtain written permission from an appropriate authority within the organization. If the written permission was not submitted with the study application at the time of IRB review (e.g., the school would not issue the letter without proof of IRB approval, etc.), the investigator must submit the written permission to the IRB prior to engaging in the research activities (e.g., recruitment, study procedures, etc.). This is an institutional requirement.

Categories 2 and 3

- Surveys and questionnaires should indicate
  - only participants 18 years of age and over are eligible to participate in the research; and
  - that participation is voluntary; and
  - that any questions may be skipped; and
  - include the investigator's name and contact information.
- Investigators should explain to participants the amount of time required to participate. Additionally, they should explain to participants how confidentiality will be maintained or if it will not be maintained.
- When conducting focus group research, investigators cannot guarantee that all participants in the focus group will maintain the confidentiality of other group participants. The investigator should make participants aware of this potential for breach of confidentiality.
- When human subjects research will be conducted in schools or places of business, investigators must obtain written permission from an appropriate authority within the organization. If the written permission was not submitted with the study application at the time of IRB review (e.g., the school would not issue the letter without proof of IRB approval, etc.), the investigator must submit the written permission to the IRB prior to engaging in the research activities (e.g., recruitment, study procedures, etc.). This is an institutional requirement.

Category 6

- Surveys and data collection instruments should note that participation is voluntary.
- Surveys and data collection instruments should note that participants may skip any questions.
- When taste testing foods which are highly allergenic (e.g., peanuts, milk, etc.) investigators should disclose the possibility of a reaction to potential subjects.

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A.4 Focus Group Material

Document 1: Agenda

PURDUE
UNIVERSITY
LYLES SCHOOL OF CIVIL ENGINEERING

Hoosier State Train Focus Group Meeting
Meeting Agenda & Meeting Objectives

10:00 am – 12:00 pm, September 28, 2015
West Lafayette, IN 47906

Meeting Objectives:

1. Identify and prioritize high-priority community goals
2. Evaluate the Hoosier State train and competing transportation modes
3. Identify funding opportunities for the Hoosier State train
4. Identify optimal conditions for financially viable services
5. Understand the role of a ridership increase
6. Identify ways to foster a ridership increase
7. Envision the role of other public transportation modes

Meeting Facilitator: *Dimitra Pyrialakou*

Agenda:

I. Welcome and introductions

II. Brief survey on planning goals and objectives & other relevant matters

III. Discussion on community goals prioritization

IV. Rating alternative transportation modes (on paper)

Short Break

V. Open discussion on:
   a) Financial viability of the Hoosier State train
   b) Ridership increase
   c) Multimodal transportation

VI. Summary and final suggestions/comments

VII. Adjournment

Document 2: Discussion Guide

DISCUSSION GUIDE-Summary
(for internal use only)

I. INTRODUCTION (20 min)

- Greeting/welcome
- Purpose of focus group, general plan, agenda
- Participants' introduction: names, agency, position in the agency
- Survey guided through verbal interaction (8 min)
- Confidentiality, etc.

II.TRANSPORTATION PLANNING GOALS-CRITERIA FOR ASSESMENT (20 min)

- Open discussion to prioritize the criteria (collected from the survey)

III.MODE ASSESSMENT BASED ON CRITERIA (10min)

- Second questionnaire with highlighted goals for rating the modes guided through verbal interaction

BREAK (5 min)

IV.FINANCIAL SUPPORT (20min)

1. What do you think about public investments in the Hoosier State train? (Prompt: since 2008, the train is operating with public funds from INDOT and local communities, how do you feel about that and about similar future funds? ..does anyone else have any other views?
2. Where do you think that money for the operations, improvement, and expansion of the Hoosier State train should come from in general? Any other appropriate funding sources you can think of? Any other thoughts?
3. If we wanted to minimize the subsidy, and aiming at a financially viable line, what circumstances/conditions do you think need to exist? What do you think it should change? How do you visualize a future that this would be possible or close to possible ? [Probe: what role do you think an increase in ridership could play?]

V.RIDERSHIP INCREASE (20min)

1. If an increase on the Hoosier State train's ridership is the goal, how could we achieve that? Are there any ways we can foster an increase? [Probe: where will the ridership come from? would this be new demand for trips not being made before, or mode shift from other modes?]
2. If we expect that the ridership will come from other modes of transportation (or mode shift), from which alternative modes would the shift come?
3. What role can other forms of public (or mass) transportation such as intercity buses play in the mix? (Probe: For example could other modes help with the "last mile" problem? Or is this even something that you are considering when looking at the developments of the Hoosier State train?)

VI.CLOSING (10min)

1. Summary (what did we achieve today, what's next)
2. Have we missed anything? Final Suggestions/Comments?

THANK YOU *(total 100+20 buffer -> 120 min)*

Document 3: On-site Survey 1

Name:
Organization:

Please review the following planning goals and objectives related to the provision of transportation services, and identify 5 most important goals for you and/or your agency you represent (check the box for those which apply).

If we have missed an important planning goal, please add it to the end of the list.

☐ Transportation safety (improve health reducing transportation related fatalities/injuries)	
☐ State of good repair (maintaining or improving operating conditions, sustaining assets)	
Economic Competitiveness	☐ Enhance productivity and growth
	☐ Improving systems' performance (efficiency, travel time reliability)
	☐ Promote land-use patterns that foster community development
	☐ Promote the adoption of new transportation technologies
Quality of Life in Communities	☐ Enhance quality of life and community well-being
	☐ Improve accessibility, mobility, and connectivity
	☐ Expand transportation choices
	☐ Promote social equity
	☐ Promote environmental justice
Environmental Sustainability	☐ Promote energy efficiency and/or reduce energy use
	☐ Mitigate environmental impacts (including water quality/quantity, air pollution, noise, damage to cultural heritage)
	☐ Adapt to climate change
Public (or Mass) Transportation Specific and Multimodality	☐ Enhance economic attractiveness of systems (e.g., reduced costs for agencies)
	☐ Enhance financial viability
	☐ Improve services to maximize mobility, accessibility, and multimodality (e.g., reduced travel time, improved on-time performance, increased frequency, route expansion)
	☐ Increase ridership
	☐ Provide quality and affordable services
	☐ Encourage use of non-motorized modes (e.g., pedestrian and bicycle travel)
☐ Other (please briefly describe):	
☐ Other (please briefly describe):	
☐ Other (please briefly describe):	

Document 3 On-site Survey 1 (Continued)

In view of the goals you indicated earlier, please answer the following questions:

1. I believe that the continuation and development/improvement (such as increased frequency, enhanced reliability, and additional amenities) of the Hoosier State line would advance progress towards the above goals.

   Strongly Disagree □ Disagree □ Neutral □ Agree □ Strongly Agree □

2. I support the idea of public investments in the Hoosier State train

   Strongly Disagree □ Disagree □ Neutral □ Agree □ Strongly Agree □

3. My agency has provided financial support for the continuation of the Hoosier State train in the past.

   Yes □ No □ I am not sure □ Non Applicable □

4. My agency is planning on financially supporting the continuation and/or improvement of the Hoosier State train in the future.

   Yes □ No □ Maybe □ Non Applicable □

5. I believe that in order for the Hoosier State line to be a financially viable transportation option, the ridership should be substantially increased.

   Strongly Disagree □ Disagree □ Neutral □ Agree □ Strongly Agree □

6. I believe that a mode shift from automobile to the Hoosier State train is vital for the continuation of the line.

   Yes □ No □ Maybe □

7. I believe that a possible discontinuance of the Hoosier State train will have significant impacts on the mobility of Indiana's residents.

