ALTERNATIVES TO SMARTPHONE APPLICATIONS FOR REAL-TIME INFORMATION AND TECHNOLOGY USAGE AMONG TRANSIT RIDERS

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ALTERNATIVES TO SMARTPHONE APPLICATIONS
FOR REAL-TIME INFORMATION AND TECHNOLOGY
USAGE AMONG TRANSIT RIDERS

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Real-time information that informs transit riders about transit schedules, next bus or train arrivals, and service alerts, is becoming increasingly available, particularly through internet-enabled smartphone applications. However, the extent of communication technology usage amongst transit riders, specifically their access to mobile applications and alternative technologies that can provide real-time information, is largely unknown. Without this information, transit agencies are risking investing in an alternative technology that may not sufficiently supply real-time information to as many as possible riders.

The purpose of this study is to identify the differences in individual technology accessibility and prioritize investing in real-time information application development that mirrors the unique characteristics of transit riders. This recognition and development will allow a wider availability of real-time information amongst transit riders. Paired with an investigation of cellular phone usage among transit riders and the general American population, an analysis of Saint Louis Metro’s Onboard Survey was performed. Cross tabulations and chi-squared tests were conducted to examine riders’ communication technology usage. Binary logit models were used to understand how, and whether, the ownership of smartphone applications is dependent on various demographic factors. These analyses identified specific demographic groups that would benefit from supplemental technology methods more conducive to their particular information accessibility. Results showed that communication technology usage has risen substantially in recent years but a portion of riders are still without access to smartphone applications. Specific demographic groups (e.g., riders over 40 years of age) were less likely to own smartphones, and these results indicate that
computer-based websites and IVR are the best supplementary alternatives for those groups.
CHAPTER I

INTRODUCTION

The emergence of mobile communication devices within the past decade not only provided connections between people but enhanced the distribution and collection of information. With the introduction of smartphones, even more innovative means to collect, store, and disseminate data are possible. Information such as news and weather reports can be instantly accessed with interfaces designed to be fast, reliable, and user-friendly. However, the relatively high cost of smartphones and accompanying data plans may serve as an ownership obstacle for some individuals.

Currently, many transit agencies are utilizing this mobile technology by providing smartphone applications and opening up their real-time information (RTI) data to allow developers to incorporate maps, schedules, and RTI information into applications. Since this technology is not available to all riders, supplementary measures such as text-messaging (SMS) or interactive voice response (IVR) can be developed to capture a larger portion of transit riders. However, limited information exists about current mobile device users, so it is unknown if these supplementary measures are capturing riders without access to smartphone applications.

This study investigates the accessibility of mobile devices and other supplementary RTI technologies to transit riders, including smartphone applications, SMS, IVR, mobile-optimized websites, and computer-based websites. Additionally, this thesis provides information regarding cell phone ownership in the United States and how this ownership compares to transit riders. Finally, an in-depth analysis of Bi-State Development Agency’s (d.b.a. Saint Louis Metro) riders’ usage of mobile devices and related technologies is discussed. Specific Metro demographic groups less likely to
own a smartphone and the best alternative RTI technologies for these riders are also identified. This in-depth analysis provides insight into what supplementary technologies to smartphone applications transit agencies should invest in so more riders have access to RTI.
CHAPTER II

BACKGROUND

2.1 Benefits of RTI

Several studies have demonstrated how RTI technology improves riders’ perceptions of a system and enhances their transit experience [1]. The presence of RTI on a system has resulted in a higher overall satisfaction with the service, due to the various positive effects resulting from RTI. For example, knowing when the next bus will arrive at a specific stop allows customers to spend less time waiting for a bus, resulting in a better utilization of their time and more efficient travel [1]. In addition, RTI increases a rider’s perception of safety and sense of security, especially for female riders. A customers’ perceived wait time is also lowered when RTI is available and this information reduces riders’ anxiety, uncertainty, and stress when riding transit [2]. The combination of these effects has also been found to increase ridership. A Chicago case study concluded, when taking various control variables into account, bus routes with CTA’s Bus Tracker had a slight increase in ridership when compared to routes without this technology [3].

While the effects of RTI have been overwhelmingly positive, there has been a lack of research regarding the availability of this technology to users, whether from mobile devices or computers. This has resulted in assumptions concerning what demographic groups do not have access to these devices and the availability of RTI as a whole. By better understanding the demographic groups more likely to not have access to RTI and what technologies they can access, a more informed decision regarding the best supplementary technology to smartphone applications can be formed.

Smartphone applications have been established as the primary tool of RTI for a
variety of reasons. First, smartphone ownership is on the rise. As of March 2013, approximately 56% of Americans own a smartphone, an increase of 81% since 2010 [4]. If this trend continues, a vast majority of Americans will own smartphones and have access to applications in the coming years. This reasoning is in conjunction with the growing availability of open data from transit agencies, sometimes provided for free [5, 6, 7]. As transit data becomes more precise and widely available, software developers will be able to create more RTI applications from this information. However, until smartphones become ubiquitous among transit riders, agencies need to understand how supplementary tools can be used to increase access to information.

2.2 Alternatives to Smartphone Applications

While smartphone applications are the new and upcoming means to provide RTI, there are alternatives to retrieve this information, including:

- Interactive Voice Response (IVR)
- Mobile-Optimized Websites
- Computer-Based Websites
- Text Messaging (SMS)
- LCD Signage

Interactive Voice Response (IVR) is software allowing telephone users to call a specified number and respond to a series of questions to obtain information. For transit RTI, the information required varies by agency. Some require a specific stop ID, while others start by asking broad questions such as desired transportation mode or the area of the city, then narrow the search using more specific information, including direction traveling and desired stop. Depending on the service, users can
input information on the phone’s number pad and/or verbally relay information for a computer to recognize.

Mobile-Optimized Websites are very similar to mobile applications. From a menu, users can specify their desired route, direction, and stop on their mobile device. While these websites do not require a smartphone, they do require the device to access the internet. The following figures (Figure 1, 2, and 3) are a series of screenshots describing what a user would see and interact with to obtain this information.

Figure 1: Screenshot of the OneBusAway Mobile Website Route Selection
Figure 2: Screenshot of the OneBusAway Mobile Website Stop Selection

Figure 3: Screenshot of the OneBusAway Mobile Website with RTI
Computer-Based Websites can be accessed through any computer with an internet connection. Similar to mobile-optimized website and mobile applications, users navigate to their desired stop or can type in a stop ID or route number. Figure 4 and 5 displays the overall map with stop locations and RTI obtained through a user selection.

Figure 4: Screenshot of the OneBusAway Computer Website with Stop Locations

Figure 5: Screenshot of the OneBusAway Computer Website with RTI
Text Messaging, or short message service (SMS), allows users with a cell phone with text messaging capabilities to receive a text message with RTI. Riders simply send a text to a unique number with a specified stop ID in the message. In less than a few minutes, the service responds back with another text message with RTI information. For example, in Figure 6, the user texted the stop ID ’570’ to the number ’41411.’ Less than a minute later, a text message was received containing RTI for all the routes served by the stop.

![Screenshot of the OneBusAway SMS Message](image)

Figure 6: Screenshot of the OneBusAway SMS Message

LCD Signage is a built-in display at stops or stations presenting when the next train is arriving, as shown by Figure 7 [8]. These are often found in large metropolitan areas such as Washington, D.C. and Chicago. While these are available to all users, regardless of cell phone ownership, they are a fixed, physical infrastructure with monetary cost to the agency. Due to the cost, it would be impossible for an agency to provide LCD Signage at all of their thousands of stops. However, for users without phones or computer access, this is the only way to obtain RTI.
Due to the variability of accessing these alternatives, including how and what information is obtained through each media, all of these technologies are not equal. The pros and cons of each alternative are fairly unique and set the precedence of what alternative is available to transit riders. For example, an individual without a smartphone cannot access mobile applications and riders without cell phones can only access LCD signage or possibly computer-based websites. In Table 1, an outline of the various pros and cons associated with each alternative technology is provided.
The type of mobile device can also hinder or help obtain access to RTI. Specifically, the type and user-friendliness of the information acquired from mobile devices will differ depending on the device’s screen size, internet browser used, the ability to use GPS for location aware, and the phone’s memory and processing speed [9]. Similarity, these differences can even occur among varying smartphone devices. The application setup for iPhones is not always the same as Androids and, if a particular phone model is new or not widely used, applications may not even be available to a user. Even further, a user’s familiarity with his/her mobile device is not consistent among all riders. Even if an individual has SMS capabilities, there is no guarantee that he/she will know how to send a text message.

<table>
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<tr>
<th>Alternative Technology</th>
<th>Pros</th>
<th>Cons</th>
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<tr>
<td>Mobile Applications</td>
<td>Easy access to multiple routes, stops, and other transit information</td>
<td>Requires smartphone with internet access</td>
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<tr>
<td></td>
<td>Many are location aware, and thus faster to access information</td>
<td>Cost of smartphone and mobile data</td>
</tr>
<tr>
<td>Interactive Voice Response</td>
<td>Only requires a cell phone, including land-lines (no additional technology is needed)</td>
<td>The user-friendliness of service varies</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Length of time to obtain real-time information varies</td>
</tr>
<tr>
<td>Mobile-Optimized Website</td>
<td>Smartphone is not required</td>
<td>Requires internet access on cell phone</td>
</tr>
<tr>
<td></td>
<td>Provides information comparable to mobile applications</td>
<td>Speed of obtaining the information varies from device’s operating speed and strength of internet connection.</td>
</tr>
<tr>
<td>Text Messaging</td>
<td>Smartphone is not required</td>
<td>Requires Stop-ID</td>
</tr>
<tr>
<td></td>
<td>Responding text message is received in less than a few minutes</td>
<td>Cell phone must have text message capabilities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A text must be received to obtain information (not updated automatically)</td>
</tr>
<tr>
<td>Computer-Based Website</td>
<td>No mobile device is required</td>
<td>Portability of computer – information cannot be accessed while at the stop</td>
</tr>
<tr>
<td></td>
<td>Provides the same, if not more, information than mobile applications</td>
<td></td>
</tr>
<tr>
<td>LCD Signage</td>
<td>Conveniently located</td>
<td>Capital cost to transit agency</td>
</tr>
<tr>
<td></td>
<td>Available to anyone</td>
<td>Only relays information for one stop/station</td>
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<td></td>
<td></td>
<td>Not portable</td>
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CHAPTER III

METHODOLOGY

In the summer of 2012 and 2013, Saint Louis Metro conducted a system-wide, on-board rider survey designed to measure satisfaction with specific service factors, travel behavior, loyalty and turnover intentions, trip-planning and information gathering preferences, and general demographics. Data specific to the technology usage and demographics of the riding population were the primary concern of this study and were extracted from the survey.

Employing a stratified random sampling strategy, proportional strata were developed based on the average daily passenger boardings by route. Additionally, the bus sampling strategy incorporated secondary attention to the day type, as well as the relative boardings occurring in Missouri and Illinois. Sampling schedules covered most of a route’s hours/days of operation, while ensuring the peak service periods were adequately sampled when ridership proportions were highest. Surveys were distributed by surveyors riding buses and trains along these routes. The total valid and usable surveys returned in 2012 were 1,611 (bus) and 1,921 (rail) for response rates of 61% and 66%, respectively. For the survey conducted in 2013, the total number of valid and usable surveys was 3,063 for bus and 2,865 for rail, resulting in a response rate of 90% and 88%, respectively.

A copy of this survey can be found in Appendix A. Specifically, the responses from questions number four, five, and 12 through 17 were used for the analysis of this thesis. The attached survey was distributed to bus riders in 2012. The questionnaire was similarly distributed among rail riders in 2012 and riders for both modes in 2013. The differences between the surveys were minor such as changing ‘2012’ to ‘2013’,
and ‘bus’ to ‘rail.’ The wording of the questions and responses were identical.

The data obtained from these surveys were organized and explained through a variety of different statistical analyses. General descriptive statistics reported the overall ownership of cell phones and different alternative technologies. To understand the characteristics of riders without access to smartphone applications, cross tabulations between smartphone ownership and rider demographics were created. Chi-square tests of independence were conducted to test whether smartphone ownership is statistically different between these different demographic attributes. Finally, binary logistic regression models for both survey years and modes provided another source of understanding how riders’ demographic characteristics affect smartphone application availability.

Peer research was also conducted to help conclude whether Metro’s technology ownership trends were common among other transit riders. The largest agencies in terms of unlinked passenger trips were selected to be part of this analysis [10]. Survey results describing an agency’s riders in regards to cell phone and smartphone technology ownership and/or usage were collected online [11] or via phone or email [Boberg, J., O’Malley, T., Pepper, J., and Shank, V., unpublished data]. A total of five agencies had surveys with this information. Furthermore, of these five agencies, three provided cross tabulations between the asked technology questions and rider’s demographics. This information was used for a comparison against data from Metro.

The following information provided in Table 2 describes which transit agencies were contacted and what information was provided.
Technology trends among Americans as a whole were also analyzed to establish a baseline of technology use to compare to transit riders [4, 12, 13]. This was collected through Pew Research Center’s Internet and American Life Project. Pew Research Center has collected information regarding the percentage of Americans with cell phones since 2004, describing the growing adoption of this new technology [12]. With the emergence of smartphones in recent years, these reports have expanded to include statistics regarding smartphone ownership among Americans [4]. And, in conjunction, additional reports regarding the availability of cell phone-related technologies, such

<table>
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<th>Full Name</th>
<th>Mobile Device Statistics</th>
<th>Demographic Cross Tabulations</th>
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<tr>
<td>BART</td>
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<td>✓</td>
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<td>Chicago Transit Authority</td>
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<td>King County Metro</td>
<td>King County DOT</td>
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<td></td>
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<td>Los Angeles County Metropolitan Transportation</td>
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<td>✓</td>
</tr>
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<td>MARTA</td>
<td>Metropolitan Atlanta Rapid Transit Authority</td>
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<td>Massachusetts Bay Transportation Authority</td>
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<td>Miami-Dade Transit</td>
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<td>MUNI</td>
<td>San Francisco Municipal Railway</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NJ TRANSIT</td>
<td>New Jersey Transit Corporation</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>NYCT</td>
<td>MTA New York City Transit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SEPTA</td>
<td>Southeastern Pennsylvania Transportation Authority</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TriMet</td>
<td>Tri-County Metropolitan Transportation District of</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>WMATA</td>
<td>Washington Metropolitan Area Transit Authority</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
as internet access and SMS, have also been written [13]. This information created the baseline of the mobile technology ownership trend among Americans, which was then compared to transit riders.
CHAPTER IV

NATIONAL AND AMERICAN TRANSIT AGENCY TRENDS

Recently, various transit agencies have collected information regarding their riders’ usage of smartphone and cell phone devices. Survey questions asking whether a rider has a mobile device or uses SMS provide insight into the adoption of the various alternative technologies, allowing conclusions to be drawn with respect to how accessible various RTI technologies are to transit riders. This information, in conjunction with general mobile and computer technology ownership among all Americans, is investigated in this chapter.

Please note, the years these surveys were conducted differ from agency to agency, as outlined by Table 3. These differing survey years only allows for a general comparison due to the continuous changing availability of these technologies.

Table 3: Year Survey was Conducted

<table>
<thead>
<tr>
<th>Agency</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>King County Metro</td>
<td>2009</td>
</tr>
<tr>
<td>TriMet</td>
<td>2009</td>
</tr>
<tr>
<td>NJ Transit</td>
<td>2011</td>
</tr>
<tr>
<td>CTA</td>
<td>2012</td>
</tr>
<tr>
<td>LAC MTA</td>
<td>2012</td>
</tr>
<tr>
<td>Saint Louis Metro</td>
<td>2013</td>
</tr>
<tr>
<td>United States</td>
<td>Varies</td>
</tr>
</tbody>
</table>
4.1 Cell Phone Ownership

Cell phones have become commonplace with 91% of Americans owning a mobile device as of May, 2013. This ownership has been steadily increasing since 2004 when 65% of Americans owned a cell phone [12]. Figure 8 describes this growing adoption.