   Strongly Disagree □ Disagree □ Neutral □ Agree □ Strongly Agree □

8. I believe that in case of discontinuance of the Hoosier State train, there are other public transportation alternatives that can absorb the ridership of the Hoosier State line, without hindering progress towards the goals stated in question 1.

   Yes □ No □ Maybe □

   If yes/maybe, please state which (select all that apply):

   Intercity bus □ Airlines □ Other □ (please state which) ________________________________

9. My agency has provided financial support for the development/improvement of other transportation modes and/or infrastructures in the past.

   Yes □ No □ I am not sure □ Non Applicable □

   If yes, please state which (select all that apply):

   Highway Infrastructure □ Air transportation □ Other □ (please state which)________________

   ____

10. My agency is planning on financially supporting the development/improvement of the above state other transportation modes and/or infrastructures in the future.

    Yes □ No □ Maybe □ Non Applicable □

11. I believe that a mode shift from automobile to alternative transportation modes for intercity trips in Indiana is important.

    Strongly Disagree □ Disagree □ Neutral □ Agree □ Strongly Agree □

12. I am interested in and willing to foster a mode shift from automobile to alternative transportation modes.

    Yes □ No □ Maybe □

Document 4 On-site Survey 2

Name:
Organization:

Transportation Mode and Infrastructure Assessment

In the following table, please rate the Hoosier State train and potential alternative transportation modes and/or associated infrastructures with respect to each of the following planning goals highlighted below (as identified during the focus group meeting).

When you score the modes and infrastructures, please consider the degree to which development/improvement of the transportation mode or infrastructure using public funds is expected to advance or hinder progress toward the goal. For example, will investing in the Hoosier State train enhance transportation safety?

Please place a mark on each scale below.

Community Goal/Criterion	Intercity Train-Hoosier State train	Highway Infrastructure	Airports	Alternative Fuel Infrastructure	Passenger Intermodal Facilities	Other
Transportation safety	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕
State of good repair	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕
Productivity and growth	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕
Systems' performance	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕
Land-use patterns	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕
New transportation technologies	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕
Quality of life and community well-being	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕
Accessibility, mobility, and connectivity	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕
Transportation choices	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕
Social equity	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕
Environmental justice	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕
Energy efficiency-reduced energy use	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕
Mitigate environmental impacts	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕
Climate change	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕
Economic attractiveness of systems	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕
Financial viability	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕
Improved services	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕
Increased ridership	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕
Quality and affordable services	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕
Use of non-motorized modes	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕
Other:________________________	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕
Other:________________________	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕
Other:________________________	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕	⊖ 0 ⊕

A.5 Summary of Survey Results

Q1	I believe that the continuation and development/improvement (such as increased frequency, enhanced reliability, and additional amenities) of the Hoosier State line would advance progress towards the above goals.
Q2	I support the idea of public investments in the Hoosier State train
Q3	My agency has provided financial support for the continuation of the Hoosier State train in the past.
Q4	My agency is planning on financially supporting the continuation and/or improvement of the Hoosier State train in the future.
Q5	I believe that in order for the Hoosier State line to be a financially viable transportation option, the ridership should be substantially increased.
Q6	I believe that a mode shift from automobile to the Hoosier State train is vital for the continuation of the line.
Q7	I believe that a possible discontinuance of the Hoosier State train will have significant impacts on the mobility of Indiana’s residents.
Q8	I believe that in case of discontinuance of the Hoosier State train, there are other public transportation alternatives that can absorb the ridership of the Hoosier State line, without hindering progress towards the goals stated in question 1.
Q9	My agency has provided financial support for the development/improvement of other transportation modes and/or infrastructures in the past.
Q10	My agency is planning on financially supporting the development/improvement of the above state other transportation modes and/or infrastructures in the future.
Q11	I believe that a mode shift from automobile to alternative transportation modes for intercity trips in Indiana is important.
Q12	I am interested in and willing to foster a mode shift from automobile to alternative transportation modes.

	Response Frequency				
	Q1	***Q2***	***Q5***	***Q7***	***Q11***
Strongly Disagree	0	0	1	0	0
Disagree	0	0	0	2	0
Neutral	1	3	2	3	5
Agree	6	3	7	6	5
Strongly Agree	11	12	8	7	8
Total Number of Responses	18	18	18	18	18

	Response Frequency						
	Q3	***Q4***	***Q6***	***Q8***	***Q9***	***Q10***	***Q12***
Not Applicable/No Response	7	8	1	0	8	10	1
Yes	7	6	5	4	6	6	11
No	1	2	5	7	1	1	0
I am not sure	3	2	7	7	3	1	6
Total Number of Responses	18	18	18	18	18	18	18

Appendix B Public Opinion Survey

B.1 Survey Instrument

Please take a few minutes to tell us what you think about the possibility of traveling using the Hoosier State train (that is, the Amtrak train running four times per week between Indianapolis and Chicago, with stops in Indianapolis, Crawfordsville, Lafayette, Rensselaer, Dyer, and Chicago).

There are no right or wrong responses; we are merely interested in your personal opinions. In your responses to the following questions, please share the thoughts that come immediately to mind.

SECTION 1

Trip characteristics and experience with the Hoosier State

1. In which station did you board the Hoosier State (or Cardinal) train? ______________________

2. In which station are you planning on getting off of the Hoosier State (or Cardinal) train? ______________

3. How many times approximately did you travel using the Hoosier State train last year (2014)? __________

SECTION 2

Please answer the following questions based on your perceptions of passenger rail.

Ease of using the Hoosier State train *(Ease, questions 1-7)*

1. My interaction with the **ticketing system** of the Hoosier State train (Amtrak) is easy and understandable.
Strongly Disagree __ Disagree __ Neutral __ Agree__ Strongly Agree__

2. My interaction with the **information (display) system** (such as electronic information boards and other systems providing real-time trip information) of the Hoosier State train (Amtrak) is easy and understandable.
Strongly Disagree __ Disagree __ Neutral __ Agree__ Strongly Agree__

3. It is easy for me to reach the closest Hoosier State station from my house.
Strongly Disagree __ Disagree __ Neutral __ Agree__ Strongly Agree__

4. It is easy for me to park my personal vehicle (car, motorcycle, etc.) near the Hoosier State train station.
I do not own a personal vehicle __Strongly Disagree __ Disagree __ Neutral __ Agree__ Strongly Agree__

5. It is easy for me to access the platform at the Hoosier State train station.
Strongly Disagree __ Disagree __ Neutral __ Agree__ Strongly Agree__

6. It is easy for me to travel with the essentials for my trip purposes (carry-on luggage, etc.).
Strongly Disagree __ Disagree __ Neutral __ Agree__ Strongly Agree__

7. Traveling with the Hoosier State train is easy for me.
Strongly Disagree __ Disagree __ Neutral __ Agree__ Strongly Agree__

Usefulness of the Hoosier State train *(Usefulness, questions 1-6)*

1. Using the Hoosier State train would enable me to reach my destination faster.
Very unlikely__ Unlikely __ Neutral __ Likely__ Very likely__

2. Taking the Hoosier State train would make my trip safer.
Very unlikely__ Unlikely __ Neutral __ Likely__ Very likely__

3. Using the Hoosier State train would enable me to use the time it takes to reach my destination more productively.
Very unlikely__ Unlikely __ Neutral __ Likely__ Very likely__

4. When I am traveling alone, using the Hoosier State train to reach my destination would cost me less.
Very unlikely__ Unlikely __ Neutral __ Likely__ Very likely__

5. When I am traveling with a group (family, friends, etc.), using the Hoosier State train to reach my destination would cost me less.
Very unlikely__ Unlikely __ Neutral __ Likely__ Very likely__

6. I find the Hoosier State train useful for my traveling purposes.
Strongly Disagree __ Disagree __ Neutral __ Agree__ Strongly Agree__

1/5

Your thoughts about the Hoosier State train *(Your thoughts, questions 1-8)*

1. If more people used the Hoosier State train, it would be good for the environment.
Strongly Disagree __ Disagree __ Neutral __ Agree__ Strongly Agree__

2. If more people used the Hoosier State train, it would contribute to the reduction of traffic congestion in the State.
Strongly Disagree __ Disagree __ Neutral __ Agree__ Strongly Agree__

For the following questions, please place a mark at the place your opinion lies on the scale. For example, if you were asked to rate how bad or good is the idea of "eating ice cream" on such a scale, the seven places would be as follows:

Bad ___ ___ ___ ___ ___ ___ ___ Good
extremely quite somewhat neither somewhat quite extremely

So, if you think that eating ice cream is a somewhat bad idea you would answer:

Bad ___ ___ ● ___ ___ ___ ___ Good

Please do not place more than one mark on a single scale.

3. Using the Hoosier State train is a __ idea for me.
Bad ___ ___ ___ ___ ___ ___ ___ Good

4. I __ traveling on the Hoosier State train.
Dislike ___ ___ ___ ___ ___ ___ ___ Like

5. Traveling on the Hoosier State train is:
Inconvenient ___ ___ ___ ___ ___ ___ ___ Convenient

6. Traveling on the Hoosier State train is:
Boring ___ ___ ___ ___ ___ ___ ___ Fun

7. Traveling on the Hoosier State train is:
Unpleasant ___ ___ ___ ___ ___ ___ ___ Pleasant

8. Traveling on the Hoosier State train is:
Painful ___ ___ ___ ___ ___ ___ ___ Enjoyable

Hoosier State train usage and personal network *(Usage and personal network, questions 1-3)*

1. Most people who influence my behavior think that I should use the Hoosier State train.
Strongly Disagree __ Disagree __ Neutral __ Agree__ Strongly Agree__

2. Most people who are important to me think that I should use the Hoosier State train.
Strongly Disagree __ Disagree __ Neutral __ Agree__ Strongly Agree__

3. People who use the Hoosier State train are people like me.
Very unlikely__ Unlikely __ Neutral __ Likely__ Very likely__

External factors *(External factors, questions 1-8)*

1. How likely is it that you can reach a desired destination using the Hoosier state train?
Very unlikely__ Unlikely __ Neutral __ Likely__ Very likely__

2. Being able to reach a desired destination would make it easier for me to use the Hoosier State train.
Strongly Disagree __ Disagree __ Neutral __ Agree__ Strongly Agree__

3. How likely is it that the Hoosier State schedule will be convenient for your travel purposes?
Very unlikely__ Unlikely __ Neutral __ Likely__ Very likely__

4. Having a convenient train schedule would enable me to use the Hoosier State train.
Strongly Disagree __ Disagree __ Neutral __ Agree__ Strongly Agree__

5. How likely is it that you can reach your destination on time using the Hoosier state train?
Very unlikely__ Unlikely __ Neutral __ Likely__ Very likely__

6. Being able to reach my destination on time would enable me to use the Hoosier State train.
Strongly Disagree __ Disagree __ Neutral __ Agree__ Strongly Agree__

7. If I wanted to, I could easily travel using the Hoosier State train.
Strongly Disagree __ Disagree __ Neutral __ Agree__ Strongly Agree__

8. There are numerous factors outside of my control that could prevent me from using the Hoosier State train.
Strongly Disagree __ Disagree __ Neutral __ Agree__ Strongly Agree__

Using the Hoosier State train in the future *(Using in the future, questions 1-3)*

1. I have plans to travel with the Hoosier State train in the next month.
Strongly Disagree __ Disagree __ Neutral __ Agree__ Strongly Agree__

2. I intend to travel with the Hoosier State train in the next month.
Strongly Disagree __ Disagree __ Neutral __ Agree__ Strongly Agree__

3. I expect to travel with the Hoosier State train in the foreseeable future.
Strongly Disagree __ Disagree __ Neutral __ Agree__ Strongly Agree__

SECTION 3

Which mode would you use? *(Which mode, questions 1-2)*

Listed below are a few activities that you may often perform. Assume that you would like to spontaneously engage in one of these activities. Which mode of transportation would you be most likely to use? Please respond quickly without much deliberation. Please place only one mark in each row.

1.a. Taking a summer excursion with friends:
car__ bus__ train__ bicycle__ walking__ other__

1.b. Going for a drink in the evening/visiting a bar:
car__ bus__ train__ bicycle__ walking__ other__

1.c. Taking a trip on a weekend with nice weather:
car__ bus__ train__ bicycle__ walking__ other__

1.d. Visiting a friend living in the same town:
car__ bus__ train__ bicycle__ walking__ other__

1.e. Routine grocery shopping:
car__ bus__ train__ bicycle__ walking__ other__

1.f. Going out for lunch:
car__ bus__ train__ bicycle__ walking__ other__

1.g. Going to participate in sports as a leisure activity:
car__ bus__ train__ bicycle__ walking__ other__

1.h. Going to the movies:
car__ bus__ train__ bicycle__ walking__ other__

1.i. Visiting Chicago for leisure:
car__ bus__ train__ bicycle__ walking__ other__

1.g. Going to work on a typical weekday:
car__ bus__ train__ bicycle__ walking__ other__

2. Whether I go to work or go shopping, I almost always travel by car.
Strongly Disagree __ Disagree __ Neutral __ Agree__ Strongly Agree__

Mode choice

In the following table, please place a check mark on the level of importance each attribute has when choosing a transportation mode for a medium-distance trip [between 3-5 hours travel].

Attribute	Not at all Important	Slightly Important	Moderately Important	Very Important	Extremely Important
a. Cost					
b. Travel time					
c. Comfort					
d. Safety					
e. Amenities (Wi-Fi, food, etc.)					
f. Flexibility of travel (be able to go wherever I want to go)					
g. Convenient/flexible schedule					
h. Reliability (not being late)					
i. Ease of traveling (minimize the effort required to travel)					

Now, please imagine that you are trying to choose between driving alone, carpool (sharing ride), intercity bus, intercity train (such as the Hoosier State train), or airplane for a medium-distance trip [between 3-5 hours travel]. In the following table, please rate with a score from 1 to 5 these transportation modes with respect to each of the following attributes. The scores indicate that the mode is:

(1) poor, (2) fair, (3) good, (4) very good, and (5) excellent with respect to this attribute.