The increase in cell phone ownership has also been seen among different transit agencies. It is important to note that these surveys were conducted in different years and questions may have varied slightly; therefore, the results cannot always be directly comparable. However, most transit agencies had similar, if not a greater, percentage of riders with cell phones when compared to the national trend.

![Figure 8: Cell Phone Ownership among Americans and Transit Riders](image)

4.2 Smartphone Ownership

As cell phones have evolved, smartphones have become the most prevalent mobile device type, as shown in Figure 9. These mobile devices are able to download mobile applications and usually include a ‘touchscreen’ interface. Some more popular models include Apple iPhone and Samsung Galaxy. Similar to cell phone ownership, there
has been a steady increase of smartphone ownership within recent years. Specifically, in 2010, 31% of Americans owned a smartphone and just three years later, 56% of Americans own a smartphone. As more Americans own cell phones, the chances of the device being a smartphone are increasing as well [4].

This trend is also true among transit riders. With the exception of one agency, transit riders’ smartphone ownership was actually higher than the national average, and for all surveys conducted in 2011 or later, the majority of transit riders own a smartphone. This suggests that more transit riders will have the ability to access smartphone applications providing RTI in the following years. Again, it is important to note that surveys among transit agencies are not necessarily directly comparable, but are provided for general trends and comparison to general population data.

Figure 9: Smartphone Ownership among Americans and Transit Riders
4.3 Availability of Alternative Technologies

Despite the increase in smartphone ownership, not all transit riders have mobile devices that are able to access RTI information due to constraints on the device, lack of certain data or internet plans, or preferences of the user. Therefore, certain technologies and access are needed to supplement smartphone applications. In particular, users with internet on cellular devices are able to access mobile-optimized websites, users with text messaging are able to send and receive SMS, users with any cellular or stationary phone can access IVR services, and those with computer internet access can access websites. The availability of all these alternative technologies to the transit riders within the different agencies are shown in the tables below.

As described in Table 4, for Americans with access to cell phones, 56% are able to use the internet on that device (approximately 48% of all Americans). In 2012, this same technology was accessible to 76% of LAC MTA and 78% of Metro riders in 2013.

Table 4: Transit Riders’ Internet Access on Mobile Device

<table>
<thead>
<tr>
<th>Agency</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>LAC MTA</td>
<td>76%</td>
<td>24%</td>
</tr>
<tr>
<td>St Louis Metro</td>
<td>78%</td>
<td>22%</td>
</tr>
<tr>
<td>United States (2012)</td>
<td>56%</td>
<td>44%</td>
</tr>
</tbody>
</table>

Information regarding text messaging availability is shown in Table 5. In 2012, of those with mobile devices, 80% used text messaging, resulting in approximately 68% of all Americans, regardless of cell phone ownership, with access to this alternative. Of Metro riders with cell phones, 91% had text messaging in 2013 while 70% of CTA riders had SMS in 2012. This difference between CTA and Metro riders may be due to the how the question was worded. CTA’s survey asked riders if they had a cell phone for texting while Metro asked their riders, “If you use a cell phone, does it have a text messaging ability that you use?” Because these surveys were conducted in different years, with different phrasing, these results only serve as an overall idea of
technology usage rather than a direct comparison.

Table 5: Transit Riders’ Text Messaging on Mobile Device

<table>
<thead>
<tr>
<th>Agency</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTA</td>
<td>70%</td>
<td>30%</td>
</tr>
<tr>
<td>St Louis Metro</td>
<td>91%</td>
<td>9%</td>
</tr>
<tr>
<td>United States (2012)</td>
<td>80%</td>
<td>20%</td>
</tr>
</tbody>
</table>

Having access to a computer with internet was available to 77% of American adults in 2011 [14]. In 2012, 93% of CTA riders had internet access through a computer while in 2013, 81% of Metro riders had this access. The full table can be seen in Table 6.

Table 6: Transit Riders’ Internet Access on a Computer

<table>
<thead>
<tr>
<th>Agency</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTA</td>
<td>93%</td>
<td>7%</td>
</tr>
<tr>
<td>St Louis Metro</td>
<td>81%</td>
<td>19%</td>
</tr>
<tr>
<td>United States (2011)</td>
<td>77%</td>
<td>23%</td>
</tr>
</tbody>
</table>

While there is a high percentage of cell phone ownership, allowing IVR access, providing RTI on a website would also be accessible by a large percentage of Americans and transit riders. However, while this is the most accessible alternative to smartphone applications, it is unknown if this technology is the best alternative. While these trends do provide a basis of comparison, the next chapter will investigate this by taking an in-depth look into Metro riders.

4.4 Demographic Characterizations of Technology Accessibility

While the focus of this study concerns communication technology utilization and availability among Saint Louis Metro riders, comparable data was gathered from other transit agencies. These agencies, specifically the Chicago Transit Authority (CTA), Los Angeles County Metropolitan Transportation Authority (LAC MTA), and the Tri-County Metropolitan Transportation District of Oregon in Portland (TriMet), have all conducted recent on-board surveys asking riders their technology usage and
demographic questions. The cross tabulations of this information, is available in Appendix B and provides a comparison tool against the distribution seen from Saint Louis Metro riders. Another cross tabulation analysis displaying the technology usage and demographics for the entire nation identifies the overall adoption of communication technology. Appendix B also provides an in-depth written analysis of these cross tabulations while a summary of these relationships are provided in this section.

4.4.1 Chicago Transit Authority

With a survey conducted in 2012, CTA’s survey questions included the ownership of smartphone, cell phone for texting, and computer internet access. The information from this survey displayed that while age has a noticeable relationship with smartphone ownership, there is an inverse relationship between income and smartphone ownership, and that the ethnicity with the lowest ownership of smartphones is African Americans.

Regarding CTA rider’s access to internet via a computer, there is an even more drastic and noticeable relationship between age and access to this technology. In addition, rider’s earning more than $60,000 are less likely to have this technology and, similar to smartphone ownership, African Americans are the least likely to have computer internet access.

4.4.2 Los Angeles County Metropolitan Transportation Authority

The cross tabulations provided by LAC MTA included two technology questions, cell phone ownership and smartphone ownership, and was conducted in 2012. Among these rider’s, those older than 50 years old are more likely to not own a cell phone or smartphone, while Asian / Pacific Islanders are the least likely ethnicity to have cell phones. As for income and cell phone ownership, generally as income increases so does cell phone ownership. However, regarding smartphone ownership, there is no drastic ownership difference among income levels.
4.4.3 Tri-County Metropolitan Transportation District of Oregon

The cross tabulations provided by TriMet included one technology questions, smartphone ownership, and was conducted in 2009. Unlike the previous transit agencies, TriMet riders’ smartphone ownership does not greatly differ among the different age categories. However, as income increases, the percentage of smartphone ownership drastically increases. Black / Africans are the ethnic group most likely to have smartphones.

4.4.4 United States

Similar to the transit agencies, information regarding smartphone ownership among Americans in 2013 displays as age increases, the percentage of smartphone ownership decreases. One major difference between Americans and transit riders is as income increases, the percentage of smartphone ownership noticeably increases as well. One similarity to Saint Louis Metro riders is Whites are the least likely to own a smartphone.

The availability of two other possible technologies that can provide real-time information is also known across Americans: Internet on Mobile Device and Text Messaging. For both of these technologies, an individual’s age is reflective on if he / she will have access to these alternatives. The probability of having internet on a cell phone, or text messaging, was higher among Americans with high income. Whites are also the ethnic group with the lowest availability of both of these alternative technologies.

4.5 Current Real-Time Information Availability among Transit Agencies

Within the past few years, there has been an emergence of real-time information among transit agencies. Riders can use this information to obtain an estimated time in which a particular bus or train will arrive at a stop. This information is particularly helpful in services with long frequencies or when riders cannot afford to miss a
particular bus or train.

To gain a better understanding of the availability of this technology, a search was conducted on various agency websites. The purpose was to find evidence of real-time information being available to transit users through six different means. These different categories include the following:

- Computer Website
- Mobile-Optimized Website
- SMS Tracking
- Telephone Service (IVR)
- Agency Mobile Application
- Data Available to Third-Party Developers

Figure 10 outlines the availability of real-time information in mid-2013 among the top 15 largest transit agencies and Saint Louis Metro.

Please keep in mind that this chart only represents real-time information services. For example, while the majority of transit agencies did have telephone service, most of these only gave information regarding scheduled service. Many of these options are available to riders but only display scheduled arrival and departure times, not real-time. In addition, many agencies have real-time available for fleet management but do not publicly provide this information; therefore, this chart is likely to change in the coming months and years.
<table>
<thead>
<tr>
<th>Agency</th>
<th>Website</th>
<th>Mobile-Optimized Website</th>
<th>SMS Tracking</th>
<th>Telephone Service*</th>
<th>Agency Mobile Applications</th>
<th>Data Available to Third-Party Developers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metropolitan Transportation Authority (MTA)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chicago Transit Authority (CTA)</td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Los Angeles County Metropolitan Transportation Authority (LA Metro)</td>
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<td>Washington Metropolitan Area Transit Authority (WMATA)</td>
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<tr>
<td>Southeastern Pennsylvania Transportation Authority (SEPTA)</td>
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<td></td>
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<tr>
<td>New Jersey Transit Corporation (NJ Transit)</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>San Francisco Municipal Railway (MUNI)</td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>King County Metro</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Bay Area Rapid Transit (BART)</td>
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<td></td>
<td></td>
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<tr>
<td>Tri-County Metropolitan Transportation District of Oregon (TriMet)</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maryland Transit Administration (MTA)</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Denver Regional Transportation District (RTD)</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Miami-Dade Transit (MDT)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>St. Louis Metro Transit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total Percentage</strong></td>
<td>81%</td>
<td>81%</td>
<td>56%</td>
<td>38%</td>
<td>50%</td>
<td>75%</td>
</tr>
</tbody>
</table>

*Light blue represents agencies that have RTI available to the public but do not promote a specific phone number to obtain this information. Instead, RTI can be acquired through customer service or a call center.
Computer-based and mobile-optimized websites are the most common RTI technology. Both of these alternative technologies are identical in terms of availability, most likely due to not requiring additional hardware or technologies to provide a mobile-based website. While a mobile-optimized website has a different layout, the information is more or less the same as a computer-based website.

In addition many agencies have opened their data to allow third-party developers to create mobile applications. In fact, this is the second most frequently-provided technology. This suggests that many agencies are willing to provide RTI through non-in-house means.

A telephone service / IVR is the least frequent technology due to the irregularities of how this data is provided, as indicated by the color difference in the column. The darker shade represents agencies that have a telephone / IVR service and advertise it on their website. The lighter shade indicates agencies that have RTI available to the public but do not promote a specific phone number to obtain this information. Instead, RTI can be acquired through customer service or call center.
CHAPTER V

METRO RIDER MOBILE AND INTERNET TECHNOLOGY UTILIZATION

In the summer of 2012 and 2013, Metro conducted an on-board survey on both their bus (MetroBus) and rail (MetroLink) service. In addition to asking questions pertaining to individual’s satisfaction with the service, questions pertaining to their communication technology usage and demographic characteristics were included. For the purpose of this study, the technology-related questions and answers included in this analysis are:

![Figure 11: Technology Questions used in Survey](image)

![Figure 12: Demographic Questions used in Survey](image)

A full copy of the survey can be found in Appendix A.

For the purpose of this analysis, smartphones were defined as an iPhone, Blackberry, Android-based, or Windows 7-based cell phone type. If a respondent selected...
any of these as their cell phone, they were considered to have a smartphone. Furthermore, if the respondent answered he/she had a smartphone and answered 'Yes' to "If you use a cell phone, does it have internet access that you use?", then that respondent was considered to have access to smartphone applications.

These questions were organized and analyzed using a variety of methods. Cross tabulations between each technology and demographic question were created as a preliminary basis for how, or if, any noticeable trends exist. This created a descriptive statistic regarding how available smartphones and the supplementary technologies are among Metro riders.

The associations found from these combinations were then explored through chi-square tests of independence. This provided verification if a statistical relationship exist between that the availability of smartphone applications and various demographic attributes. Visual inspection of these distributions as well as conclusions drawn from the cross tabulations revealed the nature of these statistical relationships (e.g. there is an inverse relationship between age and smartphone ownership). These analyses were specific to the usage of smartphone applications (i.e. having a smartphone with internet access) rather than smartphone ownership in general. It was not assumed that every rider with a smartphone would have the ability to download and access applications that require connection to the internet.

However, the chi-square tests only incorporate single demographic attributes. To understand the collective impact of all demographic characteristics on the access of smartphone applications, a binary logistic regression model was estimated.

The final analysis extracted the riders without access to smartphone applications to calculate the availability of each alternative technology to better understand what technology can supplement mobile applications. These calculations also included data respecting the overlap that occurs between technologies. For example, what percentage of riders with text messaging capabilities also had access to computer
websites? These considerations, as well as all research and data conducted prior, were then used to conclude what is the best supplementary technology to smartphone applications.

5.1 Technology Ownership Trend and Availability

Beginning in 2007, Metro included a handful of questions pertaining to technology access and ownership on their on-board surveys. While surveys were not conducted every year, these data provide a general trend of mobile technology adoption in the past six years.

Cell phone ownership has noticeably increased since 2007 for both bus and rail riders, which can be seen in Figure 13. In 2007, approximately 68% of bus riders owned a mobile device, which has since increased to 91% in 2013. While, historically, rail riders have a higher percentage of cell phone ownership, recent years (2012, 2013) have shown this gap to be smaller. This suggests that cell phone ownership among Metro riders is getting close to plateauing, with 95% as the possible maximum percentage of riders owning cell phones.

![Cell Phone Ownership among Metro Riders](image)

Figure 13: Cell Phone Ownership among Metro Riders
Smartphone ownership was not measured prior to 2012 due to the relative newness of these devices. Ownership trends in 2012 and 2013 are shown in Figure 14. This ownership slightly increased between 2012 and 2013, from approximately 70% to 73%. While this is not an indicator of a strong trend, it does demonstrate how prevalent smartphones are becoming. With nearly three quarters of the riding population using such devices, a large portion of riders have the ability to access RTI mobile applications. In addition, when compared to the national smartphone ownership trend in the United States (as mentioned earlier), this smartphone ownership amongst Metro riders is notably higher.

Figure 14: Smartphone Ownership among Metro Riders
A survey question pertaining to having internet access on a mobile device was also only asked in 2012 and 2013, as shown by Figure 15. However, similar to smartphone ownership, a high portion of cell phone owners also have the ability to access the internet. This trend does not greatly vary between bus and rail riders and has increased by over eight percent since 2012.

![Figure 15: Mobile Internet Access among Metro Riders](image)

Figure 15: Mobile Internet Access among Metro Riders
Data about text messaging on a mobile device was available from the years 2008, 2012, and 2013 and is shown in Figure 16. These percentages do not reflect individual’s ability to text but, more specifically, if they use text messaging. From 2008, there has been a notable increase in the ability to send and receive text messages. In 2008, only 64% of bus and 49% of rail riders used text messaging on their mobile device. This increased by 38% for bus and 80% for rail riders in 2012. The two most recent years did not exhibit a drastic difference between bus and rail riders, unlike the 2008 survey; but 2013 had a slight increase in text messaging usage when compared to 2012 data.

Figure 16: Text Messaging Access among Metro Riders
All four survey years asked whether an individual had access to a computer with internet access, with results displayed in Figure 17. Among rail riders, the only outstanding difference was in 2008, where 77% of riders had access to a computer, compared to approximately 85% for the remaining years, both before (2007) and after (2012, 2013). This could be a reflection of the recession, with an overall decrease in employment and, therefore, access to a computer at work.

Overall, the access to all technologies has increased within the past six years. If this trend continues, even more riders will be able to utilize RTI on smartphone applications and other, supplementary technologies.

5.1.1 Alternative Technologies by Demographic Group

In addition to identifying the demographic groups that are most likely to have access to smartphone applications, as will be explained in the next section, a quick overview of who has access to alternative technologies is described. These cross tabulations provide an overview of how, and if, riders’ demographic characteristics influence their
ability to access specific alternative technologies. These alternative technologies include mobile-based websites, text messaging, and computer-based websites. The cross tabulation figures that coincide with these descriptions can be found in Appendix C.

Also included in Appendix C is an in-depth written analysis of these relationships. This section provides general characteristics and trends experienced by both bus and rail riders in 2012 and 2013.

Regarding the availability of this alternative technology to Metro riders, an individual’s income and gender does not greatly predict his or her availability to access mobile websites. Otherwise, riders who are older than 40 years old, retired, or are White / Caucasians are the demographic characteristics most likely to not use this technology.

Comparatively, age is not as strong of an indicator of using text messaging. The percentage of riders using this technology is fairly steady until the age category of “51 to 64” and “65 +”. Similarly to mobile website usage, retirees and White / Caucasians are the most likely to not use text messaging and income does not dictate text messaging access either.

Age is also an indicator of having access to the internet through a computer. Specifically, this access is fairly consistent among riders younger than 40 years old but is noticeably lower for those older than 40 years old. Riders who are retired, homemakers, or unemployed are the most likely to not have access to this technology. One noticeable difference between this technology access when compared to the previous two technologies is the relationship with income and race. The relationship between computer internet access and income is very pronounced, with riders earning a higher income as more likely to have this access. Also, it is shown that riders who are Black / African American are the least likely ethnic group to access the internet on a computer.
5.2 Non-Smartphone Users by Demographic Group

As more riders own mobile devices, understanding who does not have potential access to RTI applications and what is the best supplementary technology can maximize the benefit from accessing this information.

Riders were categorized through cross tabulations comparing the distribution of smartphone, non-smartphone and no cell phone ownership between different demographic groups. The demographic groups investigated include age, race, employment, income, and gender.

5.2.1 Age

As shown in Figures 18 to 21, the most prominent relationship is as age increases, the percentage of riders owning a smartphone decreases. The only age group that does not follow this trend is riders under 18 years old. In fact, this age group displayed one of the highest percentages of not using a cell phone. This is most likely due to parental restrictions on having a cellular device. When comparing bus and rail riders, bus riders are slightly more likely to own a smartphone; however, the trend between both modes is fairly similar with no drastic differences. Of the five different demographics analyzed, the comparison between age and cell phone ownership was the most dominate relationship.

This trend, as age increases the percentage of smartphone ownership decreases, is also true in 2013. Even more so, riders over the age of 65 have an even lower percentage of smartphone ownership: 39% for bus and 44% for rail riders. In addition, a more noticeable portion of younger riders have a very high percentage of smartphone ownership. In 2013, approximately 80% of riders under 40 years old have smartphones. In 2012, a much smaller portion of riders own smartphones-19 to 30 years old for bus and 19 to 35 for bus riders. This suggests that smartphone adaption is most popular among the younger population and that, every age group, excluding riders over 65
years old, had a higher smartphone ownership between 2012 and 2013.

Figure 18: Cell Phone Ownership Type based on Age - Bus 2012

Figure 19: Cell Phone Ownership Type based on Age - Rail 2012
Figure 20: Cell Phone Ownership Type based on Age - Bus 2013

Figure 21: Cell Phone Ownership Type based on Age - Rail 2013
5.2.2 Race

As shown in Figures 22 to 25, in 2012, when race and cell phone ownership were compared among bus and rail riders, White / Caucasians had the lowest smartphone ownership at 59% and 61% respectively. This compared to 74% of Black / African American bus and 71% of Black / African American rail riders with smartphones. While among rail riders, Black / African Americans had the highest smartphone ownership, Latino / Hispanic Americans, followed by Asian / Asian Americans had the highest smartphone ownership among rail riders. However, the sample size for these two ethnicities is noticeably smaller, n = 71, when compared to Black / African Americans, n = 982.

The cross tabulation between race and cell phone ownership in 2013 has similar characteristics to 2012. White / Caucasians are still the demographic group with the lowest portion of riders with smartphones 62% for bus and 67% for rail riders. The rest of the demographic groups are, overall, generally in the same range with approximately 75% of riders with smartphones. The more notable difference in these groups is the range of non-smartphone ownership, especially among bus riders. Asian / Asian American and White / Caucasian bus riders have the highest portion of riders with non-smartphones at 27%; however, all Asian / Asian Americans surveyed had some type of cell phone.
Figure 22: Cell Phone Ownership Type based on Race - Bus 2012

Figure 23: Cell Phone Ownership Type based on Race - Rail 2012
<table>
<thead>
<tr>
<th>Race</th>
<th>Smartphone</th>
<th>Non-Smartphone</th>
<th>No Phone</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black/African American</td>
<td>76%</td>
<td>16%</td>
<td>8%</td>
<td>1970</td>
</tr>
<tr>
<td>White/Caucasian</td>
<td>62%</td>
<td>27%</td>
<td>11%</td>
<td>471</td>
</tr>
<tr>
<td>Asian/Asian American</td>
<td>73%</td>
<td>27%</td>
<td></td>
<td>49</td>
</tr>
<tr>
<td>Latino/Hispanic American</td>
<td>74%</td>
<td>17%</td>
<td>9%</td>
<td>35</td>
</tr>
<tr>
<td>Other</td>
<td>78%</td>
<td>12%</td>
<td>10%</td>
<td>91</td>
</tr>
</tbody>
</table>

**Figure 24: Cell Phone Ownership Type based on Race - Bus 2013**

<table>
<thead>
<tr>
<th>Race</th>
<th>Smartphone</th>
<th>Non-Smartphone</th>
<th>No Phone</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black/African American</td>
<td>77%</td>
<td>16%</td>
<td>6%</td>
<td>1401</td>
</tr>
<tr>
<td>White/Caucasian</td>
<td>67%</td>
<td>27%</td>
<td></td>
<td>967</td>
</tr>
<tr>
<td>Asian/Asian American</td>
<td>75%</td>
<td>20%</td>
<td></td>
<td>65</td>
</tr>
<tr>
<td>Latino/Hispanic American</td>
<td>74%</td>
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<td></td>
<td>39</td>
</tr>
<tr>
<td>Other</td>
<td>74%</td>
<td>18%</td>
<td>7%</td>
<td>94</td>
</tr>
</tbody>
</table>

**Figure 25: Cell Phone Ownership Type based on Race - Rail 2013**
5.2.3 Employment

Considering employment status in 2012, riders employed full-time, part-time, and student riders were the most likely to have a smartphone. This relationship can be seen in Figures 26 to 29. Among bus riders, 72%, 71%, and 72% respectively had this device while 69%, 72%, and 72% of rail riders had smartphones. This resulted in unemployed, retired, or homemaker riders as the least likely to own a smartphone with smartphone ownership percentages ranging from 54% to 57% of bus and 51% to 63% of rail riders.

The prevalence of smartphones among riders employed and/or a student is also seen in 2013. Riders who are employed and a student have an even higher percentage of smartphone ownership at over 80%. Compared to the average, overall ownership of 73%, this employment status has a high probability of having access to RTI applications. Another notable difference is among riders not employed or a student. While riders that are unemployed, retired, or a homemaker have a lower percentage of smartphone ownership, they have a high percentage of not owning any cell phone. For example, over one fifth of bus riders who are retired or homemakers do not own a cell phone.
Figure 26: Cell Phone Ownership Type based on Employment - Bus 2012

Figure 27: Cell Phone Ownership Type based on Employment - Rail 2012
Figure 28: Cell Phone Ownership Type based on Employment - Bus 2013

Figure 29: Cell Phone Ownership Type based on Employment - Rail 2013
5.2.4 Income

It was also found that smartphone ownership differed, but not drastically, among income levels. All of these cross tabulations are provided in Figures 30 to 33. For bus riders, 67% of riders with a household income below $20,000 had a smartphone while 71% riders earning over $100,000 had these devices. This difference was more noticeable among rail riders with 66% earning less than $20,000 with a smartphone, compared to 77% of riders with incomes greater than $100,000. However, this distribution is fairly minimal when compared to other demographic cross tabulations such as age and employment. Also, the lowest income bracket deviates little from the overall 2012 smartphone ownership with 69% of riders owning such device.

When compared to the 2013 cross tabulation, the distribution is very similar. Among rail riders, while there is an increase between the lowest and highest income bracket, the trend is fairly minimal, especially when compared to other demographic cross tabulations. Interestingly, the difference between these two income groups, Under $20,000 and $100,000 +, is 11% for rail riders, which is identical to the difference seen in 2012. Among bus riders, the difference between the lowest and highest income group is 5% in 2013, again reiterating that income is not an automatic indicator of smartphone ownership.
Figure 30: Cell Phone Ownership Type based on Income - Bus 2012

Figure 31: Cell Phone Ownership Type based on Income - Rail 2012
Figure 32: Cell Phone Ownership Type based on Income - Bus 2013

Figure 33: Cell Phone Ownership Type based on Income - Rail 2013
5.2.5 Gender

Finally, it was concluded that smartphone ownership did not differ between males and females, which can be seen in Figures 34 to 37. Approximately 71% of female and 67% of male bus riders had a smartphone while among rail riders, 69% of females and 68% of males had these devices.

This was also true in 2013, with 72% of female and 74% of male bus riders with smartphones and 74% of female and 73% of male rail riders owning smartphones.
Figure 34: Cell Phone Ownership Type based on Gender - Bus 2012

Figure 35: Cell Phone Ownership Type based on Gender - Rail 2012
Figure 36: Cell Phone Ownership Type based on Gender - Bus 2013

Figure 37: Cell Phone Ownership Type based on Gender - Rail 2013
These percentages allowed specific demographic groups to be identified as the most likely to not have smartphones. In order to verify that these relationships are statistical significant, additional analyses were conducted. To prepare for these tests, the data were reorganized, separating riders’ responses into those who do and those who do not have a smartphone application. Additionally, these responses were further recoded to be within a demographic category most likely to own and not own a smartphone. The results from these tests and models are explained in the subsequent sections.

5.3 Statistical Verification

5.3.1 Chi-Square Test of Independence

For this statistical test, the null hypothesis is that the distribution of riders with and without access to smartphone applications is similar for all demographic categories. This chi-square test was conducted for both the 2012 and 2013 data and separately for the bus and rail riders. Each demographic category was used in these tests and separated into two different groups, excluding gender which is naturally already in two groups. One group represented the riders within a certain demographic category that are most likely to own a smartphone with access to mobile applications. The second group represented riders most likely to not have access to this technology. The cross tabulations in the previous section were utilized to identify what how, and where, to separate these two groups. Different thresholds within each demographic attribute (i.e. Income Below $60,000 or Below $20,000) were used in preliminary tests to ensure the trend displayed by the cross tabulations were accurate. For example, setting the age threshold, between riders most likely and least likely to have access to smartphone applications, at 40 years old was consistently statistically significant, supporting the findings from the cross tabulations. This is reflected in the provided chi-square test results.
5.3.1.1 2012 Survey

The information provided in Table 7 displays the frequency distribution as well as the results of the chi-square test of independence among riders in 2012.

Table 7: Chi-Square Test of Independence - 2012

<table>
<thead>
<tr>
<th>Age</th>
<th>MetroBus Riders</th>
<th>2012 Survey</th>
<th>MetroLink Riders</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Owns a Smartphone with Internet Access</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Y</td>
<td>N</td>
<td>Chi square test of independence</td>
</tr>
<tr>
<td>40 and Under</td>
<td>62%</td>
<td>38%</td>
<td>$X^2 = 168.212, 1\ d.f.$</td>
</tr>
<tr>
<td>Over 40</td>
<td>28%</td>
<td>72%</td>
<td>$p &lt; 0.0001$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Employment</th>
<th>MetroBus Riders</th>
<th>2012 Survey</th>
<th>MetroLink Riders</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Owns a Smartphone with Internet Access</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Y</td>
<td>N</td>
<td>Chi square test of independence</td>
</tr>
<tr>
<td>Full-Time, Part-Time, Student, or Full-Time &amp; Student</td>
<td>53%</td>
<td>47%</td>
<td>$X^2 = 64.740, 1\ d.f.$</td>
</tr>
<tr>
<td>Unemployed, Homemaker, Retired</td>
<td>28%</td>
<td>72%</td>
<td>$p &lt; 0.0001$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Income</th>
<th>MetroBus Riders</th>
<th>2012 Survey</th>
<th>MetroLink Riders</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Owns a Smartphone with Internet Access</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Y</td>
<td>N</td>
<td>Chi square test of independence</td>
</tr>
<tr>
<td>Under $20,000</td>
<td>46%</td>
<td>54%</td>
<td>$X^2 = 3.105, 1\ d.f.$</td>
</tr>
<tr>
<td>Over $20,000</td>
<td>51%</td>
<td>49%</td>
<td>$p &gt; 0.05$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Race</th>
<th>MetroBus Riders</th>
<th>2012 Survey</th>
<th>MetroLink Riders</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Owns a Smartphone with Internet Access</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Y</td>
<td>N</td>
<td>Chi square test of independence</td>
</tr>
<tr>
<td>White/Caucasian</td>
<td>40%</td>
<td>60%</td>
<td>$X^2 = 8.959, 1\ d.f.$</td>
</tr>
<tr>
<td>Other</td>
<td>50%</td>
<td>50%</td>
<td>$p &lt; 0.01$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Gender</th>
<th>MetroBus Riders</th>
<th>2012 Survey</th>
<th>MetroLink Riders</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Owns a Smartphone with Internet Access</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Y</td>
<td>N</td>
<td>Chi square test of independence</td>
</tr>
<tr>
<td>Male</td>
<td>53%</td>
<td>47%</td>
<td>$X^2 = 3.759, 1\ d.f.$</td>
</tr>
<tr>
<td>Female</td>
<td>59%</td>
<td>41%</td>
<td>$p &gt; 0.05$</td>
</tr>
</tbody>
</table>

Nearly every chi-square test conducted was found to be statistically significant at the 1% level, rejecting the null hypothesis. Only rail and bus data when considering income and gender were found not to be statistically significant at the 5% level. This suggests that, when compared to other demographic characteristics, income and an individual’s gender are not a dominant indicator of smartphone ownership.

The chi-square tests investigating the age distribution were found to have the
highest $X^2$ when compared to other demographic groups. This indicates the strongest significance and concludes that smartphone ownership between riders above and below 40 years old differs. The strength of this disproportion between smartphone and non-smartphone owners is greater between these two age groups than for any other demographic categories.

The two different employment statuses and race categories identified above were also statistically significant. The unequal employment distribution between these riders could be due to a variety of factors, including the price of smartphone data plans which may be perceived as unnecessary costs by non-employed riders. In addition, students are generally below 40 years old and due to the statistically significant age relationship, it is logical that students also have access to smartphones.