Attribute	Automobile-Drive Alone	Automobile-Carpool	Intercity Bus	Intercity Train	Airplane
a. Cost					
b. Travel time					
c. Comfort					
d. Safety					
e. Amenities (Wi-Fi, food, etc.)					
f. Flexibility of travel (be able to go wherever I want to go)					
g. Convenient/flexible schedule					
h. Reliability (not being late)					
i. Ease of traveling (minimize the effort required to travel)					

SECTION 4

Now a few last demographic questions

1. Are you __ male or __ female?

2. What is your age range? 18-24 __ 25-34 __ 35-44 __ 45-54__ 55-64__ 65 and over__

3. What describes best your employment situation?
Work full time__ Work part time__ Currently unemployed __ Do not work outside home__

4. Please indicate your approximate annual household income before taxes.
(Include total income of all adults living in your household.)
Under $25,000__ $25,001-$49,999__ $50,000-$74,999__ $75,000-$99,999__ $100,000-$149,999__ $150,000 and over__

5. What is your highest level of education?
Some high school__ High school graduate__ Some college__ College graduate__ Postgraduate/professional__

6. Including yourself, how many persons are in your household? One__ Two__ Three__ Four__ Five or more__

7. Please indicate the number of children in your household under the age of 18.
None__ One__ Two__ Three__ Four or more__

8. How many personal vehicles (including cars, trucks, motorcycles, etc.) does your household have access to or own?
None__ One__ Two__ Three__ Four or more__

9. In a typical week, how many miles do you drive your personal vehicle?
I do not own a personal vehicle__ 5-99__ 100-299__ 300-499__ 500-1,000__ More than 1,000__

10. In which Indiana county is your house located?
I do not live in Indiana__ Jasper__ Lake__ Marion__ Montgomery__ Tippecanoe__ Other__
If other, please specify ________________

Thank you for your participation!

B.2 Purdue Institutional Research Board Approvals

PURDUE
UNIVERSITY

HUMAN RESEARCH PROTECTION PROGRAM
INSTITUTIONAL REVIEW BOARDS

To:	KONSTANTINA GKRITZA HAMP
From:	JEANNIE DICLEMENTI, Chair Social Science IRB
Date:	02/23/2015
Committee Action:	**Exemption Granted**
IRB Action Date:	02/21/2015
IRB Protocol #:	1502015762
Study Title:	A Comprehensive Assessment of Transit in U.S. Rural and Small Urban Areas: A Pilot Study

The Institutional Review Board (IRB) has reviewed the above-referenced study application and has determined that it meets the criteria for exemption under 45 CFR 46.101(b)(2) .

If you wish to make changes to this study, please refer to our guidance "**Minor Changes Not Requiring Review**" located on our website at http://www.irb.purdue.edu/policies.php. For changes requiring IRB review, please submit an **Amendment to Approved Study** form or **Personnel Amendment to Study** form, whichever is applicable, located on the forms page of our website www.irb.purdue.edu/forms.php. Please contact our office if you have any questions.

Below is a list of best practices that we request you use when conducting your research. The list contains both general items as well as those specific to the different exemption categories.

General

- To recruit from Purdue University classrooms, the instructor and all others associated with conduct of the course (e.g., teaching assistants) must not be present during announcement of the research opportunity or any recruitment activity. This may be accomplished by announcing, in advance, that class will either start later than usual or end earlier than usual so this activity may occur. It should be emphasized that attendance at the announcement and recruitment are voluntary and the student's attendance and enrollment decision will not be shared with those administering the course.
- If students earn extra credit towards their course grade through participation in a research project conducted by someone other than the course instructor(s), such as in the example above, the students participation should only be shared with the course instructor(s) at the end of the semester. Additionally, instructors who allow extra credit to be earned through participation in research must also provide an opportunity for students to earn comparable extra credit through a non-research activity requiring an amount of time and effort comparable to the research option.
- When conducting human subjects research at a non-Purdue college/university, investigators are urged to contact that institution's IRB to determine requirements for conducting research at that institution.
- When human subjects research will be conducted in schools or places of business, investigators must obtain written permission from an appropriate authority within the organization. If the written permission was not submitted with the study application at the time of IRB review (e.g., the school would not issue the letter without

proof of IRB approval, etc.), the investigator must submit the written permission to the IRB prior to engaging in the research activities (e.g., recruitment, study procedures, etc.). This is an institutional requirement.

Category 1

- When human subjects research will be conducted in schools or places of business, investigators must obtain written permission from an appropriate authority within the organization. If the written permission was not submitted with the study application at the time of IRB review (e.g., the school would not issue the letter without proof of IRB approval, etc.), the investigator must submit the written permission to the IRB prior to engaging in the research activities (e.g., recruitment, study procedures, etc.). This is an institutional requirement.

Categories 2 and 3

- Surveys and questionnaires should indicate
  - only participants 18 years of age and over are eligible to participate in the research; and
  - that participation is voluntary; and
  - that any questions may be skipped; and
  - include the investigator's name and contact information.
- Investigators should explain to participants the amount of time required to participate. Additionally, they should explain to participants how confidentiality will be maintained or if it will not be maintained.
- When conducting focus group research, investigators cannot guarantee that all participants in the focus group will maintain the confidentiality of other group participants. The investigator should make participants aware of this potential for breach of confidentiality.
- When human subjects research will be conducted in schools or places of business, investigators must obtain written permission from an appropriate authority within the organization. If the written permission was not submitted with the study application at the time of IRB review (e.g., the school would not issue the letter without proof of IRB approval, etc.), the investigator must submit the written permission to the IRB prior to engaging in the research activities (e.g., recruitment, study procedures, etc.). This is an institutional requirement.

Category 6

- Surveys and data collection instruments should note that participation is voluntary.
- Surveys and data collection instruments should note that participants may skip any questions.
- When taste testing foods which are highly allergenic (e.g., peanuts, milk, etc.) investigators should disclose the possibility of a reaction to potential subjects.

Ernest C. Young Hall, 10th Floor - 155 S. Grant St. - West Lafayette, IN 47907-2114 - (765) 494-5942 - Fax: (765) 494-9911

PURDUE
UNIVERSITY

HUMAN RESEARCH PROTECTION PROGRAM
INSTITUTIONAL REVIEW BOARDS

To:	KONSTANTINA GKRITZA HAMP
From:	JEANNIE DICLEMENTI, Chair Social Science IRB
Date:	04/10/2015
Committee Action:	**Exemption Granted**
IRB Action Date:	04/09/2015
IRB Protocol #:	1503015896
Study Title:	A COMPREHENSIVE ASSESSMENT OF TRANSIT IN U.S. RURAL AND SMALL URBAN AREAS: A SURVEY

The Institutional Review Board (IRB) has reviewed the above-referenced study application and has determined that it meets the criteria for exemption under 45 CFR 46.101(b)(2) .

If you wish to make changes to this study, please refer to our guidance "**Minor Changes Not Requiring Review**" located on our website at http://www.irb.purdue.edu/policies.php. For changes requiring IRB review, please submit an **Amendment to Approved Study** form or **Personnel Amendment to Study** form, whichever is applicable, located on the forms page of our website www.irb.purdue.edu/forms.php. Please contact our office if you have any questions.

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- If students earn extra credit towards their course grade through participation in a research project conducted by someone other than the course instructor(s), such as in the example above, the students participation should only be shared with the course instructor(s) at the end of the semester. Additionally, instructors who allow extra credit to be earned through participation in research must also provide an opportunity for students to earn comparable extra credit through a non-research activity requiring an amount of time and effort comparable to the research option.
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submitted with the study application at the time of IRB review (e.g., the school would not issue the letter without proof of IRB approval, etc.), the investigator must submit the written permission to the IRB prior to engaging in the research activities (e.g., recruitment, study procedures, etc.). This is an institutional requirement.

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Categories 2 and 3

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B.3 Pilot Survey

Document 1 Pilot Survey Instrument

A comprehensive assessment of public transportation in U.S. rural and small urban areas: A Pilot Questionnaire

Instructions: Please take a few minutes to tell us what you think about the possibility of travelling using the Hoosier State Line (the Amtrak train line running between Indianapolis and Chicago). There are no right or wrong responses; we are merely interested in your personal opinions. In your responses to the following questions, please share the thoughts that come immediately to mind.