These tests result in a finalized list identifying the demographic groups that are most likely to not have access to smartphone applications as well as the percentage of bus and rail riders with this demographic attribute without access to this technology:

- Above 40 years old (72% bus, 63% rail)
- Retired, unemployed, homemaker (72% bus, 67% rail)
- White / Caucasians (60% bus, 51% rail)

5.3.1.2 2013 Survey

The chi-square tests for the 2013 survey were conducted in the same fashion as for the 2012 survey. The null hypothesis, that the distribution of riders with and without smartphone applications is similar for the different demographic categories, remained the same. Table 8 displays the frequency distribution as well as the results of the chi-square test of independence among riders in 2013.
Similar to the 2012 chi-square test, nearly every test conducted was found to be statistically significant at the 1% level, rejecting the null hypothesis. Only rail (MetroLink) riders when considering race was found not to be significant in addition to gender differences among bus and rail riders. One interesting difference was the statistically significance of income. For the 2012 test, income was found not to be significant and, when analyzing the cross tabulations, the income distribution was not drastic. The difference between the cross tabulation, displaying smartphone ownership, and chi-square test of independence, analyzing access to smartphone applications, could be explained by the fact that not every rider who owns a smartphone
also has internet on the device. Smartphone ownership does not necessarily reflect on the accessibility of mobile applications.

Also, the chi-square test for the age demographic had the highest $X^2$ when compared to other demographic groups, similarly to the 2012 tests. This confirms that an individual’s age is a major contributor in smartphone ownership. Specifically, smartphone ownership among riders above 40 years old is statistically different than for riders under 40 years old.

These tests result in a finalized list identifying the demographic groups that are most likely to not have access to smartphone applications as well as the percentage of bus and rail riders with this demographic attribute without access to this technology:

- Above 40 years old (63% bus, 56% rail)
- Retired, unemployed, homemaker (65% bus, 57% rail)
- Income under $20,000 (50% bus, 44% rail)
- White / Caucasians [bus only] (52% bus)

After identifying these groups, further research was conducted to better understand the access these groups have to alternative technologies that provide RTI.

5.3.2 Binary Logistic Regression

To gain a better understanding of how rider demographics affect access to smartphone applications, different binary logistic regression models were constructed with demographic attributes as explanatory variables. Through these regressions, the relationship between these different demographic characteristics and how they all contribute to whether or not an individual has access to smartphone applications can be recognized. The data used in these regressions included all respondents and were recoded to a binary variable to represent access to smartphone and mobile internet.
On the survey, a respondent needed to specify smartphone ownership and access to the internet through a mobile device to be considered as an individual with access to smartphone applications.

The data were organized in a binary fashion, with each variable as a specific demographic characteristic. An individual was either within this demographic group or not and was indicated as ‘1’ being within this group and ‘0’ not being in this group. A total of 27 different variables were created. A full list of these variables and the definition associated with them are outlined in Appendix D in Table ???. The variable describing Age was separated into two different categories: riders above 40 years old and riders 40 years old and below. This division was due to the consistent differences between these two groups seen in the previous analyses.

For the final logit model for each year and mode, some of the demographic categories were combined. For example, instead of separating full-time and part-time employment into two variables, a new category was created called ‘Employed,’ which included individuals from both of these groups. To have all categories mutually exclusive, the variables included in these models were coded so an individual could only be in one demographic category. For example, the variables ‘EmployFT’ and ‘Employed’ were never included in the same model due to some individuals falling into both categories.

For each year and mode, initially an overall regression model was built which included all possible variables and served as the basis for the final regression model. To understand how these demographic attributes affect access to smartphone applications, these simplified models included uniform variables for each mode and year. The selection of these variables were based on what attributes were consistently significant across these four models, as determined during the process of simplifying the overall regression models. The overall logistic regressions are included in Appendix D and are shown in Tables 48 to 51.
All of these models help in understanding if these demographic characteristics contribute to the probability of an individual *not* having access to smartphone applications. In other words, if the coefficient is positive, then respondents with that demographic attribute are more likely to *not* have access to smartphone applications. This variable is then identified to be a possible demographic characteristic that is more likely to need an alternative technology to receive RTI. If a coefficient is negative, then respondents with that demographic attribute are more likely to have access to smartphone applications. Also included in these tables is the percentage of riders with that specific demographic attribute. For example, among bus riders in 2012, 55% are younger than 40 years old.

These regressions were separated by mode and by survey year, creating a total of four different models. The methodology behind each of these regressions is consistent.
5.3.2.1 Bus 2012

The final regression model for bus riders in 2012, as shown in Table 9, suggests that individuals who are 40 years of age and below or are employed and/or are students are more likely to have access to smartphone applications. This model also demonstrates that riders who are Black / African American are more likely to have access to smartphone applications when compared to other ethnic groups; however, this particular variable is not significant at the 5% level. Also, while an individual with an income higher than $80,000 is more likely to have smartphone applications, this variable is not significant at the 5% level. While a rider’s income does play a factor regarding smartphone application accessibility, this model does not allow the conclusion that an individual within a lower income bracket will not have access to smartphone applications.

Table 9: Binary Logistic Regression - Bus 2012

<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Coefficient</th>
<th>S.E.</th>
<th>% of Total Sample</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>1.432</td>
<td>0.133</td>
<td>-</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Black / African American</td>
<td>-0.100</td>
<td>0.117</td>
<td>66%</td>
<td>0.3892</td>
</tr>
<tr>
<td>40 Years Old and Below</td>
<td>-1.335</td>
<td>0.111</td>
<td>55%</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Employed and/or Student</td>
<td>-0.620</td>
<td>0.124</td>
<td>70%</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Income Over $80,000</td>
<td>-0.517</td>
<td>0.300</td>
<td>3%</td>
<td>0.085</td>
</tr>
</tbody>
</table>

Fit statistics

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Rho-Squared</td>
<td>0.175</td>
</tr>
<tr>
<td>AIC</td>
<td>2108.3</td>
</tr>
<tr>
<td>Final Log Likelihood</td>
<td>-998.9972</td>
</tr>
<tr>
<td>Total Sample Size</td>
<td>1611</td>
</tr>
</tbody>
</table>

*Positive coefficient = No Smartphone Application Access

5.3.2.2 Bus 2013

In the final logistic regression for bus riders in 2013, shown in Table 10, nearly every demographic variable included is statistically significant at the 1% level. Black / African Americans were statistically significant in predicting a rider’s smartphone application
accessibility at the 1% level and are more likely to have access to this technology. Riders who are younger than 40 years are also more likely to have access to smartphone applications and that variable is also statistically significant at the 1% level. Those who are employed and/or are a student are more likely to have access to smartphone applications but the age category has a lower beta coefficient. Income is the only demographic attribute that is not statistical significant. However, similar to the Bus 2012 regression model, individuals earning more than $80,000 are more likely to have smartphone application access.

Table 10: Binary Logistic Regression - Bus 2013

<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Coefficient</th>
<th>S.E.</th>
<th>% of Total Sample</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>1.461</td>
<td>0.099</td>
<td>-</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Black / African American</td>
<td>-0.327</td>
<td>0.088</td>
<td>69%</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>40 Years Old and Below</td>
<td>-1.262</td>
<td>0.082</td>
<td>56%</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Employed and/or Student</td>
<td>-0.925</td>
<td>0.094</td>
<td>72%</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Income Over $80,000</td>
<td>-0.503</td>
<td>0.262</td>
<td>3%</td>
<td>0.0551</td>
</tr>
</tbody>
</table>

Fit statistics

| Rho-Squared | 0.212 |
| AIC         | 3847.6 |
| Final Log Likelihood | -1830.622 |
| Total Sample Size | 3032 |

*Positive coefficient = No Smartphone Application Access

5.3.2.3 Rail 2012

Overall, the logistic regressions among rail riders when compared to bus riders are fairly similar, as shown in Table 11. Riders who are Black / African American, younger than 40 years old, are employed and/or are students, or earn an income higher than $80,000 are more likely to have access to smartphone applications and are statistical significant at the 1% level. Similarly to the previous models, age is the variable with the greatest influence regarding access. Also in predicting smartphone application access, income was found to be statistically significant at the 1% level, unlike for bus riders in 2012 and 2013. This supports the previous findings that income could
impact a rider’s ability to own smartphones and have access to applications but, this variable is not consistently statistical significant across modes and years, unlike other demographic attributes in these regression models.

Table 11: Binary Logistic Regression - Rail 2012

<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Coefficient</th>
<th>S.E.</th>
<th>% of Total Sample</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>1.361</td>
<td>0.120</td>
<td>-</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Black / African American</td>
<td>-0.329</td>
<td>0.101</td>
<td>51%</td>
<td>0.0011</td>
</tr>
<tr>
<td>40 Years Old and Below</td>
<td>-1.120</td>
<td>0.102</td>
<td>51%</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Employed and/or Student</td>
<td>-0.740</td>
<td>0.121</td>
<td>75%</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Income Over $80,000</td>
<td>-0.857</td>
<td>0.170</td>
<td>10%</td>
<td>&lt; 0.0001</td>
</tr>
</tbody>
</table>

*Fit statistics*

- Rho-Squared: 0.168
- AIC: 2534.4
- Final Log Likelihood: -1201.69
- Total Sample Size: 1921

5.3.2.4 Rail 2013

The most recent survey among rail riders, provided in Table 12, is the only regression model with all demographic attributes significant at the 1% level. Black / Africans Americans are still more likely to have access to smartphone applications when compared to other ethnic groups; however, the remaining demographic variables have smaller coefficients, suggesting that transit rider’s other demographic attributes have a stronger influence over access to smartphone applications. In fact, the demographic attribute representing riders who are 40 years of age and under has the largest-magnitude coefficient. Rail riders who are employed and/or are students are also more likely to not need an alternative technology when compared to other employment statuses. Income, with a threshold at $80,000 was also found to be statistically significant, with riders earning more than $80,000 more likely to have access to this technology.
5.3.2.5 Summary

When considering all these logistic regressions, a few overall conclusions regarding demographic attributes and smartphone application accessibility can be made. First, in every regression conducted, the rho-squared was between 0.168 and 0.212. Because these models only explain between 16.8 and 21.2% of having access to smartphone applications, there are unobserved factors that contribute to this access that are not included in these models. A rider’s demographic characteristics alone cannot predict smartphone application access.

However, certain demographic attributes were found to be consistently statistically significant in these models. Compared to other demographic characteristics, age was the most influential attribute in accessing smartphone applications among bus as well as rail riders. Not only was this variable regularly statistically significant, but was also the largest-magnitude coefficient in ever equation.

Race was also a regular factor for this prediction. For the majority of the logistic regressions, riders who were Black / African American were more likely to have access to smartphone applications. Comparatively, this variable displayed a coefficient of approximately -0.3, when statistically significant.
Riders who were employed and/or students were also more likely to have access to smartphone applications. This coefficient was stronger than that for the ethnicity category (between -0.6 and -0.9) and was always significant at the < 0.0001 level.

Though included in the initial, overall logistic regressions, gender was never a statistically significant factor in access to smartphone applications.

Finally, the statistical significance of rider’s income was not consistent across the logistic regression models. Only rail, in both 2012 and 2013, were statistically significant at the <0.0001 level. However, among all regression models, riders earning more than $80,000 were more likely to have access to smartphone applications. Though, it should be noted that only approximately 3% of bus riders’ and 11% of rail riders’ household income is above $80,000.

These conclusions allow a finalized list of specific demographic groups most likely to not have access to smartphone applications. This includes riders who are:

- Above 40 years old
- Not Black / African American
- Unemployed, Homemakers, or Retirees, or
- Income Lower than $80,000

5.4 Access to Alternative Technologies

While smartphone applications are the new and upcoming means to provide RTI, there are other alternatives to retrieve this information such as:

- Interactive Voice Response (IVR)
- Mobile-Optimized Website
- Computer-Based Website
Text Messaging (SMS)

IVR is accessible from any phone line, mobile or otherwise. Users call a specified number and speak information describing their stop, what line they want, and where they want to travel. Mobile-optimized websites are optimized for the screen size of mobile devices, as opposed to computer-based websites. Text messaging, or Short Message Service (SMS), can be used if riders text their stop ID to a specific number to receive RTI.

The technology required to benefit from RTI through these different means is not readily available to all users, however. The following section describes the ability to utilize these alternative technologies among Metro riders without access to smartphone applications.

5.4.1 All Non-Smartphone Application Users

The access to these alternative technologies depends on the capabilities of a mobile device (i.e. internet access, SMS). The next table, Table 13, displays the availability of different technologies between all Metro riders and those without access to smartphone applications in 2012. It should be noted that the availability of these alternatives includes all riders, not just those with cell phones. Therefore, these percentages will not directly reflect the data provided earlier due to including riders that do not own a cell phone in the analysis.

In addition, in regards to Table 13 and Table 14, only respondents who answered ‘Yes’ or ‘No’ on the corresponding technology question were included in these descriptive statistics. In other words, if a rider did not answer the question “If you use a cell phone, does it have a text messaging ability that you use?”, they were not included in the SMS analysis. Incomplete answers on the surveys were not automatically coded as ‘Yes’ or ‘No’. Due to this, sample sizes vary across alternative technologies.
Table 13: Metro Rider’s Access to Alternative Technologies - 2012

2012 Survey

<table>
<thead>
<tr>
<th>Alternative Technology Access</th>
<th>Bus Riders</th>
<th>Rail Riders</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All Riders</td>
<td>Riders without Smartphone Applications</td>
</tr>
<tr>
<td>IVR</td>
<td>92%</td>
<td>82%</td>
</tr>
<tr>
<td></td>
<td>N = 1434</td>
<td>N = 606</td>
</tr>
<tr>
<td>Mobile-Based Website</td>
<td>66%</td>
<td>22%</td>
</tr>
<tr>
<td></td>
<td>N = 1408</td>
<td>N = 565</td>
</tr>
<tr>
<td>SMS</td>
<td>81%</td>
<td>62%</td>
</tr>
<tr>
<td></td>
<td>N = 1397</td>
<td>N = 561</td>
</tr>
<tr>
<td>Computer-Based Website</td>
<td>76%</td>
<td>64%</td>
</tr>
<tr>
<td></td>
<td>N = 1479</td>
<td>N = 687</td>
</tr>
</tbody>
</table>

When smartphone users are removed, the accessibility to these technologies decreases. Most notably, the percentage of riders who own a cell phone with internet access decreases by over 60%, suggesting that the majority of riders with internet on their cell phone own a smartphone. This further implies that mobile-optimized websites, which require a mobile device with internet access, would not be an optimal alternative.

However, there are a high percentage of riders without smartphones who still own a cell phone, including 82% of bus and 86% of rail riders. The majority of these riders can use IVR features and this number could be higher when landlines are considered.

Another option, using SMS, is available to 62% of bus and rail riders. While this access is more prevalent than mobile-optimized websites, it does require the rider to know the ID number for a specific stop or station, which may entail improvements to bus stop signage for some agencies.

The final technology alternative is a computer-based website, which is not dependent on cell phone ownership or usage. Internet access, and therefore access to these websites, is available to the majority of riders. This is the second highest available
technology to riders without smartphones, behind IVR.

Table 14: Metro Rider’s Access to Alternative Technologies - 2013

<table>
<thead>
<tr>
<th>Alternative Technology Access</th>
<th>2013 Survey</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bus Riders</td>
</tr>
<tr>
<td></td>
<td>All Riders</td>
</tr>
<tr>
<td>IVR</td>
<td>91% N = 2738</td>
</tr>
<tr>
<td>Mobile-Based Website</td>
<td>71% N = 2667</td>
</tr>
<tr>
<td>SMS</td>
<td>82% N = 2599</td>
</tr>
<tr>
<td>Computer-Based Website</td>
<td>76% N = 2803</td>
</tr>
</tbody>
</table>

Similar conclusions can be drawn when the same data is extracted from the 2013 survey results, as shown in Table 14. There is a notable decrease in cell phone access, and thus IVR, when riders with smartphone applications are removed. Comparatively, this decrease is even greater in 2013 than it was in 2012. Access to IVR among bus riders is at 74% in 2013 and 82% in 2012. The same is true among rail riders with 81% of riders without smartphone applications having cell phones and 86% of 2012 survey respondents with this device.

Access to mobile-based websites is comparatively similar between the 2012 and 2013 survey, with approximately one fifth of the remaining respondents having this access. However, this alternative technology is not highly accessible when compared to other supplementary technologies.

The percentage of riders without smartphone applications and access to SMS, or text messaging, only slightly decreased between 2012 and 2013. While this technology is available to more riders when compared to mobile-based websites, it is still
noticeably less than the access to IVR.

Among bus riders, computer-based websites were slightly more available to riders without smartphones when compared to the availability of text messaging. However, similar to the 2012 data, more rail riders have access to computer-based websites rather than SMS. This makes computer-based websites, overall, the second most accessible alternative technology.

5.4.2 Overlap in Alternative Technologies

The setup and design of the survey allowed insight into the combinations and overlap in technology availability among Metro riders. Prior to now, the exploration of technology availability in this paper has not considered if an individual has access to multiple alternatives. Investigating these overlaps provides another method of insight into transit riders’ access to RTI technologies.

The data used to create these graphs only included valid surveys in which all technology questions were answered. The two years and two modes were separated into four different graphs and displayed in Figures 38 to 41.

![Figure 38: Overlap of Technology Availability among Riders Without Smartphone Applications - Bus 2013](image-url)
Figure 39: Overlap of Technology Availability among Riders Without Smartphone Applications - Bus 2012

Figure 40: Overlap of Technology Availability among Riders Without Smartphone Applications - Rail 2012
Figure 41: Overlap of Technology Availability among Riders Without Smartphone Applications - Rail 2013

For every analysis, the combination of IVR, SMS, and a Computer-Based Website is the most prevalent. The combination of having only these three alternative technologies is available to 25-29% of bus riders and 36-40% of rail riders. The next most-available combination for any year and mode is having every technology: IVR, SMS, Computer-Based Website, and Mobile-Website. For this portion of riders, the only technology they cannot access are smartphone applications. This demonstrates that almost of a fifth of the riders that need an alternative RTI technology would be able to access this information through any other means, as long as it is provided by the agency. The third most prevalent combination differs between bus and rail riders. Among bus riders, IVR and SMS is the next most-available combination while IVR and Computer-Based Websites are more frequently available to rail riders.

IVR is present in the top three most frequent alternative technology combinations, and therefore available to over 50% of these extracted riders. The next most prevalent technology is Computer-Based Websites for rail riders and SMS for bus riders. However, in selecting an overall, best alternative to smartphone applications,
Computer-Based Websites would be available to riders with and without a cell phone. If both IVR and Computer-Based Websites are provided to this population, 85-99% of these riders would have access to real-time information.

These overlaps in technology availability were also investigated in terms of what percentage of riders with one technology has access to another. The four graphs shown in Figures 42 to 45 display this relationship. The darker blue bar represents riders who are able to access that alternative technology in addition to another technology. The lighter blue displays the percentage of riders who can only access that particular alternative technology.

Figure 42: Ability to Access Multiple Technologies among Riders Without Smartphone Applications - Bus 2012
Figure 43: Ability to Access Multiple Technologies among Riders Without Smartphone Applications - Bus 2013

Figure 44: Ability to Access Multiple Technologies among Riders Without Smartphone Applications - Rail 2012
As established before, among these riders without access to smartphone applications, a majority of them have a cell phone and thus IVR. When the makeup of these riders is considered, the vast majority can also access RTI through other means. Only between 4 and 9% of these riders have IVR and would not be able to have access to RTI if an agency invested in another technology. In regards to the remaining technologies, everyone who has access to a Mobile-Based Website or SMS also has the ability to receive RTI through other means—one of which is IVR. A large portion of riders with access to Computer-Based Websites have access to another technology.

It is also important to note the riders that do not have access to RTI through any mobile or computer-based technology and would have to rely on signage at a station/stop in order to access this information. Surprisingly, when comparing 2012 and 2013 data among both modes, there has been an increase in the percentage of riders within this group. This provides a reminder to agencies that a portion of riders will not be able to access RTI through phones and computers. Investing in signage at stations is the only way these riders will have access to the positive effects of RTI.
In addition, in many agencies, LCD signage is already present in major stations and stops. Including RTI in these feeds allows this information to be seen by everyone, not just riders without access to mobile devices and computers. While a large portion of riders do have access to various alternative technologies, agencies should not forget these portion of riders with no other means of obtaining RTI.
CHAPTER VI

DISCUSSION

One of the great benefits of RTI is the range of technologies providing this type of data. Utilizing the different types of communication on cell phones, as well as computers, allows a greater portion of the transit riding population to access this information. However, as mobile technology becomes increasingly oriented around smartphone applications, understanding the different alternative technologies ensures this information can be available to as many riders as possible. In the previous sections, the availability of these non-smartphone technologies has been discussed, forming a basis of which technology is the best alternative.

6.1 Recommended Alternative to Smartphone Applications

The results from the previous analysis illustrated that IVR captures the most transit riders without access to smartphone applications. Specifically in 2013, 74% of bus and 81% of rail riders without smartphones do have access to cell phones, which allows them to access IVR information.

However, selecting the ‘next best’ alternative to smartphone applications is not that straightforward. There are many factors to consider when determining this solution, such as the goals and resources of an agency and the unknown optimal balance between information and availability of a technology.

In addition, the optimal balance between the amount of information a specific technology provides and an individual’s preference for that technology is unknown. For example, while IVR is the most available alternative technology, it requires the user to know specific stop information or navigate a, potentially lengthy, menu tree. Also, depending on the service, IVR is limited to receiving information one stop at a
time. On the other hand, mobile-optimized websites, the least available alternative, provide information very similar to smartphone applications and can include route maps and service alerts. In other words, not all technologies are created equal. This optimal balance is unidentified and can also be subjective. One user may prefer the information provided through SMS while another rider may prefer his/her personal computer to receive RTI. Some studies confirm that not all RTI technologies are equal. A study of riders in Calgary, Canada stated that browsing a website was the most preferred method for planning a trip and that preferences could change depending on whether the customer is planning a trip or already en-route [15].

Considering this information, it is recommended that agencies invest in computer-based websites as the best alternative to smartphone applications. While this alternative had the second-highest availability among Metro’s non-smartphone users, it provides more information than IVR, including maps and RTI for multiple routes and stops. However, the combination of two or more alternatives increases the accessibility and availability of RTI. Based on the data provided by Metro and the known resources of the agency, it is suggested to invest in a computer-based website that can be utilized by individual riders as well as call center operators. This way, riders with access to a computer, some of which do not have access to cell phones, will still be able to access RTI. If operators also have access to this technology, they will be able to provide RTI through the agency’s call center, allowing riders who are not in front of, or own, a computer to also access this information. This method will allow 93% of rail and 86% of bus riders without access to smartphone applications to be able to use RTI.

However, it is also suggested that agencies not only consider the other alternative technologies and provide them as a means to access RTI if possible but to also invest in LCD Signage. This research demonstrated that a non-trivial portion of riders do not have access to any technology and rely on these signs to know when their next
bus or train is arriving. Many agencies already have the infrastructure in stations, allowing the integration with RTI to be possible. The placement of these fixed signs can also be strategic, optimizing where they are located based on the demographics of the riders and ridership at specific stops. For example, agencies can identify locations and neighborhoods where riders above 40 years old live and work. LCD Signage can be installed in the more heavily utilized transit stops in these areas and serve these riders, who have been previously identified as more likely to rely on this technology to receive RTI.

### 6.2 Future Research

Future research defining the preferences for using the different RTI technologies among transit riders will better conclude what is the best alternative technology to smartphone applications. This will create a basis of how riders select their preferred technology based on what is available to them, what information can be obtained through that technology, and what they actually use.

Also, due to the constantly evolving world of mobile devices, applications, and the internet, the availability of and preferences for various technologies will change over time. Just as smartphones have evolved from cellular phones over the past decade, the emergence of a new mobile technology could occur, resulting in yet another new alternative to smartphone applications. For example, tablets are becoming an increasingly available technology that has the ability to not only access the internet but download mobile applications [16]. Agencies need to be mindful of these changes and understand the riding population’s access and preferences regarding these technologies.

An additional study investigating these changing ownership trends by forecasting smartphone and cell phone ownership in the sequential years would also be helpful in the decision-making process. By predicting how many riders will have access to
smartphone application RTI in the future, agencies could better understand what alternative technology to invest in and how prevalent this technology will be among transit riders. Agencies can also utilize this research by projecting where these riders will live and work. The placement of LCD Signage in strategic locations, allowing riders without smartphones to access RTI, can also be reflective of these projections and provide support for installation. By understanding not only the ridership population but also how it will change over time, agencies can make better informed decisions and improvements for their riders.
CHAPTER VII

CONCLUSION

This thesis investigated how accessible mobile devices and other supplementary RTI technologies are to transit riders. The ownership of smartphones and other mobile devices has been steadily increasing in recent years among Metro riders, other transit agencies’ riders, and the nation. The majority of Metro riders own smartphones and on the whole, Saint Louis Metro riders have access to one or more alternative technologies.

However, it was found that there are certain demographic groups less likely to own a smartphone, particularly riders over 40 years old. The other RTI technologies available to riders include SMS, IVR, mobile-based websites and computer-based websites. After considering the availability of these technologies among non-smartphone owners and the information each provides, it was concluded that computer-based websites and IVR are the best supplementary technologies to smartphone applications. IVR can be supplemental, as the population with access to phones, both cellular and otherwise, is the largest among transit riders, especially those at-risk categories of riders without access to a smartphone. In all, smartphone applications and other technologies providing RTI are becoming increasingly available and popular among transit riders. By understanding who and how many riders have access to this information, this resource can be better developed and targeted to provide RTI to more riders.
APPENDIX A

SURVEY DESIGN

### 2012 Bus Customer Satisfaction Survey

**COMPLETE SURVEY & ENTER A DRAWING TO WIN A $100 GIFT CERTIFICATE OF YOUR CHOICE!**

As a thank you for providing Metro with your feedback, your name will be entered into a drawing for ten $100 gift certificates. Please circle the gift certificate you would like to receive if you are a winner:

1) Best Buy  2) Wal-Mart  3) Target  4) Metro Transit Passes  5) St. Louis Originals (35 Restaurants)

Please take a moment to provide Metro with your feedback. The information you provide is considered confidential and will be used for research and service improvement purposes only.

<table>
<thead>
<tr>
<th>1) Please rate each feature associated with your experience traveling on Metro <em>BUSES.</em></th>
<th>IMPORTANCE</th>
<th>SATISFACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Buses operate on time</strong></td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td><strong>Ability to make transfer connections</strong></td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td><strong>Ability to travel when and where desired</strong></td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td><strong>Personal security at transit centers and train stations</strong></td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td><strong>Personal security while riding</strong></td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td><strong>Security of cars at park and ride lots</strong></td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td><strong>Ease of paying fare when boarding</strong></td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td><strong>Enforcement of paying fare when boarding</strong></td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td><strong>Availability of benches or shelter at bus stops</strong></td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td><strong>Cleanliness and maintenance of transit centers</strong></td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td><strong>Cleanliness inside buses</strong></td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td><strong>Availability of seating on buses</strong></td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td><strong>Ease of reading printed route schedules</strong></td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td><strong>Helpfulness of Transit Information Call Line</strong></td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td><strong>Helpfulness of Metro website information</strong></td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td><strong>Communication of service changes or disruptions</strong></td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td><strong>Driver courtesy</strong></td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td><strong>Driver clearly announces stops</strong></td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td><strong>Driver ability to safely operate bus</strong></td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td><strong>Value of bus service for fare paid</strong></td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td><strong>Overall quality of bus service</strong></td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td><strong>Overall satisfaction with bus service</strong></td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
</tbody>
</table>

Please turn over and continue – thanks!

Figure 46: Metro Survey - Page 1
2) How do you get information about Metro? (Circle all that apply)
1) www.metrostlouis.org  4) Metro Transit Information Call Line  7) Newspaper/Magazine
2) MetroRide Store  5) NextStopSTL blog  8) Advertising (buses, trains, rail platforms, bus shelters)
3) Radio  6) Printed transit schedules  9) Other: ____________________

3) If you need information to plan a trip, do you prefer to use:
1) Transit Information Call Line  3) Printed schedules  5) Google Transit  7) HopStop
2) Metro Website’s TripFinder  4) NextStopSTL blog  6) Bing Transit  8) Other: ____________________

4) What type of cell phone do you mainly use?
1) iPhone  2) Blackberry  3) Android-based  4) Windows 7-based  5) Non-Smartphone  6) Don’t use a cell phone
   → If you use a cell phone, does it have internet access that you use?  Yes  No
   → If you use a cell phone, does it have a text messaging ability that you use?  Yes  No

5) Do you have internet access from a computer at home, work, school, or other place? Yes  No

6) Why did you use Metro today instead of another way of traveling? (Circle all that apply)
1) Good for the environment  5) I do not drive  9) Convenience
2) Better use of time  6) No car, truck, or motorcycle available to use
3) Faster than driving  7) My employer offers a transit benefit  10) Other: ____________________
4) Cheaper than driving  8) Want to avoid road construction/congestion

7) How many days per week do you use Metro Transit?  1  2  3  4  5  6  7  Don’t use it every week  1st time riding

8) How many total transfers between bus-bus, bus-rail, or rail-rail are you making on this one-way trip?  0  1  2  3+  4

9) How long have you been using Metro Transit?  1) Less than 1 year  2) 1 - 2 yrs  3) 3 - 5 yrs  4) More than 5 yrs

10) Do you expect to be using Metro Transit one (1) year from now? Yes  No

11) Would you recommend Metro bus service to others?  1) Definitely not  2) Probably not  3) Possibly  4) Probably  5) Definitely

12) I am: Male  Female

13) I am:  1) Black/African American  2) White/Caucasian  3) Latino/Hispanic American  4) Asian/Asian American  5) Other

14) My age is:  □18 or under  □19 - 24  □25 - 30  □31 - 35  □36 - 40  □41 - 45  □46 - 50  □51 - 64  □65 - 74  □75+

15) I am (circle all that apply):  1) Employed Full-Time  2) Employed Part-Time  3) Unemployed  4) Student  5) Homemaker  6) Retired

16) Including yourself, how many people live in your household?  

17) What was your combined household income before taxes in 2011?
1) Under $20,000  2) $20,000 - $39,999  3) $40,000 - $59,999  4) $60,000 - $79,999  5) $80,000 - $99,999  6) $100,000 or more

18) What is the zip code where you live?  

19) What is the zip code where you work?  

CONTACT INFORMATION HELD CONFIDENTIAL!  **Price Drawing Contact Information – Winners will be contacted by 7/31/12**
First & Last Name: __________________________ Street Address: __________________________
City: __________________________ State: __________ Zip: __________
Phone Number: __________________________ Email: __________________________

If you would prefer to mail your postage-paid survey, simply fold the survey in half, seal the edge, and drop in the mail.
You may also scan and email the survey to: researchrider@metrostlouisorg

Figure 47: Metro Survey - Page 2
APPENDIX B

TECHNOLOGY ACCESSIBILITY BY DEMOGRAPHIC CHARACTERISTICS: ALL TRANSIT AGENCIES

B.1 CTA

With a survey conducted in 2012, CTA’s survey questions included the ownership of smartphone, cell phone for texting, and computer internet access.

B.1.1 Cell Phone Type

Tables referring to the following analysis are provided in Tables 15 - 18.

As with the findings from Saint Louis Metro’s survey, as age increases, the percentage of riders with cell phones and smartphone decreases. However, this trend among CTA riders is more drastic, with overall percentages being lower than Saint Louis Metro’s.

In addition, while there is no notable difference between male and female ownership of cell phones, there is nearly a ten percentage different in smartphone ownership. There was a minimal difference of cell phone ownership and gender among Saint Louis transit riders as well as other agencies.

The income distribution shows that as income increases, the percentage of riders with a smartphone increases while the percentage of riders who do not own a cell phone decreases. However, the percentage of riders with a cell phone for texting does not greatly fluctuate between different income brackets.