Familiarity
Have you ever used the Hoosier State line? (If yes) how many times during the past year? (If zero) how many times during the past decade/your lifetime? (If many) how many times during the past month/week? (If no) have you ever used another Amtrak line (or other passenger rail in the U.S.)?

Usefulness
How useful do you find the system for your travel purposes? What are some of the advantages of using the Hoosier state line instead of using another transportation mode (personal automobile, intercity bus, airplane)? What are some of the disadvantages? What else comes to mind when you think about using the Hoosier State line in terms of its usefulness?

Ease of Use
How easy or difficult do you think it is to use the passenger rail system? What motivates you to use the system? Could you name some of the barriers you find in using the system? How much effort do you think is required to use the system? Why? What else comes to mind when you think about using the Hoosier State line in terms of how easy or difficult it is to use it?

Attitude to the Hoosier State
Do you think that using the Hoosier State line is a good or bad idea? How do you feel when using the system (or how do you think you would feel if you were to use the system)? How would you describe your experience?

Normative referents
When it comes to your travels on the Hoosier State line, there might be individuals or groups in your personal network who would think you should or should not perform this behavior. Please identify individuals or groups who would approve or think you should use the system. Please identify individuals or groups who would disapprove or think you should not use the system. Sometimes, when we are not sure what to do, we look to see what others are doing. Please list the type of individuals or groups who are most likely to use the Hoosier State line. Please list the individuals or groups who are least likely to use the Hoosier State line.

Commuting with the Hoosier
If you could commute with the Hoosier State line (e.g., your job was located near a neighboring station), would you choose to do so? Why or why not? Would you ever consider the possibility of commuting using the Hoosier State line? If you could not find a job in your area, would you ever search for jobs in the communities along the Hoosier State line with the possibility that you could use the system to commute? Why or why not? If not, which factors would need to change for you to consider commuting using the Hoosier State line?

Control factors
Do you think that it is up to you whether or not you choose the Hoosier State line to commute? Why or why not? Please list any factors or circumstances that would make it easy for you or enable you to use the Hoosier State line. Please list any factors or circumstances that would make it difficult or prevent you from using the Hoosier State line.

Evaluating factors

Please list 5 characteristics of transportation modes that you take into consideration when you choose a mode for a trip. What else comes to mind when you think about choosing a mode? How would you reach your final decision?

Document 2 Summary of Pilot Survey Results

SUBJECT/COLLECTIVE RESPONSES	COMMENTS
Familiarity	
Most of the participants of the pilot survey had taken the Hoosier State train at least three times.	*From this preliminary qualitative analysis, it seems that the familiarity with the mode might be correlated with the attitude towards the system (though not so much with the opinion on the usefulness and ease of use). At this point, we are not able to tell whether the attitude affects the decision to take the system, or the decision to take the system affects the attitude.* *In our theoretical model we speculate that the attitude affects the decision for the most part (because it is expected that many residents have a strong opinion regarding the system but less residents have actually used the system).*
Elements that affect the "Usefulness"	
1. Travel time (both speed and inconvenient connections) 2. Cost of travel for individual and for a group 3. Inconvenient schedule 4. Frequency of services 5. Unreliability of services/delays 6. Inflexibility/no control over travel 7. Central location of stations 8. Not deal with traffic/do not have to park 9. Productive travel time 10. Safety 11. Comfort-convenient sitting space 12. If you are travelling long distance (not many luggage allowed) 13. Pleasant trip (Wi-Fi, food, and all additional amenities)	*In this model, so far, we do not see that the perceived ease of use affects the perceived usefulness of the system. This might be that the perceived usefulness in our case has stronger effects in the decision to choose the train.* *It seems that there might be some relations with the control factors, the normative referents, the attitude towards all modes, as well as the habitual behavior (inferred from nay of the questions). In theory, it is difficult to single out a mode in the minds of a decision maker: he/she most of the time will think in terms of trade-offs.*

Document 2 Summary of Pilot Survey Results (Continued)

Elements that affect the “Ease of Use” based on the responses	
1. a. Ticketing system (online purchase, choice of cell-phone display) b. need an online reservation 2. Accessibility of the station (both for the station—e.g., no elevators, and for the last mile) 3. Availability of parking close to the station 4. Not spending the effort to drive and find parking 5. Not having to arrive early and go through security 6. Carrying luggage 7. The information system in the station 8. Familiarity with the system might play a role 9. Train environment (clean restrooms, room temperature, slippery floors)	*The word ease is unclear. If the statement is “overall it is easy to use the Hoosiers (Amtrak)”, or “*it is easy for me to take the train…” *people will respond like they were asked if it is useful (will talk/think about frequency, cost, schedule, etc.). I found that people respond more accurately to the information when the word “effort” is involved in the question.*
Elements that affect the “Attitude to the Hoosier State train”	
1. Environmental potential: environmental friendly 2. Mitigation of traffic: remedy for traffic congestion 3. Productive time 4. Slow pace: antsy/bored; boring 5. Comfort/relaxed; pleasant/restful 6. Necessity/no acceptable alternatives	*The general question “do you think it is a good or bad idea” captured a lot of what people explained later.* *It seems that the attitude is correlated with the perceived usefulness, but not so much with the intention to use. Looking at the responses, it is possible that the attitude is strongly correlated with the normative references (but the direction is not clear: i.e., does our environment affect us or we choose connections similar to ourselves?).*
Normative referents	
1. People who care about the environment 2. People who grew up in a heavily automobile dependent environment/people who grew up in areas with a popular passenger rail system 3. People who like/dislike driving 4. People who do not own an automobile 5. Railroad fanatics 6. People who value reliability/control/time 7. People with time commitments 8. People who care about money (low income or otherwise) 9. People who are concerned with the economic viability of Hoosier State (deficit); people who are against this service 10. People who enjoy travelling with the train	*From the responses we see that people find a strong relationship between habit and familiarity with the decision to use the system as well as with the behavior towards the system.*

Document 2 Summary of Pilot Survey Results (Continued)

Commuting with the Hoosier State train	
1. Productive time 2. Stress free ride 3. Schedule and frequency 4. Distance 5. Delays (time commitment) 6. Cost (frequent user discounts/cards)	
Control factors	
1. Flexibility of travel (reach desired destinations) 2. Over cost 3. Over Schedule and frequency 4. Over Delays 5. Over More Productive time within trains	*Control is not to be confused with the usefulness or ease of use. So questions suggested by the literature like "for me to take the Hoosiers state train next time would be easy-difficult" will only confuse the respondent and the info will overlap with previous questions.*
Evaluating factors	
1. Cost 2. Travel time 3. Comfort 4. Safety 5. Pleasant trip/Amenities (Wi-Fi, food, comfortable waiting space in stations) 6. Schedule (departure and arrival times) 7. Mode accessibility 8. Flexibility 9. Need to drive or not 10. Reliability (delays)	

Appendix C Structural Equation Modeling

C.1 Data Preparation

Table C.1 Kurtosis and Skewness, Survey Data

	Kurtosis	Skewness
MEDIAN(Ease1)	2.235	
MEDIAN(Ease6)	2.847	
Ease7	2.018	
MEDIAN(Hatt4_1)	2.463	
MEDIAN(Hatt5_1)	2.992	
MEDIAN(Hab2)	11.213	
MEDIAN(Hab3)	9.738	
MEDIAN(Hab4)	12.720	
MEDIAN(Hab6)	43.961	
MEDIAN(Sex)	-2.006	
MEDIAN(Child)	2.830	
MEAN(HST)	167.668	11.379

Code	**Question**
Ease1	My interaction with the ticketing system of the Hoosier State train (Amtrak) is easy and understandable.
Ease6	It is easy for me to travel with the essentials for my trip purposes (carry-on luggage, etc.).
Ease7	Traveling with the Hoosier State train is easy for me.
Hatt4_1	I *(Dislike : Like)* traveling on the Hoosier State train.
Hatt5_1	Traveling on the Hoosier State train is: *(Inconvenient : Convenient)*.
Hab2	Indicator for auto-dependence for: *going for a drink in the evening/visiting a bar*.
Hab3	Indicator for auto-dependence for: *going for taking a trip on a weekend with nice weather*.
Hab4	Indicator for auto-dependence for: *going for visiting a friend living in the same town.*
Hab6	Indicator for auto-dependence for: *going out for lunch.*
Sex	Are you a (male/female)?
Child	Please indicate the number of children in your household under the age of 18.
HST	How many times approximately did you travel using the Hoosier State train last year (2014)?