Another difference from Saint Louis Metro and CTA is the cross tabulations between cell phone type and race. As will be seen among Saint Louis Metro riders,
White / Caucasians generally exhibited the lowest percentage of smartphone ownership; however, among CTA riders, they are the highest with African Americans having the lowest percentage. However, there is not a drastic difference among these different ethnicities in regards to the percentage of riders who overall own or do not use a cell phone.

Table 15: Cell Phone Ownership Among CTA Riders Based on Age

<table>
<thead>
<tr>
<th>Age</th>
<th>Cellphone for Texting</th>
<th>Smartphone</th>
<th>No Cell Phone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 18 Years old</td>
<td>75%</td>
<td>35%</td>
<td>4%</td>
</tr>
<tr>
<td>18-24</td>
<td>85%</td>
<td>55%</td>
<td>1%</td>
</tr>
<tr>
<td>24-29</td>
<td>79%</td>
<td>66%</td>
<td>1%</td>
</tr>
<tr>
<td>30-34</td>
<td>78%</td>
<td>66%</td>
<td>1%</td>
</tr>
<tr>
<td>35-39</td>
<td>75%</td>
<td>58%</td>
<td>2%</td>
</tr>
<tr>
<td>40-44</td>
<td>73%</td>
<td>50%</td>
<td>2%</td>
</tr>
<tr>
<td>45-49</td>
<td>75%</td>
<td>37%</td>
<td>8%</td>
</tr>
<tr>
<td>50-54</td>
<td>70%</td>
<td>30%</td>
<td>11%</td>
</tr>
<tr>
<td>55-59</td>
<td>64%</td>
<td>25%</td>
<td>14%</td>
</tr>
<tr>
<td>60-64</td>
<td>53%</td>
<td>25%</td>
<td>22%</td>
</tr>
<tr>
<td>65 and older</td>
<td>43%</td>
<td>24%</td>
<td>26%</td>
</tr>
</tbody>
</table>

Table 16: Cell Phone Ownership Among CTA Riders Based on Gender

<table>
<thead>
<tr>
<th>Gender</th>
<th>Cellphone for Texting</th>
<th>Smartphone</th>
<th>No Cell Phone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>75%</td>
<td>45%</td>
<td>6%</td>
</tr>
<tr>
<td>Male</td>
<td>72%</td>
<td>54%</td>
<td>7%</td>
</tr>
</tbody>
</table>
Table 17: Cell Phone Ownership Among CTA Riders Based on Income

<table>
<thead>
<tr>
<th>Income</th>
<th>Cellphone for Texting</th>
<th>Smartphone</th>
<th>No Cell Phone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than $11,000</td>
<td>73%</td>
<td>23%</td>
<td>10%</td>
</tr>
<tr>
<td>$11,000-$15,000</td>
<td>72%</td>
<td>32%</td>
<td>12%</td>
</tr>
<tr>
<td>$15,000-$25,000</td>
<td>78%</td>
<td>32%</td>
<td>8%</td>
</tr>
<tr>
<td>$25,000-$40,000</td>
<td>76%</td>
<td>43%</td>
<td>8%</td>
</tr>
<tr>
<td>$40,000-$60,000</td>
<td>72%</td>
<td>51%</td>
<td>5%</td>
</tr>
<tr>
<td>$60,000-$75,000</td>
<td>75%</td>
<td>58%</td>
<td>4%</td>
</tr>
<tr>
<td>$75,000-$100,000</td>
<td>72%</td>
<td>67%</td>
<td>5%</td>
</tr>
<tr>
<td>$110,000-$125,000</td>
<td>75%</td>
<td>68%</td>
<td>4%</td>
</tr>
<tr>
<td>$125,000-150,000</td>
<td>73%</td>
<td>76%</td>
<td>2%</td>
</tr>
<tr>
<td>$150,000-$200,000</td>
<td>76%</td>
<td>78%</td>
<td>3%</td>
</tr>
<tr>
<td>$200,000 or More</td>
<td>75%</td>
<td>77%</td>
<td>2%</td>
</tr>
</tbody>
</table>

Table 18: Cell Phone Ownership Among CTA Riders Based on Race

<table>
<thead>
<tr>
<th>Race</th>
<th>Cellphone for Texting</th>
<th>Smartphone</th>
<th>No Cell Phone</th>
</tr>
</thead>
<tbody>
<tr>
<td>African-American</td>
<td>75%</td>
<td>30%</td>
<td>8%</td>
</tr>
<tr>
<td>White/Caucasian</td>
<td>73%</td>
<td>61%</td>
<td>5%</td>
</tr>
<tr>
<td>Hispanic/Latino</td>
<td>70%</td>
<td>48%</td>
<td>9%</td>
</tr>
<tr>
<td>Asian/Pacific Is.</td>
<td>68%</td>
<td>52%</td>
<td>6%</td>
</tr>
<tr>
<td>Other (non-white)</td>
<td>70%</td>
<td>49%</td>
<td>5%</td>
</tr>
</tbody>
</table>

B.1.2 Internet Access in General

Tables referring to the following analysis are provided in Tables 19 - 22.

Among CTA riders, as age increases, the percentage of riders with internet access in general decreases. While this was also true among Saint Louis Metro riders, there is a more notable decrease among CTA riders. Also, these percentages are higher when
compared to Saint Louis Metro, implying that, as a whole, CTA riders are more likely to have computer internet access.

As for the cross tabulation between gender and internet access in general, there is absolutely no difference, which is similar to Saint Louis Metro’s distribution.

The cross tabulation between race and internet access displays that there is no notable difference between ethnicities besides African Americans. While the percentage difference among the different races was more apparent for Saint Louis Metro riders, Black / African Americans were the least likely to have internet access in general, similar to CTA riders.

Table 19: Computer Internet Access Among CTA Riders Based on Age

<table>
<thead>
<tr>
<th>Age</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 18 Years old</td>
<td>98%</td>
<td>2%</td>
</tr>
<tr>
<td>18-24</td>
<td>97%</td>
<td>3%</td>
</tr>
<tr>
<td>24-29</td>
<td>98%</td>
<td>2%</td>
</tr>
<tr>
<td>30-34</td>
<td>98%</td>
<td>2%</td>
</tr>
<tr>
<td>35-39</td>
<td>96%</td>
<td>4%</td>
</tr>
<tr>
<td>40-44</td>
<td>95%</td>
<td>5%</td>
</tr>
<tr>
<td>45-49</td>
<td>93%</td>
<td>7%</td>
</tr>
<tr>
<td>50-54</td>
<td>88%</td>
<td>12%</td>
</tr>
<tr>
<td>55-59</td>
<td>87%</td>
<td>13%</td>
</tr>
<tr>
<td>60-64</td>
<td>83%</td>
<td>17%</td>
</tr>
<tr>
<td>65 and older</td>
<td>80%</td>
<td>20%</td>
</tr>
</tbody>
</table>
Table 20: Computer Internet Access Among CTA Riders Based on Gender

<table>
<thead>
<tr>
<th>Gender</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>93%</td>
<td>7%</td>
</tr>
<tr>
<td>Male</td>
<td>93%</td>
<td>7%</td>
</tr>
</tbody>
</table>

Table 21: Computer Internet Access Among CTA Riders Based on Income

<table>
<thead>
<tr>
<th>Income</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than $11,000</td>
<td>79%</td>
<td>21%</td>
</tr>
<tr>
<td>$11,000-$15,000</td>
<td>82%</td>
<td>18%</td>
</tr>
<tr>
<td>$15,000-$25,000</td>
<td>91%</td>
<td>9%</td>
</tr>
<tr>
<td>$25,000-$40,000</td>
<td>95%</td>
<td>5%</td>
</tr>
<tr>
<td>$40,000-$60,000</td>
<td>98%</td>
<td>2%</td>
</tr>
<tr>
<td>$60,000-$75,000</td>
<td>99%</td>
<td>1%</td>
</tr>
<tr>
<td>$75,000-$100,000</td>
<td>99%</td>
<td>1%</td>
</tr>
<tr>
<td>$110,000-$125,000</td>
<td>100%</td>
<td>0%</td>
</tr>
<tr>
<td>$125,000-150,000</td>
<td>100%</td>
<td>0%</td>
</tr>
<tr>
<td>$150,000-$200,000</td>
<td>98%</td>
<td>2%</td>
</tr>
<tr>
<td>$200,000 or More</td>
<td>100%</td>
<td>0%</td>
</tr>
</tbody>
</table>

Table 22: Computer Internet Access Among CTA Riders Based on Race

<table>
<thead>
<tr>
<th>Race</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>African-American</td>
<td>86%</td>
<td>14%</td>
</tr>
<tr>
<td>White/Caucasian</td>
<td>98%</td>
<td>2%</td>
</tr>
<tr>
<td>Hispanic/Latino</td>
<td>94%</td>
<td>6%</td>
</tr>
<tr>
<td>Asian/Pacific Is.</td>
<td>97%</td>
<td>3%</td>
</tr>
<tr>
<td>Other (non-white)</td>
<td>97%</td>
<td>3%</td>
</tr>
</tbody>
</table>
B.2 LAC MTA

The cross tabulations provided by LAC MTA included two technology questions, cell phone ownership and smartphone ownership, which were compared against age, gender, race, and income. This survey was completed in 2012, the same year as the first Saint Louis Metro survey.

B.2.1 Cell Phone Ownership

Tables referring to the following analysis are provided in Tables 23 - 26.

For the cross tabulation between age and cell phone ownership, there is a slight decrease in the percentage of riders with cell phones as age increases. Similarly to the percentage distribution from Saint Louis Metro’s survey, this decrease is most notable for those older than 50 years old. Also, riders under 18 years old do not necessarily follow this trend, most likely due to parental restrictions.

Also similar to Saint Louis Metro is the gender distribution which has a fairly equal percentage of cell phone ownership between males and females.

Among LAC MTA riders, there are a slightly higher percentage of Black riders with cell phone when compared to White riders. This difference is more apparent among Saint Louis Metro riders. However, nearly all of Saint Louis Metro’s Asian / Pacific Islander riders had access to a cell phone while this ethnic group has the lowest percentage of riders with cell phones when compared to other LAC MTA riders.

As for income and cell phone ownership, generally as income increases so does cell phone ownership. This relationship is more apparent among LAC MTA riders when compared to Saint Louis Metro riders.

While the riders of these two agencies, generally, follow the same trend, there are a greater percentage of Saint Louis Metro riders with access to cell phones when compared to LAC MTA riders.
Table 23: Cell Phone Ownership Among LAC MTA Riders Based on Age

<table>
<thead>
<tr>
<th>Age</th>
<th>Have Cell Phone</th>
<th>No Cell Phone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 18</td>
<td>73%</td>
<td>27%</td>
</tr>
<tr>
<td>18 - 22</td>
<td>80%</td>
<td>20%</td>
</tr>
<tr>
<td>23 - 49</td>
<td>79%</td>
<td>21%</td>
</tr>
<tr>
<td>50 - 64</td>
<td>72%</td>
<td>28%</td>
</tr>
<tr>
<td>65 +</td>
<td>59%</td>
<td>41%</td>
</tr>
</tbody>
</table>

Table 24: Cell Phone Ownership Among LAC MTA Riders Based on Gender

<table>
<thead>
<tr>
<th>Gender</th>
<th>Have Cell Phone</th>
<th>No Cell Phone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>76%</td>
<td>24%</td>
</tr>
<tr>
<td>Female</td>
<td>78%</td>
<td>22%</td>
</tr>
</tbody>
</table>

Table 25: Cell Phone Ownership Among LAC MTA Riders Based on Income

<table>
<thead>
<tr>
<th>Income</th>
<th>Have Cell Phone</th>
<th>No Cell Phone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under $15,000</td>
<td>73%</td>
<td>27%</td>
</tr>
<tr>
<td>$15,000 - $24,999</td>
<td>78%</td>
<td>22%</td>
</tr>
<tr>
<td>$25,000 - $34,999</td>
<td>79%</td>
<td>21%</td>
</tr>
<tr>
<td>$35,000 - $49,999</td>
<td>83%</td>
<td>17%</td>
</tr>
<tr>
<td>$50,000 - $99,999</td>
<td>83%</td>
<td>17%</td>
</tr>
<tr>
<td>$100,000 +</td>
<td>85%</td>
<td>15%</td>
</tr>
</tbody>
</table>
Table 26: Cell Phone Ownership Among LAC MTA Riders Based on Race

<table>
<thead>
<tr>
<th>Race</th>
<th>Have Cell Phone</th>
<th>No Cell Phone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black</td>
<td>83%</td>
<td>17%</td>
</tr>
<tr>
<td>White</td>
<td>79%</td>
<td>21%</td>
</tr>
<tr>
<td>Latino</td>
<td>74%</td>
<td>26%</td>
</tr>
<tr>
<td>Asian / Pacific Is.</td>
<td>70%</td>
<td>30%</td>
</tr>
<tr>
<td>American Indian</td>
<td>83%</td>
<td>17%</td>
</tr>
<tr>
<td>Other</td>
<td>79%</td>
<td>21%</td>
</tr>
</tbody>
</table>

B.2.2 Smartphone Ownership

Tables referring to the following analysis are provided in Tables 27 - 30.

Please note, this data is only for those with cell phones. In other words, riders without cell phones are not included in these percentages.

For the comparison of smartphone ownership and age, generally as age increases the percentage of smartphone ownership decreases. This is especially true for riders over the age of 50. Not only is this trend also true for Saint Louis Metro, but the percentage of smartphone ownership is more or less the same.

Similar to Saint Louis Metro’s survey results, the distribution of males and females in regards to smartphone ownership is fairly equal among LAC MTA riders.

Among LAC MTA riders, the ethnic group with the highest percentage of smartphone ownership is American Indians, with Whites displaying the lowest percentage. However, the ethnic group ‘Other’ did not have the highest percentage of smartphone ownership among Saint Louis Metro riders but had fairly higher percentages among LAC MTA riders, comparatively. One similarity was among Whites and Asian / Pacific Islanders, who, among LAC MTA and Saint Louis Metro riders, displayed a low percentage of smartphone ownership when compared with other ethnic groups.

There does not appear to be a drastic change in the percentage of smartphone
owners among the different income brackets. While there was an increase in the percentage of smartphone owners as income increased among Saint Louis Metro riders, this trend was minimal and tests showed that there was no consistent statistical relationship between income and smartphone ownership.