C.2 Technology Adoption Model (Model 1)

Table C.2 Model 1, Exploratory Factor Analysis, Pattern Matrix

	Factor						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Ease7	0.846						
Ease6	0.754						
Ease1	0.722						
Ease5	0.670						
Ease2	0.642						
Fun3		1.004					
Fun2		0.792					
Fun1		0.729					
Int2			1.005				
Int1			0.913				
Int3			0.345				
BC_Recode				0.816			
BC7				0.788			
Usef1				0.478			
Usef6				0.463			
Usef2				0.389			
Hab1_tr					0.953		
Hab_nonmot					0.822		
Hab_auto					0.610		
SN1						0.999	
SN2						0.789	
HAtt1							1.037
Hatt2							0.677

Table C.3 Model 1, Exploratory Factor Analysis, Suitability

Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy		0.806
Bartlett's Test of Sphericity	Approx. Chi-Square	4590.795
	Degrees of Freedom	253
	Significance	0.000

Table C.4 Model 1, Exploratory Factor Analysis, Total Variance Explained

Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6.239	27.126	27.126	2.536	11.024	11.024
2	2.408	10.471	37.596	4.174	18.149	29.173
3	2.092	9.096	46.692	1.955	8.499	37.672
4	1.977	8.595	55.288	1.579	6.864	44.536
5	1.449	6.299	61.587	1.280	5.567	50.102
6	1.261	5.481	67.068	2.067	8.985	59.087
7	1.028	4.472	71.540	0.741	3.220	62.307

Table C.5 Model 1, Exploratory Factor Analysis, Discriminant Validity

Factor Correlation Matrix							
Factor	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1	1.000	0.343	0.135	0.599	0.066	0.281	0.337
2	0.343	1.000	0.102	0.549	0.023	0.282	0.440
3	0.135	0.102	1.000	0.299	0.122	0.196	0.127
4	0.599	0.549	0.299	1.000	0.077	0.483	0.484
5	0.066	0.023	0.122	0.077	1.000	0.162	0.033
6	0.281	0.282	0.196	0.483	0.162	1.000	0.310
7	0.337	0.440	0.127	0.484	0.033	0.310	1.000

Table C.6 Model 1, Exploratory Factor Analysis, Reliability

Factor	Cronbach's Alpha	N of Items
1	0.834	5
2	0.857	3
3	0.948	2
4	0.696	5
5	0.804	3
6	0.910	2
7	0.819	2

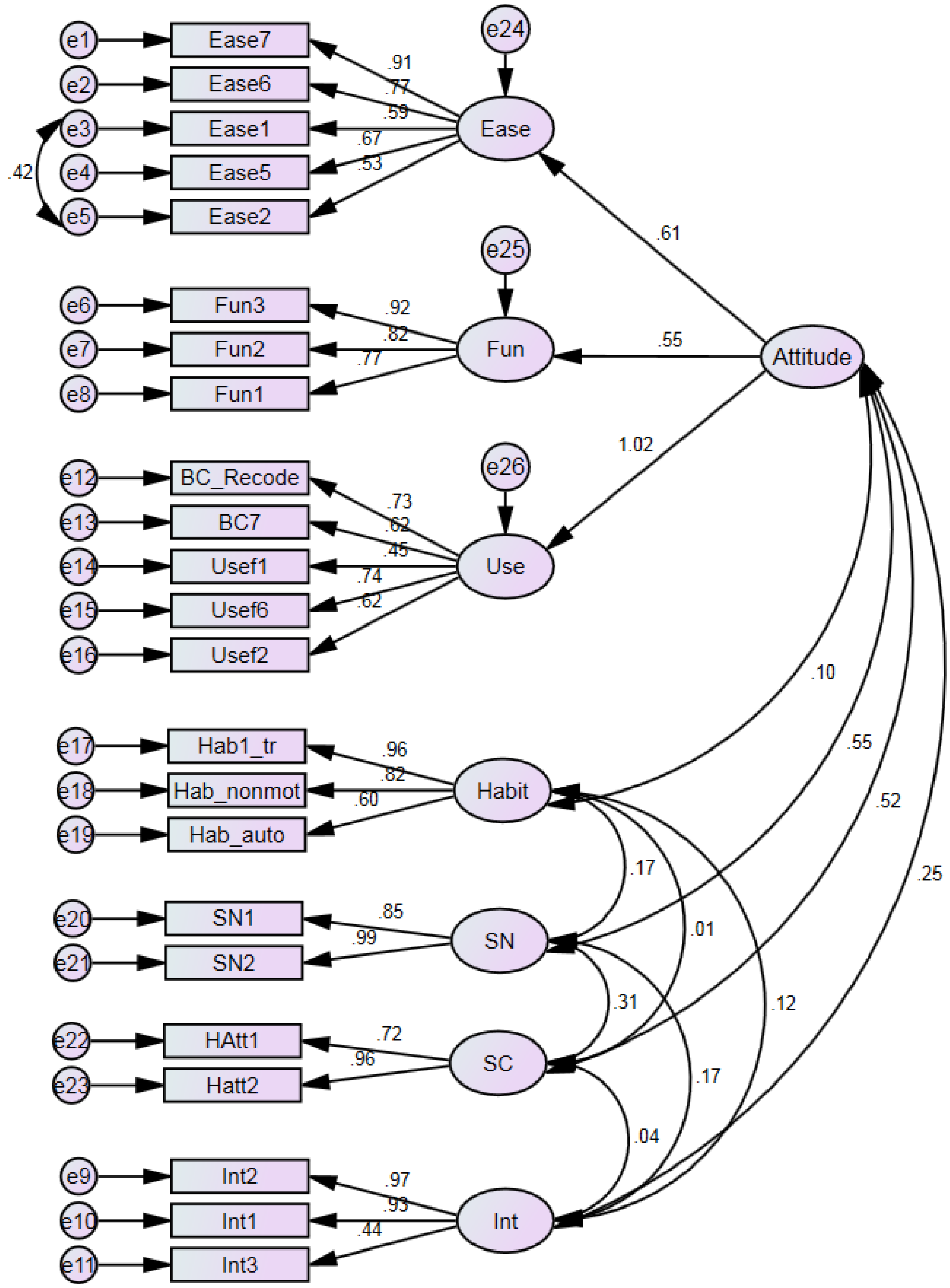

Figure C.1 Model 1, Confirmatory Factor Analysis

Table C.7 Model 1, CFA, Model Goodness of Fit

CMIN

Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	60	384.335	216	.000	1.779
Saturated model	276	.000	0		
Independence model	23	4693.619	253	.000	18.552