Table 27: Smartphone Ownership Among LAC MTA Riders Based on Age

<table>
<thead>
<tr>
<th>Age</th>
<th>Smartphone</th>
<th>Non-Smartphone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 18</td>
<td>74%</td>
<td>26%</td>
</tr>
<tr>
<td>18 - 22</td>
<td>80%</td>
<td>20%</td>
</tr>
<tr>
<td>23 - 49</td>
<td>80%</td>
<td>20%</td>
</tr>
<tr>
<td>50 - 64</td>
<td>58%</td>
<td>42%</td>
</tr>
<tr>
<td>65 +</td>
<td>49%</td>
<td>51%</td>
</tr>
</tbody>
</table>

Table 28: Smartphone Ownership Among LAC MTA Riders Based on Gender

<table>
<thead>
<tr>
<th>Gender</th>
<th>Smartphone</th>
<th>Non-Smartphone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>76%</td>
<td>24%</td>
</tr>
<tr>
<td>Female</td>
<td>75%</td>
<td>25%</td>
</tr>
</tbody>
</table>

Table 29: Smartphone Ownership Among LAC MTA Riders Based on Income

<table>
<thead>
<tr>
<th>Income</th>
<th>Smartphone</th>
<th>Non-Smartphone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under $15,000</td>
<td>74%</td>
<td>26%</td>
</tr>
<tr>
<td>$15,000 - $24,999</td>
<td>76%</td>
<td>24%</td>
</tr>
<tr>
<td>$25,000 - $34,999</td>
<td>79%</td>
<td>21%</td>
</tr>
<tr>
<td>$35,000 - $49,999</td>
<td>76%</td>
<td>24%</td>
</tr>
<tr>
<td>$50,000 - $99,999</td>
<td>78%</td>
<td>22%</td>
</tr>
<tr>
<td>$100,000 +</td>
<td>79%</td>
<td>21%</td>
</tr>
</tbody>
</table>
Table 30: Smartphone Ownership Among LAC MTA Riders Based on Race

<table>
<thead>
<tr>
<th>Race</th>
<th>Smartphone</th>
<th>Non-Smartphone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black</td>
<td>76%</td>
<td>24%</td>
</tr>
<tr>
<td>White</td>
<td>69%</td>
<td>31%</td>
</tr>
<tr>
<td>Latino</td>
<td>76%</td>
<td>24%</td>
</tr>
<tr>
<td>Asian / Pacific Is.</td>
<td>71%</td>
<td>29%</td>
</tr>
<tr>
<td>American Indian</td>
<td>81%</td>
<td>19%</td>
</tr>
<tr>
<td>Other</td>
<td>80%</td>
<td>20%</td>
</tr>
</tbody>
</table>
B.3 TriMet

The cross tabulations provided by TriMet included one technology question, smartphone ownership, which was compared against four demographics: age, gender, race, and income. This survey was conducted in 2009.

B.3.1 Cell Phone Type

Tables referring to the following analysis are provided in Tables 31 - 34.

Unlike the other transit agencies, there is no strong trend between age and cell phone ownership. There is a slight decrease in smartphone ownership as age increases, but this only becomes apparent for riders older than 25 years old. Likewise, there is no overall trend between age and non-smartphone ownership as well as age and not using a cell phone. Saint Louis Metro has a stronger relationship between age and cell phone type.

For the cross tabulation between cell phone type and gender, however, there is no noticeable difference between males and females. While this is also true for Saint Louis Metro riders, there is a much higher percentage of smartphone owners in general when compared to TriMet riders.

Unlike the trend displayed by Saint Louis Metro riders, there is a noticeable relationship between TriMet’s riders in terms of income and cell phone type. As income increases, the percentage of smartphone ownership drastically increases and the percentage of riders that do not use a cell phone decreases. This trend was only slightly represented by Saint Louis Metro riders and was found to not be statistically significant.

Among TriMet riders, the ethnic group with the highest percentage of smartphone ownership is Black / African Americans and Other, which is more or less true among Saint Louis Metro riders. However, the ethnic group with the next highest percentage is White / Caucasians, who actually have the lowest percentage of smartphone
ownership among Saint Louis Metro riders.

Table 31: Cell Phone Ownership Among TriMet Riders Based on Age

<table>
<thead>
<tr>
<th>Age</th>
<th>Smartphone</th>
<th>Non-Smartphone</th>
<th>No Cell Phone</th>
</tr>
</thead>
<tbody>
<tr>
<td>16 to 17</td>
<td>19%</td>
<td>69%</td>
<td>13%</td>
</tr>
<tr>
<td>18 to 24</td>
<td>25%</td>
<td>64%</td>
<td>11%</td>
</tr>
<tr>
<td>25 to 34</td>
<td>32%</td>
<td>56%</td>
<td>12%</td>
</tr>
<tr>
<td>35 to 44</td>
<td>27%</td>
<td>58%</td>
<td>14%</td>
</tr>
<tr>
<td>45 to 54</td>
<td>20%</td>
<td>67%</td>
<td>13%</td>
</tr>
<tr>
<td>55 to 64</td>
<td>23%</td>
<td>59%</td>
<td>18%</td>
</tr>
<tr>
<td>65 +</td>
<td>11%</td>
<td>72%</td>
<td>17%</td>
</tr>
</tbody>
</table>

Table 32: Cell Phone Ownership Among TriMet Riders Based on Gender

<table>
<thead>
<tr>
<th>Gender</th>
<th>Smartphone</th>
<th>Non-Smartphone</th>
<th>No Cell Phone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>26%</td>
<td>61%</td>
<td>12%</td>
</tr>
<tr>
<td>Female</td>
<td>21%</td>
<td>63%</td>
<td>16%</td>
</tr>
</tbody>
</table>

Table 33: Cell Phone Ownership Among TriMet Riders Based on Income

<table>
<thead>
<tr>
<th>Income</th>
<th>Smartphone</th>
<th>Non-Smartphone</th>
<th>No Cell Phone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than $20,000</td>
<td>9%</td>
<td>50%</td>
<td>41%</td>
</tr>
<tr>
<td>$20,000 to $39,999</td>
<td>18%</td>
<td>62%</td>
<td>19%</td>
</tr>
<tr>
<td>$40,000 to $59,999</td>
<td>15%</td>
<td>75%</td>
<td>11%</td>
</tr>
<tr>
<td>$60,000 to $99,999</td>
<td>21%</td>
<td>71%</td>
<td>8%</td>
</tr>
<tr>
<td>$100,000 +</td>
<td>49%</td>
<td>46%</td>
<td>5%</td>
</tr>
<tr>
<td>Race</td>
<td>Smartphone</td>
<td>Non-Smartphone</td>
<td>No Cell Phone</td>
</tr>
<tr>
<td>-----------------------</td>
<td>------------</td>
<td>----------------</td>
<td>---------------</td>
</tr>
<tr>
<td>Black / African American</td>
<td>33%</td>
<td>61%</td>
<td>6%</td>
</tr>
<tr>
<td>White / Caucasian</td>
<td>25%</td>
<td>63%</td>
<td>12%</td>
</tr>
<tr>
<td>Latino / Hispanic American</td>
<td>18%</td>
<td>50%</td>
<td>31%</td>
</tr>
<tr>
<td>Asian / Asian American</td>
<td>10%</td>
<td>81%</td>
<td>10%</td>
</tr>
<tr>
<td>Native American</td>
<td>13%</td>
<td>75%</td>
<td>13%</td>
</tr>
<tr>
<td>Pacific Islander</td>
<td>0%</td>
<td>80%</td>
<td>20%</td>
</tr>
<tr>
<td>Bi-racial / Multi-racial</td>
<td>29%</td>
<td>51%</td>
<td>20%</td>
</tr>
<tr>
<td>Other</td>
<td>50%</td>
<td>50%</td>
<td>0%</td>
</tr>
</tbody>
</table>
B.4 United States

Tables referring to the following analysis are provided in Tables 35 - 38.

B.4.1 Smartphone Ownership

The most recent smartphone ownership data was from 2013. Similar to the transit agencies, as age increases, the percentage of smartphone ownership decreases. More so, this decrease is more noticeable among all Americans then when compared to transit riders. The decrease of smartphone ownership in regards to age is more gradual among transit riders while this cross tabulation decreases by over 60% between 18 and 65 year olds. Also, the percentage of smartphone ownership for those older than 35 becomes noticeably lower than what was displayed by Saint Louis Metro riders. This suggests that, on a whole, transit riders are more likely to own a smartphone, especially for the older population.

As for gender, there is no noticeable difference between males and females in terms of smartphone ownership.

Unlike the trend displayed by Saint Louis Metro, as income increases among Americans, so does the percentage of smartphone ownership. The difference between lower and higher income smartphone ownership is especially noticeable with Americans earning more than $75,000 over 80% more likely to own a smartphone when compared to Americans earning less than $30,000. This percentage difference among Saint Louis Metro riders was only an increase of 10% in 2012.

Similar to Saint Louis Metro, Blacks are the race most likely to own smartphones with Whites exhibiting the lowest percentage. While the trend is similar, this smartphone ownership is more than ten percent lower when compared to Saint Louis Metro.
Table 35: Smartphone Ownership Among Americans Based on Age

<table>
<thead>
<tr>
<th>Age</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>18 - 24</td>
<td>79%</td>
<td>21%</td>
</tr>
<tr>
<td>25 - 34</td>
<td>81%</td>
<td>19%</td>
</tr>
<tr>
<td>35 - 44</td>
<td>69%</td>
<td>31%</td>
</tr>
<tr>
<td>45 - 54</td>
<td>55%</td>
<td>45%</td>
</tr>
<tr>
<td>55 - 64</td>
<td>39%</td>
<td>61%</td>
</tr>
<tr>
<td>65+</td>
<td>18%</td>
<td>82%</td>
</tr>
</tbody>
</table>

Table 36: Smartphone Ownership Among Americans Based on Gender

<table>
<thead>
<tr>
<th>Gender</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td>59%</td>
<td>41%</td>
</tr>
<tr>
<td>Women</td>
<td>53%</td>
<td>47%</td>
</tr>
</tbody>
</table>

Table 37: Smartphone Ownership Among Americans Based on Income

<table>
<thead>
<tr>
<th>Income</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than $30,000</td>
<td>43%</td>
<td>57%</td>
</tr>
<tr>
<td>$30,000 - $49,999</td>
<td>52%</td>
<td>48%</td>
</tr>
<tr>
<td>$50,000 - $74,999</td>
<td>61%</td>
<td>39%</td>
</tr>
<tr>
<td>$75,000 +</td>
<td>78%</td>
<td>22%</td>
</tr>
</tbody>
</table>

Table 38: Smartphone Ownership Among Americans Based on Race

<table>
<thead>
<tr>
<th>Race</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>White, Non-Hispanic</td>
<td>53%</td>
<td>47%</td>
</tr>
<tr>
<td>Black, Non-Hispanic</td>
<td>64%</td>
<td>36%</td>
</tr>
<tr>
<td>Hispanic</td>
<td>60%</td>
<td>40%</td>
</tr>
</tbody>
</table>
B.4.2 Internet on Cell Phone

Tables referring to the following analysis are provided in Tables 39 - 42.

Reports publishing the cross tabulation between internet on cell phone and demographics is from 2012. While the cross tabulation between age and internet on cell phone displays an inverse relationship, the change in percentage between those older than 65 and between 18 to 29 is sustainable with an increase of 500%. While this relationship is strong among Saint Louis Metro riders, it is not this drastic.

Similar to the other cross tabulations between gender and communication technologies, there is no notable difference between males and females in regards to internet on cell phones.

The trend among Americans is, as income increases, the percentage of smartphone ownership increases as well. This is especially true between the categories of $50,000 - $74,999 and $75,000 +. In comparison, there was no overall trend for Saint Louis Metro riders.

Also similar to the smartphone ownership distribution, Whites are the most likely to not have internet on their cell phone. Also, Hispanics are the most likely to have access to this technology, which is similar to Saint Louis Metro riders.

Table 39: Internet on Cell Phone Among Americans Based on Age

<table>
<thead>
<tr>
<th>Age</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>18 - 29</td>
<td>77%</td>
<td>23%</td>
</tr>
<tr>
<td>30 - 49</td>
<td>69%</td>
<td>31%</td>
</tr>
<tr>
<td>50 - 64</td>
<td>40%</td>
<td>60%</td>
</tr>
<tr>
<td>65 +</td>
<td>13%</td>
<td>87%</td>
</tr>
</tbody>
</table>
Table 40: Internet on Cell Phone Among Americans Based on Gender

<table>
<thead>
<tr>
<th>Gender</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td>57%</td>
<td>43%</td>
</tr>
<tr>
<td>Women</td>
<td>56%</td>
<td>44%</td>
</tr>
</tbody>
</table>

Table 41: Internet on Cell Phone Among Americans Based on Income

<table>
<thead>
<tr>
<th>Income</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than $30,000</td>
<td>52%</td>
<td>48%</td>
</tr>
<tr>
<td>$30,000 - $49,999</td>
<td>51%</td>
<td>49%</td>
</tr>
<tr>
<td>$50,000 - $74,999</td>
<td>60%</td>
<td>40%</td>
</tr>
<tr>
<td>$75,000 +</td>
<td>71%</td>
<td>29%</td>
</tr>
</tbody>
</table>

Table 42: Internet on Cell Phone Among Americans Based on Race

<table>
<thead>
<tr>
<th>Race</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>White, Non-Hispanic</td>
<td>52%</td>
<td>48%</td>
</tr>
<tr>
<td>Black, Non-Hispanic</td>
<td>60%</td>
<td>40%</td>
</tr>
<tr>
<td>Hispanic</td>
<td>66%</td>
<td>34%</td>
</tr>
</tbody>
</table>

B.4.3 Text Messaging on Cell Phone

Tables referring to the following analysis are provided in Tables 43-46.

The data for this cross tabulation was also gathered from 2012 reports. While Americans between 18 and 49 have a very high percentage of text messaging availability, it quickly drops off to 72% then 34% among those 50 to 64 years old and 65 and over, respectively. This drop is also seen among Saint Louis Metro riders, though not as drastic.
Similar to the other cross tabulations there is no notable difference between males and females in regards to text messaging availability.

Among Saint Louis Metro riders, there is no notable trend between income and text message capabilities, with availability around 90%. Among all Americans, there is an inverse relationship between text messaging and income; as income increases, the availability of text messaging increases as well. This change occurs and is most notable around the income of $50,000.

Similar to Saint Louis, the cross tabulation between race and text messaging availability are fairly similar between different groups. Latino / Hispanic Americas do have the highest availability when compared to other groups and, for both Saint Louis and the United States, Whites have the smallest percentage though not drastically lower than the other groups.

Table 43: Text Messaging Cell Phone Among Americans Based on Age

<table>
<thead>
<tr>
<th>Age</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>18 - 29</td>
<td>97%</td>
<td>3%</td>
</tr>
<tr>
<td>30 - 49</td>
<td>92%</td>
<td>8%</td>
</tr>
<tr>
<td>50 - 64</td>
<td>72%</td>
<td>28%</td>
</tr>
<tr>
<td>65 +</td>
<td>34%</td>
<td>66%</td>
</tr>
</tbody>
</table>

Table 44: Text Messaging Cell Phone Among Americans Based on Gender

<table>
<thead>
<tr>
<th>Gender</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td>81%</td>
<td>19%</td>
</tr>
<tr>
<td>Women</td>
<td>80%</td>
<td>20%</td>
</tr>
</tbody>
</table>
Table 45: Text Messaging Cell Phone Among Americans Based on Income

<table>
<thead>
<tr>
<th>Income</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than $30,000</td>
<td>78%</td>
<td>22%</td>
</tr>
<tr>
<td>$30,000 - $49,999</td>
<td>78%</td>
<td>22%</td>
</tr>
<tr>
<td>$50,000 - $74,999</td>
<td>89%</td>
<td>11%</td>
</tr>
<tr>
<td>$75,000 +</td>
<td>90%</td>
<td>10%</td>
</tr>
</tbody>
</table>

Table 46: Text Messaging Cell Phone Among Americans Based on Race

<table>
<thead>
<tr>
<th>Race</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>White, Non-Hispanic</td>
<td>79%</td>
<td>21%</td>
</tr>
<tr>
<td>Black, Non-Hispanic</td>
<td>80%</td>
<td>20%</td>
</tr>
<tr>
<td>Hispanic</td>
<td>85%</td>
<td>15%</td>
</tr>
</tbody>
</table>
APPENDIX C

ALTERNATIVE TECHNOLOGIES BY DEMOGRAPHIC CHARACTERISTICS: SAINT LOUIS METRO

C.1 Mobile Website

Graphs referring to the following analysis are provided in Figures 48 to 67.