RMR, GFI

Model	RMR	GFI	AGFI	PGFI
Default model	.068	.922	.900	.721
Saturated model	.000	1.000		
Independence model	.433	.376	.319	.345

Baseline Comparisons

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Default model	.918	.904	.962	.956	.962
Saturated model	1.000		1.000		1.000
Independence model	.000	.000	.000	.000	.000

Parsimony-Adjusted Measures

Model	PRATIO	PNFI	PCFI
Default model	.854	.784	.821
Saturated model	.000	.000	.000
Independence model	1.000	.000	.000

NCP

Model	NCP	LO 90	HI 90
Default model	168.335	117.534	226.985
Saturated model	.000	.000	.000
Independence model	4440.619	4221.837	4666.661

FMIN

Model	FMIN	F0	LO 90	HI 90
Default model	.991	.434	.303	.585
Saturated model	.000	.000	.000	.000
Independence model	12.097	11.445	10.881	12.027

RMSEA

Model	RMSEA	LO 90	HI 90	PCLOSE
Default model	.045	.037	.052	.878
Independence model	.213	.207	.218	.000

Table C.7 Model 1, CFA, Model Goodness of Fit (Continued)

AIC

Model	AIC	BCC	BIC	CAIC
Default model	504.335	512.247	742.150	802.150
Saturated model	552.000	588.396	1645.948	1921.948
Independence model	4739.619	4742.652	4830.781	4853.781

ECVI

Model	ECVI	LO 90	HI 90	MECVI
Default model	1.300	1.169	1.451	1.320
Saturated model	1.423	1.423	1.423	1.516
Independence model	12.216	11.652	12.798	12.223

HOELTER

Model	HOELTER .05	HOELTER .01
Default model	254	270
Independence model	25	26

Table C.8 Model 1, SEM, Model Goodness of Fit

CMIN

Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	58	384.541	218	.000	1.764
Saturated model	276	.000	0		
Independence model	23	4693.619	253	.000	18.552

RMR, GFI

Model	RMR	GFI	AGFI	PGFI
Default model	.068	.922	.901	.728
Saturated model	.000	1.000		
Independence model	.433	.376	.319	.345

Baseline Comparisons

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Default model	.918	.905	.963	.956	.962
Saturated model	1.000		1.000		1.000
Independence model	.000	.000	.000	.000	.000

Table C.8 Model 1, SEM, Model Goodness of Fit (Continued)

Parsimony-Adjusted Measures

Model	PRATIO	PNFI	PCFI
Default model	.862	.791	.829
Saturated model	.000	.000	.000
Independence model	1.000	.000	.000

NCP

Model	NCP	LO 90	HI 90
Default model	166.541	115.822	225.116
Saturated model	.000	.000	.000
Independence model	4440.619	4221.837	4666.661

FMIN

Model	FMIN	F0	LO 90	HI 90
Default model	.991	.429	.299	.580
Saturated model	.000	.000	.000	.000
Independence model	12.097	11.445	10.881	12.027

RMSEA

Model	RMSEA	LO 90	HI 90	PCLOSE
Default model	.044	.037	.052	.898
Independence model	.213	.207	.218	.000

AIC

Model	AIC	BCC	BIC	CAIC
Default model	500.541	508.190	730.429	788.429
Saturated model	552.000	588.396	1645.948	1921.948
Independence model	4739.619	4742.652	4830.781	4853.781

ECVI

Model	ECVI	LO 90	HI 90	MECVI
Default model	1.290	1.159	1.441	1.310
Saturated model	1.423	1.423	1.423	1.516
Independence model	12.216	11.652	12.798	12.223

HOELTER

Model	HOELTER .05	HOELTER .01
Default model	256	272
Independence model	25	26

C.3 Model Based on the Theory of Planned Behavior (Model 2)

Table C.9 Model 2, Exploratory Factor Analysis, Pattern Matrix

	Factor				
	1	**2**	**3**	**4**	**5**
Int2	0.983				
Int1	0.937				
Int3	0.356				
Hab1_tr		0.952			
Hab_nonmot		0.822			
Hab_auto		0.611			
SN2			0.956		
SN1			0.914		
SN3			0.343		
Hatt3				0.852	
Hatt4				0.787	
Hatt5				0.610	
BC7					0.854
BC_Recode					0.571

Table C.10 Model 2, Exploratory Factor Analysis, Suitability

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.741
Bartlett's Test of Sphericity	Approx. Chi-Square	2617.029
	Degrees of Freedom	91
	Significance	0.000

Table C.11 Model 2, Exploratory Factor Analysis, Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Factor	**Total**	**% of Variance**	**Cumulative %**	**Total**	**% of Variance**	**Cumulative %**
1	4.095	29.250	29.250	2.836	20.254	20.254
2	2.272	16.230	45.480	2.083	14.881	35.135
3	1.863	13.304	58.784	2.103	15.022	50.157
4	1.283	9.167	67.950	1.346	9.615	59.771
5	0.888	6.342	74.292	0.494	3.529	63.301

Table C.12 Model 2, Exploratory Factor Analysis, Discriminant Validity

Factor Correlation Matrix					
Factor	**1**	**2**	**3**	**4**	**5**
1	1.000	0.118	0.193	0.190	0.276
2	0.118	1.000	0.154	0.013	0.099
3	0.193	0.154	1.000	0.473	0.484
4	0.190	0.013	0.473	1.000	0.626
5	0.276	0.099	0.484	0.626	1.000

Table C.13 Model 2, Exploratory Factor Analysis, Reliability

Factor	**Cronbach's Alpha**	**N of Items**
1	0.811	3
2	0.804	3
3	0.784	3
4	0.769	3
5	0.696	2