Among bus and rail riders, there is a definite relationship between age and access to mobile websites. This is especially true among riders who are older than 40 years old with approximately 50% possessing this technology. For riders under 40, access to this technology is fairly consistent. Regarding employment status, riders who are employed and/or are students are the most likely to have the ability to use this technology. Of the remaining groups, riders who are retired exhibit the lowest percentage of mobile website accessibility. Similar to smartphone ownership, there is a fairly minimal relationship between income and access to mobile websites. Overall, the percentage of riders with access to this alternative is fairly steady across all income brackets. Concerning ethnicities, White / Caucasians are the least likely to have access to this technology.
C.1.1 Age

Figure 48: Mobile Website Access based on Age - Bus 2012

Figure 49: Mobile Website Access based on Age - Bus 2013
Figure 50: Mobile Website Access based on Age - Rail 2012

Figure 51: Mobile Website Access based on Age - Rail 2013
C.1.2 Race

Figure 52: Mobile Website Access based on Race - Bus 2012

Figure 53: Mobile Website Access based on Race - Bus 2013
Figure 54: Mobile Website Access based on Race - Rail 2012

Figure 55: Mobile Website Access based on Race - Rail 2013
C.1.3 Income

Figure 56: Mobile Website Access based on Income - Bus 2012

Figure 57: Mobile Website Access based on Income - Bus 2013

101
Figure 58: Mobile Website Access based on Income - Rail 2012

Figure 59: Mobile Website Access based on Income - Rail 2013
C.1.4 Employment

![Bar chart for employment status](image)

Figure 60: Mobile Website Access based on Employment - Bus 2012

![Bar chart for employment status](image)

Figure 61: Mobile Website Access based on Employment - Bus 2013
Figure 62: Mobile Website Access based on Employment - Rail 2012

Figure 63: Mobile Website Access based on Employment - Rail 2013
C.1.5 Gender

![Bar chart showing mobile website access based on gender for Bus 2012.]

Figure 64: Mobile Website Access based on Gender - Bus 2012

![Bar chart showing mobile website access based on gender for Bus 2013.]

Figure 65: Mobile Website Access based on Gender - Bus 2013
Figure 66: Mobile Website Access based on Gender - Rail 2012

Figure 67: Mobile Website Access based on Gender - Rail 2013
C.2 Text Messaging

Graphs referring to the following analysis are provided in Figures 68 to 87.

The trend regarding the age of riders and the ability to send and receive text messages is not as consistent as was seen in the smartphone distribution. Until around the age of 50, there is a high and steady portion of riders able to use a SMS service. After this age, however, there is a decrease in text messaging accessibility. Still, the majority of these riders still have the ability to use this service. While riders who are employed and/or students are the most likely to have access to text messaging, there is still a large portion of riders unemployed or who are homemakers with this technology. Across all modes and years, riders who are retired are the least likely to access SMS. Regarding riders with different household incomes, there is no trend. The level of an individual’s income does not dictate an individuals’ ability to access text messaging. Among bus riders, White / Caucasians had the lowest percentage of text messaging access, though a majority of these riders still have access. On the other hand, rail riders’ ability to send and receive text messages is fairly consistent among all ethnic groups.
C.2.1 Age

Figure 68: Text Messaging Access based on Age - Bus 2012

Figure 69: Text Messaging Access based on Age - Bus 2013
Figure 70: Text Messaging Access based on Age - Rail 2012

Figure 71: Text Messaging Access based on Age - Rail 2013
C.2.2 Race

Figure 72: Text Messaging Access based on Race - Bus 2012

Figure 73: Text Messaging Access based on Race - Bus 2013
Figure 74: Text Messaging Access based on Race - Rail 2012

Figure 75: Text Messaging Access based on Race - Rail 2013
C.2.3 Income

Figure 76: Text Messaging Access based on Income - Bus 2012

Figure 77: Text Messaging Access based on Income - Bus 2013
Figure 78: Text Messaging Access based on Income - Rail 2012

Figure 79: Text Messaging Access based on Income - Rail 2013
C.2.4 Employment

Figure 80: Text Messaging Access based on Employment - Bus 2012

Figure 81: Text Messaging Access based on Employment - Bus 2013
Figure 82: Text Messaging Access based on Employment - Rail 2012

Figure 83: Text Messaging Access based on Employment - Rail 2013
C.2.5 Gender

Figure 84: Text Messaging Access based on Gender - Bus 2012

Figure 85: Text Messaging Access based on Gender - Bus 2013
Figure 86: Text Messaging Access based on Gender - Rail 2012

Figure 87: Text Messaging Access based on Gender - Rail 2013
C.3 Computer Internet Access

Graphs referring to the following analysis are provided in Figures 88 to 107.

Similar to the other two technology alternatives, the ability to access a computer with internet is fairly consistent until age 40. Riders who are older than 40 years old have a slightly lower probability of computer accessibility. Among bus and rail riders, riders who are students are the most likely to have access to a computer, followed by those who are employed. The remaining employment groups, (retired, homemaker, unemployed) have a noticeably lower percent of computer access. Compared to the other technology alternatives, there is a clear relationship between income and computer access. Riders within the income bracket ‘Under $20,000’ are the least likely to use a computer and, as income increases, the percentage of ownership increases as well. For example, among bus riders in 2013, 69% of riders earning less than $20,000 had computer access while 93% of riders earning more than $100,000 had this access. Another deviation from the trend seen within other alternative technologies is the race distribution. Black / African Americans are, overall, the least likely to have computer internet access. However, there is still a majority of this ethnic group that is able to access this technology. For example, approximately 82% of Black / African American rail riders in 2013 can access internet on a computer.
C.3.1 Age

Figure 88: Access to Computer-Based Websites based on Age - Bus 2012

Figure 89: Access to Computer-Based Websites based on Age - Bus 2013
Figure 90: Access to Computer-Based Websites based on Age - Rail 2012

Figure 91: Access to Computer-Based Websites based on Age - Rail 2013
### C.3.2 Race

<table>
<thead>
<tr>
<th>Race</th>
<th>Yes</th>
<th>No</th>
<th>Sample Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black/African American</td>
<td>75%</td>
<td>25%</td>
<td>n = 1016</td>
</tr>
<tr>
<td>White/Caucasian</td>
<td>72%</td>
<td>28%</td>
<td>n = 271</td>
</tr>
<tr>
<td>Asian/Asian American</td>
<td>96%</td>
<td>4%</td>
<td>n = 53</td>
</tr>
<tr>
<td>Latino/Hispanic American</td>
<td>80%</td>
<td>20%</td>
<td>n = 20</td>
</tr>
<tr>
<td>Other</td>
<td>88%</td>
<td>12%</td>
<td>n = 43</td>
</tr>
</tbody>
</table>

**Figure 92: Access to Computer-Based Websites based on Race - Bus 2012**

<table>
<thead>
<tr>
<th>Race</th>
<th>Yes</th>
<th>No</th>
<th>Sample Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black/African American</td>
<td>75%</td>
<td>25%</td>
<td>n = 2026</td>
</tr>
<tr>
<td>White/Caucasian</td>
<td>79%</td>
<td>21%</td>
<td>n = 479</td>
</tr>
<tr>
<td>Asian/Asian American</td>
<td>92%</td>
<td>8%</td>
<td>n = 51</td>
</tr>
<tr>
<td>Latino/Hispanic American</td>
<td>89%</td>
<td>11%</td>
<td>n = 36</td>
</tr>
<tr>
<td>Other</td>
<td>79%</td>
<td>21%</td>
<td>n = 90</td>
</tr>
</tbody>
</table>

**Figure 93: Access to Computer-Based Websites based on Race - Bus 2013**
Figure 94: Access to Computer-Based Websites based on Race - Rail 2012

Figure 95: Access to Computer-Based Websites based on Race - Rail 2013
C.3.3 Income

Figure 96: Access to Computer-Based Websites based on Income - Bus 2012

Figure 97: Access to Computer-Based Websites based on Income - Bus 2013
Figure 98: Access to Computer-Based Websites based on Income - Rail 2012

Figure 99: Access to Computer-Based Websites based on Income - Rail 2013
C.3.4 Employment

Figure 100: Access to Computer-Based Websites based on Employment - Bus 2012

Figure 101: Access to Computer-Based Websites based on Employment - Bus 2013
Figure 102: Access to Computer-Based Websites based on Employment - Rail 2012

Figure 103: Access to Computer-Based Websites based on Employment - Rail 2013
C.3.5 Gender

Figure 104: Access to Computer-Based Websites based on Gender - Bus 2012

Figure 105: Access to Computer-Based Websites based on Gender - Bus 2013
Figure 106: Access to Computer-Based Websites based on Gender - Rail 2012

Figure 107: Access to Computer-Based Websites based on Gender - Rail 2013
# APPENDIX D

## BINARY LOGISTIC REGRESSION

Table 47: Logistic Regression - Variable Definitions

<table>
<thead>
<tr>
<th>Demographic Category</th>
<th>Variable Name</th>
<th>Variable Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NoSmartint</td>
<td>Individual does NOT have access to Smartphone Applications</td>
</tr>
<tr>
<td>Gender</td>
<td>Male</td>
<td>Male</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>Female</td>
</tr>
<tr>
<td>Race</td>
<td>Black_AfricanAmerican</td>
<td>Black / African American</td>
</tr>
<tr>
<td></td>
<td>White_Caucasian</td>
<td>White / Caucasian</td>
</tr>
<tr>
<td></td>
<td>Latino_HispanicAmerican</td>
<td>Latino / Hispanic American</td>
</tr>
<tr>
<td></td>
<td>Asian_American</td>
<td>Asian / Asian American</td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>Race is defined as 'Other'</td>
</tr>
<tr>
<td>Age</td>
<td>X40andBelow</td>
<td>Respondent is less than 41 years old</td>
</tr>
<tr>
<td></td>
<td>Above40</td>
<td>Respondent is more than 40 years old</td>
</tr>
<tr>
<td>Employment Status</td>
<td>EmployFT</td>
<td>Employed Full-Time</td>
</tr>
<tr>
<td></td>
<td>EmployPT</td>
<td>Employed Part-Time</td>
</tr>
<tr>
<td></td>
<td>Unemploy</td>
<td>Unemployed</td>
</tr>
<tr>
<td></td>
<td>Student</td>
<td>Student</td>
</tr>
<tr>
<td></td>
<td>Homemaker</td>
<td>Homemaker</td>
</tr>
<tr>
<td></td>
<td>Retired</td>
<td>Retired</td>
</tr>
<tr>
<td></td>
<td>EmpFTandStu</td>
<td>Employed Full-Time AND a Student</td>
</tr>
<tr>
<td></td>
<td>EmpPTandStu</td>
<td>Employed Part-Time AND a Student</td>
</tr>
<tr>
<td></td>
<td>Employed</td>
<td>Employed Full-Time OR Employed Part-Time</td>
</tr>
<tr>
<td></td>
<td>EmployStu</td>
<td>Employed Full/Part-Time AND a Student</td>
</tr>
<tr>
<td>Household Income</td>
<td>Under20000</td>
<td>Income Less than $20,000</td>
</tr>
<tr>
<td></td>
<td>X20K40K</td>
<td>Income is $20,000 to $40,000</td>
</tr>
<tr>
<td></td>
<td>X40K60K</td>
<td>Income is $40,000 to $60,000</td>
</tr>
<tr>
<td></td>
<td>X60K80K</td>
<td>Income is $60,000 to $80,000</td>
</tr>
<tr>
<td></td>
<td>X80K100K</td>
<td>Income is $80,000 to $100,000</td>
</tr>
<tr>
<td></td>
<td>X100KPlus</td>
<td>Income is over $100,000</td>
</tr>
<tr>
<td></td>
<td>Under60K</td>
<td>Income is less than $60,000</td>
</tr>
<tr>
<td></td>
<td>Over80K</td>
<td>Income is over $80,000</td>
</tr>
</tbody>
</table>
Table 48: Logistic Regression with All Variables - Bus 2012

<table>
<thead>
<tr>
<th>Demographic Category</th>
<th>Variable Name</th>
<th>Coefficient</th>
<th>S.E.</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Intercept</td>
<td>1.232</td>
<td>0.187</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Gender</td>
<td>Male</td>
<td>0.130</td>
<td>0.112</td>
<td>0.2470</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>Base Case</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Race</td>
<td>Black AfricanAmerican</td>
<td>-0.126</td>
<td>0.196</td>
<td>0.5210</td>
</tr>
<tr>
<td></td>
<td>White Caucasian</td>
<td>0.152</td>
<td>0.229</td>
<td>0.5070</td>
</tr>
<tr>
<td></td>
<td>Latino HispanicAmerican</td>
<td>-0.861</td>
<td>0.546</td>
<td>0.1145</td>
</tr>
<tr>
<td></td>
<td>Asian AsianAmerican</td>
<td>-0.258</td>
<td>0.342</td>
<td>0.4509</td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>Base Case</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>X40andBelow</td>
<td>-1.400</td>
<td>0.120</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td></td>
<td>Above40</td>
<td>Base Case</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employment Status</td>
<td>EmployFT</td>
<td>-0.356</td>
<td>0.177</td>
<td>0.0450</td>
</tr>
<tr>
<td></td>
<td>EmployPT</td>
<td>-0.426</td>
<td>0.207</td>
<td>0.0400</td>
</tr>
<tr>
<td></td>
<td>Unemploy</td>
<td>0.497</td>
<td>0.239</td>
<td>0.0377</td>
</tr>
<tr>
<td></td>
<td>Student</td>
<td>-0.051</td>
<td>0.242</td>
<td>0.8334</td>
</tr>
<tr>
<td></td>
<td>Homemaker</td>
<td>0.490</td>
<td>0.458</td>
<td>0.2843</td>
</tr>
<tr>
<td></td>
<td>Retired</td>
<td>Base Case</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>EmpFTandStu</td>
<td>-0.461</td>
<td>0.379</td>
<td>0.2247</td>
</tr>
<tr>
<td></td>
<td>EmpPTandStu</td>
<td>-0.831</td>
<td>0.399</td>
<td>0.0374</td>
</tr>
<tr>
<td>Household Income</td>
<td>Under20000</td>
<td>0.034</td>
<td>0.159</td>
<td>0.8317</td>
</tr>
<tr>
<td></td>
<td>X20K40K</td>
<td>-0.201</td>
<td>0.174</td>
<td>0.2481</td>
</tr>
<tr>
<td></td>
<td>X40K60K</td>
<td>-0.182</td>
<td>0.213</td>
<td>0.3945</td>
</tr>
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<td></td>
<td>X60K80K</td>
<td>-0.122</td>
<td>0.309</td>
<td>0.6939</td>
</tr>
<tr>
<td></td>
<td>X80K100K</td>
<td>-0.966</td>
<td>0.463</td>
<td>0.0369</td>
</tr>
<tr>
<td></td>
<td>X100KPlus</td>
<td>Base Case</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fit statistics</td>
<td>Rho-Squared</td>
<td>0.190</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>AIC</td>
<td>2014.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Log Likelihood</td>
<td>-988.414</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 49: Logistic Regression with All Variables - Bus 2013

<table>
<thead>
<tr>
<th>Demographic Category</th>
<th>Variable Name</th>
<th>Coefficient</th>
<th>S.E.</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Intercept</td>
<td>1.634</td>
<td>0.168</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Gender</td>
<td>Male</td>
<td>0.004</td>
<td>0.083</td>
<td>0.9607</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>Base Case</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Race</td>
<td>Black_AfricanAmerican</td>
<td>-0.333</td>
<td>0.145</td>
<td>0.0214</td>
</tr>
<tr>
<td>Race</td>
<td>White_Caucasian</td>
<td>-0.045</td>
<td>0.169</td>
<td>0.7918</td>
</tr>
<tr>
<td>Race</td>
<td>Latino_HispanicAmerican</td>
<td>-0.046</td>
<td>0.386</td>
<td>0.9053</td>
</tr>
<tr>
<td>Race</td>
<td>Asian_AfricanAmerican</td>
<td>0.305</td>
<td>0.329</td>
<td>0.3533</td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>Base Case</td>
<td></td>
<td></td>
</tr>
<tr>
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Table 50: Logistic Regression with All Variables - Rail 2012

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Table 51: Logistic Regression with All Variables - Rail 2013

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