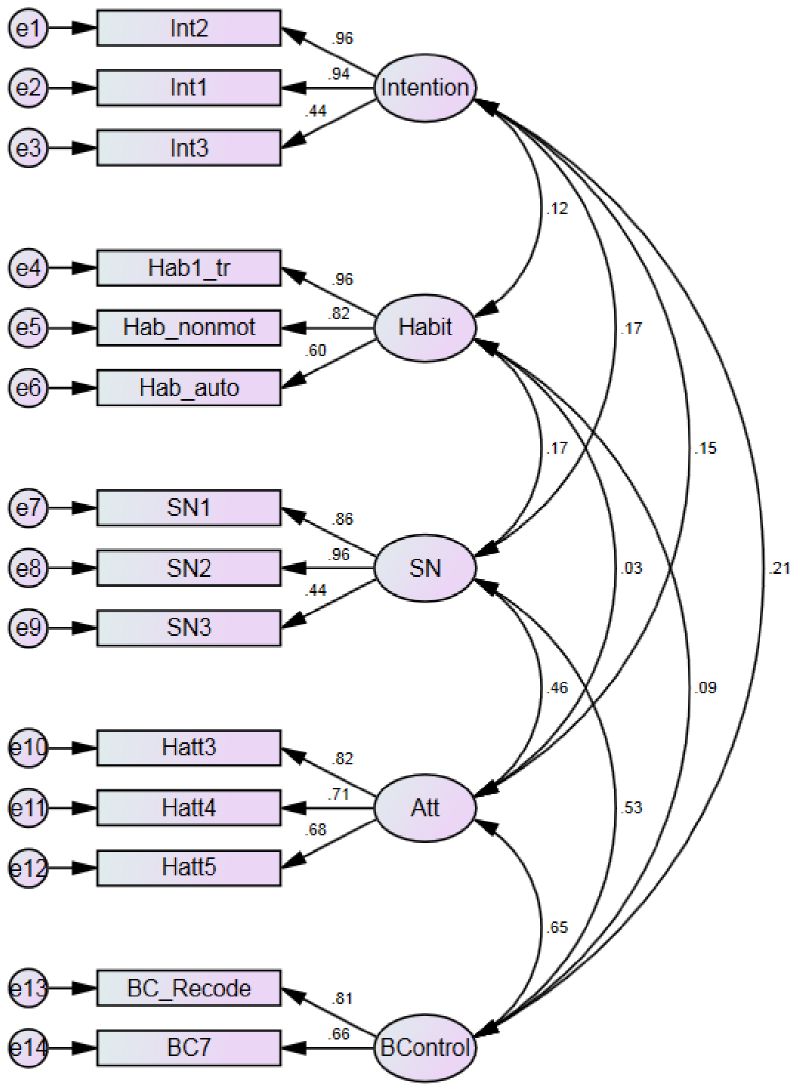

Figure C.2 Model 2, Confirmatory Factor Analysis

Table C.14 Model 2, CFA, Model Goodness of Fit

CMIN

Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	38	149.375	67	.000	2.229
Saturated model	105	.000	0		
Independence model	14	2654.660	91	.000	29.172

RMR, GFI

Model	RMR	GFI	AGFI	PGFI
Default model	.074	.951	.923	.607
Saturated model	.000	1.000		
Independence model	.643	.472	.391	.409

Baseline Comparisons

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Default model	.944	.924	.968	.956	.968
Saturated model	1.000		1.000		1.000
Independence model	.000	.000	.000	.000	.000

Parsimony-Adjusted Measures

Model	PRATIO	PNFI	PCFI
Default model	.736	.695	.713
Saturated model	.000	.000	.000
Independence model	1.000	.000	.000

NCP

Model	NCP	LO 90	HI 90
Default model	82.375	50.765	121.718
Saturated model	.000	.000	.000
Independence model	2563.660	2399.228	2735.423

FMIN

Model	FMIN	F0	LO 90	HI 90
Default model	.385	.212	.131	.314
Saturated model	.000	.000	.000	.000
Independence model	6.842	6.607	6.184	7.050

RMSEA

Model	RMSEA	LO 90	HI 90	PCLOSE
Default model	.056	.044	.068	.187
Independence model	.269	.261	.278	.000

Table C.14 Model 2, CFA, Model Goodness of Fit (Continued)

AIC

Model	AIC	BCC	BIC	CAIC
Default model	225.375	228.431	375.991	413.991
Saturated model	210.000	218.445	626.176	731.176
Independence model	2682.660	2683.786	2738.150	2752.150

ECVI

Model	ECVI	LO 90	HI 90	MECVI
Default model	.581	.499	.682	.589
Saturated model	.541	.541	.541	.563
Independence model	6.914	6.490	7.357	6.917

HOELTER

Model	HOELTER .05	HOELTER .01
Default model	227	252
Independence model	17	19

Table C.15 Model 2, SEM, Model Goodness of Fit

CMIN

Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	45	302.793	126	.000	2.403
Saturated model	171	.000	0		
Independence model	18	2867.440	153	.000	18.741

RMR, GFI

Model	RMR	GFI	AGFI	PGFI
Default model	.215	.922	.894	.679
Saturated model	.000	1.000		
Independence model	.613	.511	.454	.457

Baseline Comparisons

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Default model	.894	.872	.936	.921	.935
Saturated model	1.000		1.000		1.000
Independence model	.000	.000	.000	.000	.000

Table C. 15 Model 2, SEM, Model Goodness of Fit (Continued)

Parsimony-Adjusted Measures

Model	PRATIO	PNFI	PCFI
Default model	.824	.737	.770
Saturated model	.000	.000	.000
Independence model	1.000	.000	.000

NCP

Model	NCP	LO 90	HI 90
Default model	176.793	129.657	231.634
Saturated model	.000	.000	.000
Independence model	2714.440	2544.252	2891.963

FMIN

Model	FMIN	F0	LO 90	HI 90
Default model	.780	.456	.334	.597
Saturated model	.000	.000	.000	.000
Independence model	7.390	6.996	6.557	7.454

RMSEA

Model	RMSEA	LO 90	HI 90	PCLOSE
Default model	.060	.051	.069	.027
Independence model	.214	.207	.221	.000

AIC

Model	AIC	BCC	BIC	CAIC
Default model	392.793	397.427	571.154	616.154
Saturated model	342.000	359.610	1019.772	1190.772
Independence model	2903.440	2905.294	2974.784	2992.784

ECVI

Model	ECVI	LO 90	HI 90	MECVI
Default model	1.012	.891	1.154	1.024
Saturated model	.881	.881	.881	.927
Independence model	7.483	7.044	7.941	7.488

HOELTER

Model	HOELTER .05	HOELTER .01
Default model	197	213
Independence model	25	27

VITA

VITA

V. Dimitra Pyrialakou received her Diploma in Civil Engineering from the National Technical University of Athens, Greece, in 2011. In 2012 she started her Ph.D. studies in the Department of Civil, Construction and Environmental Engineering at Iowa State University (ISU). In August 2013, she was accepted to Purdue University (Purdue) to continue her Ph.D. studies in the area of transportation and infrastructure systems engineering in the Lyles School of Civil Engineering.

Throughout her years of study as an undergraduate and graduate research assistant, Dimitra has worked on several projects involving public transportation and airport operations and transportation planning and evaluation. Her current research interests involve the use of statistical, econometric, and economic analysis tools in the areas of transportation planning and development, travel behavior, sustainability and transportation energy, and transportation equity.

Dimitra has also served as a teaching assistant at both ISU and Purdue for undergraduate- and graduate-level courses. During her last year of studies at Purdue she also served as the instructor for CE 36100, Transportation Engineering, an introductory undergraduate-level course covering the principles of transportation engineering and touching on a variety of subjects, from transportation planning and highway engineering to operations and traffic analysis.

Dimitra has received several prestigious scholarships and honors from the university and various professional organizations, for example, the 2013 Dwight David Eisenhower Graduate Fellowship. She is also a co-author on several peer-reviewed journal publications and conference papers. Dimitra is an active member of many professional organizations and committees, including the national Transportation Research Board (TRB) Standing Committee on Commuter Rail Transportation (AP070). She has also held several leadership positions throughout her years of study, for example, secretary (2014-2015) and community service coordinator (2015-2016) for the Institute of Transportation Engineers Purdue Student Chapter.

Upon receiving her Ph.D. from Purdue University in August 2016, Dimitra joined the Department of Civil and Environmental Engineering at West Virginia University as an Assistant Professor in the area of sustainable planning and evaluation of mass and rail transportation.

PUBLICATIONS

PUBLICATIONS

PEER-REVIEWED JOURNAL PUBLICATIONS

Pyrialakou, V. D., Gkritza, K., Fricker, J., Accessibility, Mobility, and Realized Travel Behavior: Assessing Rural Disadvantage from a Policy Perspective. *Journal of Transport Geography*, Vol. 51, 2016, pp.252-269.

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Pyrialakou, V. D., Gkritza, K., Exploring the Opinions of Passenger Rail Riders: Evidence from the Hoosier State train. In *Proceedings of the 2016 Joint Rail Conference*. 2016 Joint Rail Conference, April 12-15, 2016, Columbia, SC.

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